Draft

Groundwater
Farmer-Managed Irrigation Systems
and
Sustainable Groundwater Management

A South Asian Regional Workshop of the FMIS Network

18 – 21 May 1992
Dhaka, Bangladesh

VOLUME I

INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE
Colombo, Sri Lanka

IIMI

INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE
P. O. Box 2075, Colombo, Sri Lanka

Tel: 94-1-567404 Tlx: 22318 & 22907 IIMIHQ CE Fax: 94-1-566854 EMail: IIMI 157: CGI 129

South Asian Regional Workshop on
Groundwater Farmer-Managed Irrigation Systems and
Sustainable Groundwater Management

18-21 May 1992 - Dhaka, Bangladesh

22 April 1992

Dear Colleague,

In this volume you will find the first set of 24 papers. You will receive the second set of papers as Volume II on arrival in Dhaka if not before. We hope that this will give you sufficient time to read the papers before the workshop. We expect to receive 30 papers to be presented at the workshop. Please bring this volume with you to Dhaka.

We look forward to your participation at the workshop.

Workshop Coordinators,

SHAUL MANOR
FMIS Network Coordinator
International Irrigation Management Institute
Colombo, Sri Lanka

DONALD PARKER
Head, Field Operations
International Irrigation Management Institute
Dhaka, Bangladesh

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South Asian Regional Workshop on
Groundwater Farmer-Managed Irrigation Systems and
Sustainable Groundwater Management

18-21 May 1992 - Dhaka, Bangladesh

ANNOUNCEMENT NO.1

Workshop Schedule

The workshop will be held at:

Bangladesh Agricultural Research Council (BARC)
Farmgate, Dhaka, Bangladesh

Sunday, May 17

1700 - 1900	Registration followed by an informal gathering at the Sundarban Hotel

Monday, May 18

0800 - 0900	Registration (continuation) at BARC
0900 - 0945	Opening Session
0945 - 1000	Coffee
1000 - 1300	Plenary Session
1300 - 1400	Lunch
1400 - 1530	Group Discussion
1530 - 1545	Coffee
1545 - 1715	Plenary Session
1900	Reception and Dinner at Sonargaon Hotel

Tuesday, May 19

Morning	Depart from Dhaka on the two-day field trip to Rajshahi Overnight at Rural Development Academy Return to Dhaka on Wednesday evening

Wednesday, May 20

0830 - 0900	Plenary Session
0900 - 1030	Group Discussion
1030 - 1045	Coffee
1045 - 1230	Group Discussion
1230 - 1330	Lunch
1330 - 1545	Plenary Session
1545 - 1600	Coffee
1600 - 1700	Closing Session

127, Sunil Mawatha, Pelawatte via Colombo, Sri Lanka.

There will be no individual presentation of papers as a number of participants have been requested ahead of time to prepare synthesis presentations of a set of papers during the first plenary session. This will be followed by group discussions and then by the finalization of the list of issues to be discussed during the workshop and a definition of the output.

Field Trip

A field trip to various farmer-managed groundwater irrigation systems has been arranged for Tuesday and Wednesday, May 19 and 20. This field trip, by being scheduled during the middle of the four days, is designed to be an integral part of the workshop rather than an add-on. Arrangements have been made to fly participants to Rajshahi (west of Dhaka) on the morning of the 19th. We will see two or three types of groundwater irrigation systems plus a historical site during the day and will stay overnight at the Rural Development Academy near Bogra. On the 20th morning two more systems will be visited. During the afternoon and evening we will travel by road back to Dhaka, a trip that will include a two-hour ferry crossing of the Jamuna (brahmaputra) River.

For participants not funded by the workshop, field trip costs (room, board and transportation) have been included in the workshop registration fee.

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ANNOUNCEMENT NO.2

General Information

Workshop Venue

The workshop will be held at:

Bangladesh Agricultural Research Council (BARC)
Farmgate, Dhaka, Bangladesh

During the time of the workshop, the organization of events will be handled by the Dhaka IIMI office:

Dr. Donald E Parker
Head, Bangladesh Field Operations
IIMI
56A, Road 16 (new)
Dhanmandi R.A., Dhaka - 1209
Bangladesh

Tel: (880-2) 324128 Fax: (880-2) 813095 (Attn. IIMI) Tlx: 642940 ADAB BJ
Telephone at residence: 880-2-883690

Accommodation

Reservations have been made for foreign participants at the following hotel in Dhaka:

Sundarban Hotel
1/D, Free School Street
Sonargaon Road
(opposite Sonargaon Hotel)
Dhaka - 1205

Tel: 880-2-505055 to 505059 Tlx: 642928 SUN HT BJ

Check-in date	Sunday, 17 May, 1992
Field trip	Tuesday/Wednesday, 19/20 May, 1992
Check-out date	Friday, 22 May, 1992
Duration of Hotel stay in Dhaka	4 nights

Participants not funded by the workshop are kindly requested to make their payments during the time of registration upon arrival. The cost per person per night (excluding meals) will be approximately US$33 ($132 for 4 nights).

Travel Arrangements

For Participants travelling from Nepal: The IIMI office in Nepal will make all travel arrangements.

For Participants travelling from Pakistan: The IIMI office in Pakistan will make all travel arrangements.

For Participants travelling from India and Sri Lanka: Mr. Mohan Abayasekara, Travel and Conference Coordinator of the IIMI headquarters in Sri Lanka will make all travel arrangements.

Those participants who are not funded by the workshop should ensure that they inform the workshop organizers their date and time of arrival and flight number.

Airport Arrival in Dhaka

Arrangements will be made to meet all participants arriving on international flights at Zia International Airport in Dhaka. In case you miss our representative, please take a taxi to the hotel. There is a fixed rate taxi service that can be arranged from a desk just outside the terminal building. There is a display of posted rates to various city destinations at this desk. The fare to the Sundarban Hotel, if not listed separately, is the same as that to the nearby Sonargaon Hotel. Please beware of pick-pockets working in the crowds in and near the terminal building.

Currency

The exchange rate is 39 Taka = 1 US Dollar. Money exchange desks are situated in the customs area at the Airport.

Dhaka

Dhaka is the capital city of Bangladesh and is situated roughly in the center of the country. Day-time temperature in May is likely to be between 35 and 38 degrees Celsius with some humidity.

If you have any other questions please feel free to contact the workshop organizers - Shaul Manor in Colombo or Donald Parker in Dhaka. Please note that all papers should however be addressed to the IIMI office in Colombo.

* * * * * * *

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ANNOUNCEMENT NO.3

Issues for Discussion

The following list of issues would serve as a guideline for discussion at the group sessions during the workshop. The list of issues should refer to different environments including areas of water surplus and water deficit and areas of conjunctive and non-conjunctive use of water. This list will be discussed and finalized during the first session.

1. Objectives of Groundwater Development

- Growth
- Sustainability
- Equity
- Poverty Alleviation
- Gender

2. Intervention Issues Related to:

a. **Price Policy**

- Subsidies for boring, hiring or purchasing of pumpsets, on-farm distribution, etc.
- State-managed tubewells
- Encouraging water markets
- Electric power supply and pricing:
  - mode - pro-rata, flat, 2 part
  - level
  - rationing
  - collection of charges
  - ownership/contracting/wholesaling
- Diesel price levels

b. **Technology**

- Encouragement in small pumps
- Ban on big pumps; import or production of diesel pumps, etc.
- Control of turbine pumps
- Encourage investments in power saving devices
- Rapid rural electrification
- Dedicated powerlines
- Subsidize pipelines and on-farm canal lining
- Encourage drip and sprinkler irrigation
- Support services for installation, maintenance, repairs, etc.
- Conjunctive management
- Augment recharge through surface water irrigation systems
- Agricultural technologies:
  - high return to water
  - water saving/conservation
  - saline tolerance
  - better use of rainfall

c. **Institutional**

- Farmer co-operatives/groups/associations for tubewell operations (group tubewells)
- Landless group for lift irrigation
- Priority for Small Farmers/Marginal Farmers (SF/MF) in power connections
- Involvement of NGO for equitable and efficient allocation
- Subsidies for SF/MF for selling water
- Credit to SF/MF
- Agricultural Extension
- Irrigation Extension
- Intensive groundwater survey, development and monitoring
- Law and Legislation:
  - regulation of groundwater - technology, spacing and use
- Property rights in groundwater:
  - definition
  - allocation
  - enforcement
  - institutional forms
    - wateruser associations
    - farmer groups
    - cooperatives
    - districts
    - landless groups
    - credit organization

d. **Others**

- Drawdown effects
- Saline intrusion
- Drainage and waterlogging
- Groundwater and:
  - health
  - education
  - gender
- Land consolidation and tenure
- Land reforms:
  - tenancy regulation
  - redistribution
  - government lands - waste, etc.
- Rural infrastructure policy
- Agricultural credit policy
- Water demand versus supply management
- Rural infrastructure policy
- Law and order
- Groundwater Districts
- Mixed Public/Private forms of Management
  - contracting
  - franchising

3. <u>Research Priorities</u>

4. <u>Agendas for Action</u>

* * * * * * *

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Announcement No.4

List of Participants

Country	Name of Participant	Institute
Bangladesh	M Asaduzzaman	BADC
	A K M Moniruzzaman	BARC
	M D Harun-ur-Rashid	BARI
	Anisur Rahman	Bangladesh Water Dev. Board
	M A Ghani	World Bank
	S A Rana	World Bank
	Santosh Chandra Sarker	Proshika Manobik Unnayan Kendra
	M N Islam	BRRI
	Aung K Hla	BADC
	M A Kalam	BADC
	W M H Jaim	Rural Development Academy
	Abdus Sattar Mandal	Bangladesh Agricultural Univ.
	T H Miah	Bangladesh Agricultural Univ.
	Lutfor Rahman Khan	Bangladesh Agricultural Univ.
	M A Hakim	IIMI - Bangladesh
	M A Sattar	IRRI
Canada	Manuel Olin	Irrigation Management Consultant
China	Han Chang Gang	Shandong Project
	Huang Qi Shu	Shandong Project
	Sun Fu Wen	Shandong Project
	Xue Jian Hua	Shandong Project
	Wang Yong Le	Water Res. Dept. of Anhui Prov.
	Tao Yue Zan	Water Res. Dept. of Anhui Prov.
India	S T Somashekhara Reddy	Indian Institute of Management
	M Venkata Reddy	Inst. for Social & Eco. Change
	Marcus H Moench	VIKSAT
	D S K Rao	Nat. Bank for Agric.& Rural Chg.
	S Janakarajan	Madras Institute of Dev. Studies
	T Prasad	Patna University

Country	Name of Participant	Institute
Indonesia	Sigit Supadmo Arif	Gadjah Mada University
	Agus Pakpahan	Ministry of Agriculture
	Santo Purnomo H	Ministry of Public Works
	Subuh Nirwono	Ministry of Public Works
	Daud Berahmana	Ministry of Agriculture
Nepal	Narayan Prasad Upadhyay	CEPA
	N Ansari	Ministry of Water Resources
	Ujjwal Pradhan	IIMI - Nepal
	Ganesh Thapa	Ministry of Agriculture
Pakistan	Irshad Ahmed	Irrigation & Power Department
	Musthtaq Ahmad Gill	Water Management - Punjab
	Javed Saleem	WAPDA
	(3 Participants)	CTA/PATA Project
Philippines	Charles Robert Blessley	IRRI
	Vicente S Flores	NIA
Sri Lanka	Marcus M Karunanayake	Univ. of Sri Jayawardenepura
	R de Silva Ariyabandu	ARTI
	M D C Abhayaratna	Univ. of Sri Jayawardenepura
Thailand	J P Grindey	Sukhothai Groundwater Project
UK	R William Palmer-Jones	University of East Anglia
	Linden Vincent	ODI
USA	B C Barah	Duke University
Others	R Sakthivadivel	IIMI Sri Lanka
	Nanda Abeywickrema	IIMI Headquarters
	Donald Parker	IIMI Bangladesh
	Khalid Mohtadullah	IIMI Headquarters
	John Ambler	Ford Foundation - India

Organizing Committee:

Shaul Manor (Chairman)
Donald Parker
R Sakthivadivel
Sattar Mandal

22 April 1992

VANATHAVILLU FARMER MANAGED IRRIGATION SYSTEM IN SRI LANKA : IMPLICATIONS FOR SUSTAINABLE USE OF GROUNDWATER

M.M. Karunanayake*

ABSTRACT

The paper looks at the imperatives of sustainable groundwater utilization in the context of the virtual failure of the Vanathavillu FMIS located in the Puttalam district of Sri Lanka. The object in setting - up the FMIS was to utilize groundwater for the cultivation of subsidiary field crops to enhance farmer incomes and season proof households. Altogether 168 farmers were given 0.4 ha allotments in the FMIS. While the Irrigation Department was responsible for pump operation and maintenance the farmers were collectively responsible for on-farm water distribution and maintenance of the distribution network. Despite initial success the Vanathavillu FMIS has lost its momentum and the farmers have taken to the cultivation of permanent crops and rainfed field crops in place of irrigated agriculture. In the Vanathavillu FMIS sustainability has been undermined by technical, agricultural, institutional and organisational problems. For sustainable groundwater utilization changes have to be made in water management, crop agronomy, infrastructure availability and system management. There is a need to better integrate the FMIS into the regional economy. Issues of sustainability have to be viewed in the larger context of the macro policy environment.

INTRODUCTION

This study focusses on the imperatives of sustainable groundwater utilization taking into account the reasons for the virtual failure of the Vanathavillu Groundwater FMIS. Hence the study utilizes an inductive approach. In relation to Vanathavillu the term FMIS needs qualification. The system had been set-up with State intervention but the management responsibilities (land development through the cultivation of subsidiary crops, water distribution at the field level and maintenance of the distribution network in particular within each allotment) had devolved on the farmer community. However, from the very inception of the FMIS there had been total dependence on the State (represented by the Department of Irrigation) for the lifting of groundwater to meet the irrigation requirements of the farmers. Thus in the Vanathavillu FMIS the farmers had not performed a resource management function at the source.

* Professor of Geography,University of Sri Jayewardenepura, Nugegoda, Sri Lanka.

This study is based on data derived from the author's previous field work in Vanathavillu (Karunanayake, 1983) supported by a rapid appraisal of the system in March 1992 involving field observations as well as discussions with key informants from among both farmers and officials.

GEOGRAPHICAL SETTING

Vanathavillu FMIS is located in the Divisional Secretary's Division of Vanathavillu in the Puttalam District of Sri lanka (Fig 1). Climatically Vanathavillu lies in the Arid Zone of Sri Lanka1. The average annual rainfall is below 1270 mm and there are about 200 non - rainy days in the year. The dry months of June to September are generally water deficient. The average annual temperature varies between 26o - 28oC.

The terrain of the region is flat to undulating. In general the soils consist of Red-Yellow Latasols. These soils are neutral to medium acid in reaction and are well suited to the cultivation of subsidiary food crops under irrigation.

Whereas most parts of the Island are underlain by a basement complex of metamorphic rocks, the Vanathavillu FMIS is located in the southern part of a 200 km long limestone belt stretching along the northern and northwestern coastal areas. The confined nature of the aquifer is found to create artesian conditions in Vanathavillu. Estimates of groundwater resources available vary between 5 - 20 million cubic metres per year (NARESA, 1991).

VANATHAVILLU FMIS

The Vanathavillu FMIS was set-up in 1968. Although 29 tube wells were sunk only 8 wells were ultimately developed owing to problems of salinity and low water yields (Fig 1). Of the production wells one was set aside for the exclusive purpose of providing water to the Vanathavillu town area. Overtime, the

Table I: Data on Production Wells

Well No	Diameter (cms)	Total Depth(m)	Depth to Water Level (m)	Yield l/p/s	Extent Irrigated(ha)
P9	20	124	25	23	14.4
W4	25.4	67	27	30	16.8
W5	25.4	131	32	23	17.2
W6	30.4	91	38	38	9.2

Source: Adapted from Project Report on Rehabilitation of Vanathavillu Ground Water Project : Office of the Irrigation Engineer, Puttalam (1990).

LOCATION

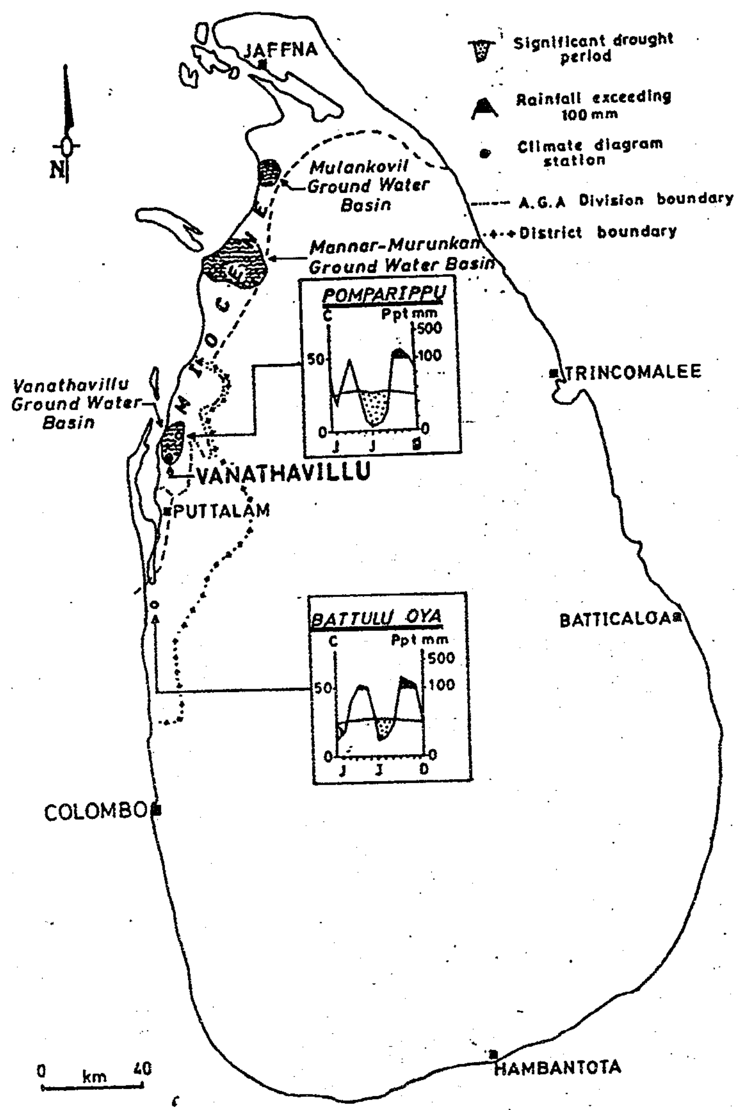

Fig: 1

DISTRIBUTION OF TUBE WELLS

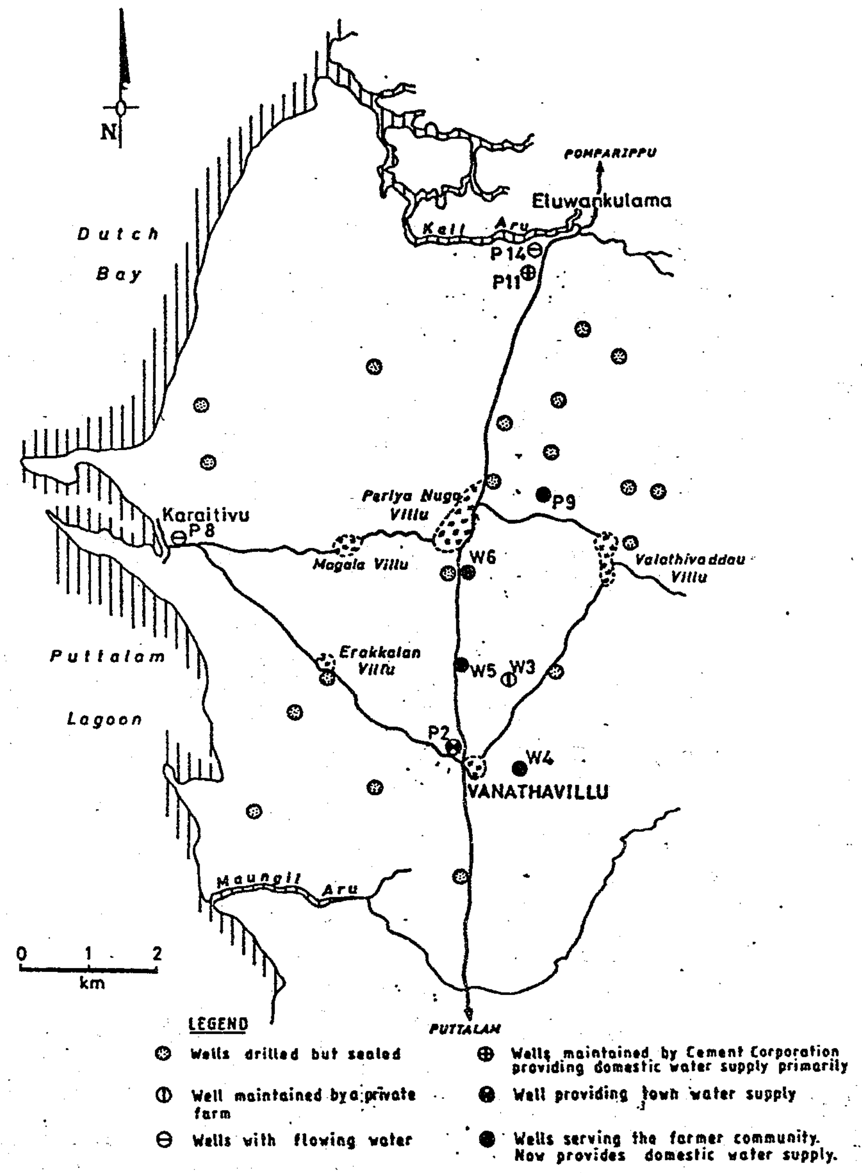

Fig: 2

number of production wells serving the farmer community has declined to four2 (Table 1). Marked salinity variations have been observed in these wells.

At the inception a total of 168 families was provided with irrigable land with each family receiving a 0.4 ha allotment. All original allottees were from nearby villages. The allottees were required to grow subsidiary field crops utilizing ground water for irrigation.

Each tubewell was equipped with a diesel engine powered pump to lift ground water. It was the responsibility of the Irrigation Department to operate and maintain the pumps. The cost of fuel was met by the Department of Irrigation. Pump operation was in the hands of casual operators of the Irrigation Department. Though a pilot scheme was launched to price irrigation water, this was resisted by the farmers who damaged the water meters installed for the purpose.

Irrigation water was led from the pumping station to the farmers' plots along pipelines buried underground and provided with control devices. The farmers were expected to mind the control stop taps with due concern for the irrigation requirements of others during pump operation. It was also their responsibility to attend to any minor maintenance work on the pipelines within their allotments. The method of irrigation was to hand irrigate the crops by first letting the water collect in four small tanks usually located within the four corners of each allotment. The water was delivered to the farmers fields twice daily.

Eventhough the Vanathavillu FMIS had seen some success initially, it has lost its momentum for reasons discussed below. At present there is no groundwater irrigated agriculture. Instead farmers have taken to the cultivation of permanent crops in their allotments. To a limited extent subsidiary field crops are grown during the rainy season. Consequently the Vanathavillu FMIS functions in a state of interia. No irrigation water is provided to the farmers but water for domestic use is provided on a restricted schedule. The Irrigation Department has had to depend on the decentralized budget3 and the Integrated Rural Development Programme for funds to meet the cost of fuel. In 1990 the expenditure on fuel was Rs 315,000/- (US$ 7500).

FACTORS UNDERMINING SUSTAINABILITY

Technical

Among factors undermining the sustainability of the Vanathavillu FMIS the technical problems contributing to the inefficiency of the irrigation system are most evident. Over the years, the cost of fuel has risen, while the pumps have become obsolete. Repairs have been difficult because of the problems and delays in obtaining spare parts. This has been further complicated by the fact that there are no agents for the particular brand(s) of pumps installed. Therefore, the system has lacked in resiliency to deal with contingency situations. The need to overhaul the water lifting system after a given time span had not been built into project planning.

There have also been problems relating to the layout of the distribution system. Some allotments are found to be at distances of 2 - 4 km from the pumping points. There are also allotments that are located on relatively high ground. With the decreasing efficiency of the pumps it has become difficult to pump water at the required pressure to reach the tail ends of the system or the allotments on relatively higher ground. Pump pressure tests had not been performed on a regular basis at least in the recent past.

Agricultural

Sustainability of the Vanathavillu FMIS has also been undermined by agricultural problems. Although a minor agricultural research station had been set - up at Eluwankulam it had not had the capacity to carry out adaptive research to benefit the farmers on problems such as moisture stress, effect of salinity on crop yields, irrigation requirements of crops etc.

Irrigation schedules based on time length of application rather than on moisture stress had also affected crop performance. Furthermore, irrigation efficiencies had been retarded by poor water management which resulted in wasteful utilization of water. High salinity had been a problem faced by some Vanathavillu farmers.

Hence a kind of agricultural involution has taken place whereby the farmers have lapsed into a system of agriculture comprising permanent tree crops supplemented by rainfed field crops in place of lift irrigated agriculture.

Institutional

The institutional delivery system for credit and inputs have been unsatisfactory. The situation has shown little improvement over the years. There are 05 sales outlets, 08 authorized dealers, a fertilizer and a fuel store in the Vanathavillu division (IRDP, 1990). The sales outlets primarily distribute consumer items on the ration. The institutional set- up is not geared to purchase farm produce. Although a rural bank is available for the division and had 1140 savings accounts in 1990 it does not provide credit facilities. The savings totalled Rs

106960/- (US$ 2547) i.e. Rs 94/- (or US$ 2.2 per holder). These figures indirectly reflect the poor savings capacity of the Vanathavillu farmers.

Another institutional problem but of a different kind is that the farmers have not been issued with title to their allotments in keeping with the State land policy based on lease in perpetuity. As such many farmers have had no permanent interest in their allotments. Indeed, there are allotments that have changed hands many times for the same reason.

Organisational

The failure to set - up viable pump committees and farmers organisations is particularly striking. There has been too much dependence on the irrigation bureaucracy and the farmers had shown little interest to capacitate themselves for the collective good. In general the farmer organisations have lacked in self reliance and failed to play an adequately participatory role in system management.

REHABILITATING VANATHAVILLU FMIS

Proposals to rehabilitate Vanathavillu FMIS is contained in a report titled Rehabilitation of Vanathavillu Groundwater Project prepared by the Office of the Irrigation Engineer, Puttalam (1990).

In regard to water use it is proposed that the existing diesel engines and pumps which are old and in need of frequent repairs be replaced with electrically operated submersible deep well pumps. These will be linked to the existing delivery system. The distribution network is to be rehabilitated by installing control devices such as valve gates, control stop taps and meters in place of those which are found to be demaged or unserviceable. The provision of a three phase supply of electricity is anticipated for the operation of the electric pumps.

A project management plan has been drawn up which places the Vanathavillu FMIS under the supervision of the Pradeshiya Sabha (Divisional Council). Each pump will have an operator (an employee of the Irrigation Department) and a project committee consisting of representatives of farmers served by a particular pump. The necessary technical inputs will be provided by the Irrigation and the Agricultural Departments.

A limitation of the proposed plan is that it does not address the issue of sustainable development of the system. Moreover, the potential for farmer management of the system is underplayed. Thus the role of the project committees is merely to " assist Pradeshiya Sabha in the smooth functioning of the Project."

IMPLICATIONS FOR SUSTAINABILITY

The most serious problem facing the Vanathavillu farmers had been the absence of a dependable water supply. The system was not geared to the swift repair of pumps. Consequently there were long delays in restoring the irrigation water supply when pumps failed. The plan to replace the water lifting system with new electrically operated submersible deep well pumps is a step in the right direction. But from a sustainability point of view it is equally important to see to the up-keep of the system by an anticipatory approach to repair and maintenance, where the more frequently needed spare parts are available ex-stock and pump testing is carried out as a matter of routine. It has been pointed out by Sne (1991) that pump performance tests enable to determine pump regimes and bring down operational costs. Furthermore, the need to overhaul the system once every 8 to 10 years appears to be necessary for sustainable groundwater utilization.

Hence, funds for pump operation and maintenance are a crucial issue from a long-term perspective. It has been previously mentioned that the farmers had been used to a system of free delivery of water at State expense. The plan of rehabilitation envisages the provision of a metered water supply which will cost the user Rs 14/- per unit of 222 litres (1 US $= Rs 42). In discussions with the farmers it emerged that they were not averse to a water levy provided there is a dependable supply of irrigation water. Volumetric pricing of water has the likelihood of inculcating disciplined water use.

In the long term there has also to be a change in pump ownership. At present the pumps are owned by the Irrigation Department. However, it would serve the interests of sustainability better if the pumps are owned and maintained by the pump committees. The State could subsidize the cost of the pump to the tune of 25 percent or more and the balance could be advanced as a loan to the pump committee through the formal banking system, recoverable within a specified time period. It is also important to 'socialize' pump use by transferring the technical know how of pump maintenance to the pump committees (or to their representatives).

There appears to be no problem of groundwater availability in Vanathavillu in the short - term. To ensure sustainability over the long - term it is useful to develop a data base on groundwater behaviour with reference to availability, rechargeability, fluctuations and trends.

It is evident that sustainable groundwater utilization will also depend on the extent to which the pump committees are empowered to carry out their functions. Hitherto, farmer organizations in Vanathavillu had been participatory only to a limited degree (i.e. to the extent it placed demands on the irrigation and the political bureaucracy). The type of responsibilities that should devolve on the pump committees in respect of pump ownership, operation and maintenance have been mentioned. The pump committees should be backed by farmers organisations with wide ranging responsibilities to assist them - supervision of on - field water distribution, collection of water levies and conflict resolution. But to achieve this kind of transformation it is important that the farmers are in a position to capacitate themselves. Hence, the catalytic intervention of a social mobiliser is called for to bring about the needed attitudinal changes.

Sustainable groundwater utilization necessitates that greater attention be paid to crop agronomy with particular reference to water stress, salinity thresholds and cropping cycles. The agricultural research station at Eluwankulama has no links with the farmers. Discussions revealed a need for situation specific adaptive research. Another useful area of research is to formulate and field test rational irrigation schedules based on crop water stress, in place of time based applications.

It was noted that the farmers had reacted to irrigation failure by planting their allotments with drought resistant permanent crops. However, a consequence of this has been that some farmers have grown permanent crops over their entire allotment without considering the possibility of reverting to irrigated agriculture in the future. Hence, rationalisation of land use within each allotment is a necessary prerequisite to resume and to sustain groundwater irrigated agriculture.

Another issue that has to do with sustainable groundwater utilization in Vanathavillu is that of land ownership. The original beneficiaries had been allotted land in terms of the provisions of the Land Development Ordinance on perpetual lease but had not been issued with title deeds to the allotments. The present State policy is to confer conditional rights of ownership in terms of the Swarnabhoomi concept4. So far no Swarnabhoomi titles have been issued to Vanathavillu farmers. The matter is complicated by the fact that many of the original allottees have sold or otherwise disposed of their land to the present occupants, though such transactions are not permitted by Law.

It was earlier mentioned that there were institutional limitations which constrained the performance of the Vanathavillu FMIS. Thus even at present the rural banking system is not geared to meet the credit needs of the farmers. Similar shortcomings in the provision of services have also been to the disadvantage of the farmers. In particular they have had to depend on informal rather than formal market networks. The implication, therefore, is that to ensure sustainability a FMIS should be an integral component of the prevailing regional economy. Hence, horizontal linkages have to be promoted with the rural and urban service centres of the larger region through the strengthening of appropriate (e.g. transport and market) linkages.

A final implication for sustainability is the need for a macro policy environment favouring rural development. It means that some of the problems undermining sustainability of FMISs such as Vanathavillu can only be resolved through macro policies which support the rural sector. Yet in Sri Lanka as in many developing countries the converse is true. Hence, these tendencies have to be reversed through both a rational macro policy environment and a committed political ideology favouring the rural sector.

CONCLUSIONS

This study has demonstrated that in the Vanathavillu FMIS sustainability has been undermined by technical, agricultural, organisational and institutional problems. For sustainable development not only should viable farmer organisations be set-up but important changes have also to be effected in water management, crop agronomy and research, infrastructure and the overall responsibility for system management. The need to access infrastructure requires that the Vanathavillu FMIS be better integrated into the regional economy. The point is made that issues of sustainability cannot be viewed in isolation but within the larger context of the macro policy environment. It is imperative that in some areas of system management (e.g. aquifer management, monitoring of tube well performance and agronomic research) State agencies play a continuing and supportive role.

ACKNOWLEDGEMENTS

Thanks are due to Mr L. Perera, G.A. Puttalam and Mr L. Mahanama, Divisional Secretary / Additional G.A. Vanathavillu for the assistance provided during field work and to Mr G.F. de Alwis for preparing the maps.

NOTES

1. The term Arid Zone is used in a relative sense. According to Koppen - Geiger Climatic Classification Sri Lanka belongs to Af and Aw types, where A refer to mean monthly temperatures over 18oC, f sufficient precipitation in all months and w dry season in winter.

2. One well is maintained by a private farm and the remaining two by the Cement Corporation.

3. Refers to the annual budgetary allocation form the Centre.

4. Issue of conditional title to land.

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farmer managed irrigation systems | groundwater | tank irrigation

FMIS OF GROUND WATER: AT WHOSE COST?
A Study from Karnataka, India

S.T. SOMASHEKHARA REDDY[1]

ABSTRACT: In the expansion of area irrigated in India the role of ground water is quite significant. Being a private enterprise, of late, in areas where it is difficult to strike ground water, especially in drought prone regions of South India, farmers are getting organized to share the ground water. These organizations are largely based on 'market relations'. Where on individual basis or collectively few of these who are in need of water for irrigation purchase water from an individual who is successful in tapping abundant ground water. However, such organizations in the midst of surface irrigation systems called 'Tanks' are threatening the survival of FMIS in tank irrigated areas. The objective of the paper is to examine how the FMIS of ground water threatens the survival of FMIS in tank irrigated areas in two villages of Karnataka, India.

INTRODUCTION

Independent India has expanded its irrigated area from 20.9 million hectares in 1950-51 to 40 million hectares by 1990-91. Within this expanded area, the area irrigated by wells amounts almost to 50 per cent (Table.1). However, of late, there is a comment that, this enhancement in number of wells has contributed to declining groundwater levels. A decline by 5 meters to 10 meters has been felt through out the country(CMIE 1990). As a consequence the area irrigated by each well has declined in few regions such as, Kolar district of Karnataka where there was a large scale dependency on wells for irrigational requirements. Due to higher concentration of wells and availability of low quantum of ground water, there is a decline in area irrigated by each well. (Table.2). One of the measures that have been adopted by the farmers to meet the declining ground water levels is by sharing the ground water, that was tapped by the fortunate. In few areas, those farmers who are in requirement of water for irrigation and are unable to tap ground water purchase water from the one who was able to tap. In few other areas, farmers lease in lands along with water from the one who was successful enough to tap the ground water. These types of sharing ground water have given raise to formation of informal organisations among the farmers. The objective of this paper, is to examine the impact of these FMIS for ground water on FMIS for tank irrigated areas. As the ground water aquifers in South India have a direct linkage for percolation purposes to tanks (STS Reddy 1989). An attempt is also made to examine, how can an FMIS of tank irrigated areas can regulate FMIS of ground water in having access to water stored in the tank.

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FIELD OF STUDY

For the study, two villages in Karnataka having FMIS for both tank and wells were selected. One of the villages, Gattallagollahalli (GG Halli) was the one where FMIS for tank has been disbanded from 1987, but few FMIS for ground water are functioning effectively. An other village Bodampalli was selected, as that village had FMIS for both tank and ground water. Both FMIS are functioning to-date. GG Halli was selected in order to examine the possibility of impact of FMIS of groundwater on FMIS of tank and Bodampalli was selected in order to examine the factors that contribute for co-existence of both FMIS.

GG Halli located in semi-arid district of Tumkur owns a tank called as GG Halli tank. This tank has command area of 72 farmers owning 70 acres. The area irrigated exclusively by wells is 61 acres and the area irrigated both by tank and well is 38.72 acres. Thus nearly 50 per cent of the area in the tank command is having access to ground water.

Bodampalli is a village in highly drought prone district of Kolar owning nearly 14 tanks, of which, only two, Munganakunta (MK) and Doddakere (DK) are the biggest. These two put together irrigate 43.52 acres. In this village wells irrigate 27.60 acres. Roughly 42 acres of land in command area of the tanks has access to wells.

WATER MANAGEMENT

In GG Halli, prior to 1987 FMIS of tank used to allocate water, especially in summer on hourly basis. Quantum of water available in the tank after the month of February was estimated at the rate of one hour flow to one acre in a week.. Estimating the number of waterings available cropping pattern was determined. After exhausting the stored water within the tank, the two springs within the bed of the tank was utilised to supply water by deepening the spring and the canal connecting the spring with sluice. To avail the water each irrigator was supposed to contribute labour at the rate of one person per day per one acre to desilt the canal and to deepen the spring canal every day (Willy Douma et al., 1989).

Those who failed to contribute the expected labour were to pay a fine equivalent to a day's labour. When fine was not paid the 'panchayat' had the right to withhold water (Coward 1990). To bring about effective distribution of water, each canal had three leaders and a waterman. There was a record-keeper for each canal. Canal leaders and record-keepers were supervised by the executive body, wherein the 'patel' (incharge of law and order) was the presiding officer. Incidentally he owned highest acreage of land within the command area. The village tax collector called 'shanubog' was the secretary of the panchayat. Even though these hereditary posts were abolished by the government in 1976, the individuals continued to hold their offices in the 'panchayat' for tank.

In Bodampalli for both the tanks a system of water management called 'DAMOOSI' was practiced. In this system equivalent to the quantum of water available to irrigate paddy crop an area within the command area of a tank was declared as a property of FMIS for that cropping season. Such declared area was distributed among the irrigators on the basis of the proportion of area selected to the actual size of the command area of the tank (STS Reddy, 1989 & 1991).

To estimate the quantum of water available, to ear-mark the area for growing crops and to supervise distribution of water, there was an executive committee headed by a 'patel', who is supported by 'Shanubog'. As in the case of GG Halli, in this case also, the patel was the one owning highest acreage in the command area of both the tanks. These two officials were supported by waterman. With the abolition of hereditary posts, the patel continued to be the head of executive committee. After his death, his son,who is now an elected representative of the village to Mandal Panchayat, heads the executive committee. The family of 'Shanubog' migrated to nearby urban area by disposing off their holdings. Presently, two relatives to head of executive committee, perform the duties of 'shanubog'. There was no exclusive record-keeper, 'shanubog' was the record keeper.

USE OF GROUND WATER

HISTORY: Traditionally, it is in the command area of the tanks and around the command area that ground water was exploited through shallow wells. The water in wells was utilised in summer months or during drought seasons, to meet the shortages in surface flow. Such conjunctive uses was by the entire community of irrigators, even if the wells were owned individually. Such a collective action was a necessity as the technology of drafting such as bucket drawn by animals or swing buckets operated by two human beings required more labour. The sharing of groundwater in such ways was under the supervision of 'panchayat' for tank. 'Panchayat' was the name of the organisation that managed the water in the command area. The wells outside the command area were permitted only for meeting drinking water requirements.

The cropping pattern that was permitted was paddy, in summer months, semi-wet crops like ragi or ground nuts in monsoon. In between to exhaust soil moisture a vegetable crop was taken. In what was grown, there was no place for individual choice, it was always a decision by the 'panchayat', on behalf of all the irrigators (Willy Douma et.al., 1989).

CHANGE IN DRAFTING TECHNOLOGY

The change in the utilisation of ground water did happen with the arrival of electric run pumpsets. The governments both at the center and at the state levels encouraged digging wells away from the command area through liberal loan facilities to individual farmers. Such loans when invested in digging wells and the power run pumpsets provided a chance for individualism to emerge. As the finance was from the state, the community being subordinated to the power of state, failed to enforce any of its regulations on the individual going in for a well and a pumpset. Few farmers who happen to own a well utilised both tank and well for irrigational purposes. Such farmers were able to take more number of crops than those who are totally depending on tank for water, especially during post-monsoon months,wherein the chances of water availability from the tank was low. Such low-yields from the tank had compelled well owners to utilise the ground water for conjunctive uses in summer months. This sort of dependency had coerced them to continue as members of 'panchayat'.

HIGHER DEPENDENCY ON WELLS

Being located in drought prone region both the villages were regular victims to drought. From 1901-1980, approximately 20-25% of the period was drought hit for both Kolar and Tumkur districts. From 1981-1990 more than 50% of the period was drought affected (Willy Douma et. al., 1989). Consequence of this enhanced drought is, on one hand, there was a shortage of water collection in the tank and on the other greater need to tap ground water for growing crops. These two aspects encouraged farmers to go in for wells as an insurance against drought. Consequently, in GG Halli, number of wells increased from 40 in 1959-60 to 69 wells by 1987. 21 wells were constructed from 1980. Due to drought almost every alternative year, to tap ground water which was declining every year, on one hand the depth of wells had to be deepened, and secondly, every increase in depth demanded new technologies to replace kapile (animal drawn lift) and Manual lifting. This initiated installation of diesel or electric run pumpsets. Liberal loans available from Government under various schemes helped in the installation of pumpsets and borewells. An interesting aspect is, from 1987 as deepening of wells beyond a point was not feasible due to soil conditions, farmers had to go in for tube wells (STS Reddy). Two-type of tube wells were attempted. 32 farmers went in for tube wells within a well they own already. 13 farmers went in for surface tube-wells. Unlike in the past the success in striking sufficient water was limited. In 1987 out of seven farmers, who planned to instal tube-wells only one succeeded. Similarly, in 1989 out of three one succeeded. In 1990, five succeeded out of 14, and in 1991, one out of five. In installing a tube-well within a dug well about 14 people succeeded. Thus only 22 farmers succeeded in striking sufficient water. Similarly, in Bodampalli village from 1959 to 1980 number of wells increased from mere 15 to that of 45. Later on, due to hard-rock beneath the surface no new wells could be dug. The only alternative path available for them was to go in, firstly to tube-wells and secondly, to share the yield of a well with others. In Bodampalli, even though about 38 farmers tried to go in for tube-wells, only 7 farmers succeeded. This failure to strike water by everyone, enabled the search for alternative ways of acquiring water for irrigation. One such possibility was sharing the water available in a tube well yielding surplus water.

FORMATION OF GROUNDWATER FMIS

Installing a tube-well and a pump-set to lift water being highly cost-intensive it was prohibitive for every farmer owning land. It was also difficult to obtain loans issued by various agencies of government, as one of the conditions levied was that the loanee should be owning a minimum of one hectare of land at the site where tube-well has to be installed. Due to exorbitant tax levied on registering the inheritance rights of an individual to the piece of land one cultivates many poor farmers could not avail loan from governmental agencies. This can be clearly seen in case of those who have not gone in for tube-wells. In both the villages it is those who own lands above an hectare of wet land are predominant, among those who own a tube well (Table 3) As a consequence those who could not avail loan from Government due to various constraints were forced to look for alternative sources from which they can draw water for irrigational purpose.. The best alternative source for drawing water was to approach those farmers who have become successful in tapping such a ground water resource, which yields them surplus beyond their consumption levels. This was helpful to those whose wells yield surplus water. Such farmers through sharing ground water at a cost can recover part of their investment at an early date. This mutually beneficial act helped in the formation of four ground water FMIS in GG Halli and one in Bodampalli. In GG Halli, in one of the FMIS, normally called Narasimiah group the cost of installing a tube well and the pumpset is borne by six members at the rate of Rs.8,000/- each. Each member is eligible to irrigate one acre of land. The cost of electricity is borne equally by all the members. Even though there is no restriction on the type of crops to be grown, all the six members have planted sericulture in half an acre and in the rest they are growing one crop of paddy in an year, especially in monsoon months. here in water from the well is utilised as an insurance against availability of water from tank.

Apart from Narasimaiah group there are three more FMIS, they are named, on the basis of the owner of the well. In the group called Ramachandrappa group there are twelve members and each one of them has a liberty to grow any crop but have to pay 1/3 of the produce to the well-owner as a fee for drawing water from the well. Of the twelve members 5 members irrigate less than half an acre, 4 members irrigate less than a quarter, and the other irrigate more than 3/4 of an acre.

In Kenchappa group and Narayanappa group, the membership is of 5 members each. In both the groups, the members have to pay Rs.25 per every hour of water flow. As a consequence there is no restriction on the crop to be grown. In both the groups most of the members irrigate less than half-a-acre. In all the organisations the owners of well, except in Narasimaiah group, have the freedom to grow any crop they wish and the extent they like.

In Bodampalli there is only one group which shares water from a tube-well. In this, there are only three members and they draw water only for growing a crop of cotton for developing foundation seeds. As this crop is of six months in duration and as each member earns an income above Rs. one lakh, the members pay Rs.50 for every hour of water flow to half an acre. The reason for only one FMIS of ground water in this village is that out of 45 wells in the command area of both the tanks in 40 wells brothers are sharing wells which are parental properties. As a consequence nearly 68 families own 45 wells. Many a time, brothers from a family will be sharing water in more than one well. In all such cases, each brother operate independently but the quantum of water available in the well is equally shared. As these wells are operated purely as a concern of a particular family they cannot be regarded as FMIS.

As a consequence of installing tube-wells and by sharing water, in GG Halli out of 72 irrigators in the command area of the tank, 50 irrigators happen to have an access to alternative sources for irrigation. In Bodampalli, out of 63 irrigators in both the command areas, 50 irrigators have access to well irrigation.

THE IMPACT

The impact of formation ground water FMIS on tank FMIS can be examined in terms of organisation, crops and the irrigators as a whole. In both villages to distribute available quantum of water in the tanks there were 'panchayats.' These panchayats were extending rights to irrigators on the basis of compliance to obligations as determined by the panchayat(Coward 1990). In bringing about compliance, the role of 'patel' as a person incharge of law and order and 'shanubog' as revenue tax collector were crucial. The multiplicity of powers invested in these offices could bring about compliance. Even after the abolition of these hereditary posts, in both the villages of both ' patel' and 'Shanubog' got elected to the 'Mandals' or the office of administration at the grass root level. As elected officials their accessibility to various officers and centers of power added strength to their positions they hold in their respective FMIS. Such offices could bring about compliance to obligations levied by FMIS of tank.

The 'patel' and 'shanubog' being biggest land-owning individuals could bring about compliance from others by themselves compiling to the obligations. Further being biggest land-owners in the command area their contribution of labour to various activities formed the biggest chunk. In GG Halli on any day patel owning seven acres, had to contribute seven laborers for any activity for a day. Similarly, 'Shanubog' was contributing five laborers. In Bodampalli patel was contributing four laborers and the 'shanubog' was contributing three laborers. Such contributions happens to be the highest for any individual land owner in the command areas concerned. The patel of GG halli is sharing water from his tube well with twelve others, who own land in the command area of the tank and whose holdings are located in the neighborhood of his field. Similarly, shanubog, who is in the process of migrating to the urban area, owns a tube well and shares water with five members. Similarly, almost all the leaders own wells on their own and only two of them are sharing water with others. As a consequence, on one hand all those who were responsible to run FMIS have formed FMIS of groundwater. As a result by utilising all the four ground water FMIS, 28 members are benefitted. Since, water from tubewell, especially in summer, is highly assured, these farmers have withdrawn from participating in the desiltation of canals and deepening of spring. In addition to these farmers, there are other 18 irrigators who own a well individually. Thus nearly 46 irrigators out of 72 in GG halli considers wells has highly assured source of water than tank. Such considerations are withholding them from contributing labour to desilt canals and in deepening spring canals every day in summer months. At present those farmers (36) who have no access to any alternate source for irrigation are left to manage the tank.

The ability to develop alternative source of irrigation by 46 out of 72 irrigators in GG Halli there is a reduction in the number of laborers available to desilt or deepen the spring every day. The quantum of labour to be invested by those who now have to depend totally on tank is far higher than what that used to before 1987. This consideration of higher labour input to avail water for irrigation in summer, has prevented even those 36 people who have no access to any alternative resources to disband the FMIS for tank. Further those people who mattered highly in bringing about confirmation to obligations of panchayat, after developing access to alternative resource like owning a tube well, regard contribution of labour to FMIS of tank as uneconomical. For such people investing of labour on the lands irrigated by tube-wells seems to be highly economical. As a consequence, these executives responsible for conducting the meetings and demanding confirmation, have failed to hold any meeting of FMIS of tank. In their absence, no other person could conduct any transactions. As a result the panchayats suffered without a proper incumbent to these offices. The FMIS is almost defunct from 1987 (Janakarajan).

One of the reasons for many to shift their attention to wells than tank was the freedom to grow crops that one wishes. In the command area of a tank, the cropping pattern was always determined by the panchayat. Normally, the preferences of panchayat was for paddy, ragi or ground nut. The deviants were punished by withdrawing water facilities. These crops except groundnut were not economical as the prices are regulated by government. By installing a tube-well the farmer had an opportunity to grow any crop that was considered by him as economical. Majority of those who own tube-wells and those who have gone in for sharing water grow mulberry. By feeding mulberry leaves to silk worms, the farmers can harvest four to six crops of silk cocoons in a year. Which by an approximation can yield per harvest Rs.5 to 6 thousands per crop of mulberry in half an acre. This income is for higher by many times, compared to paddy crop. The possibility of such an income at least four to six times an year has made the irrigators to loose interest in managing the tank from which they can raise one or two crops of paddy or ragi.

In Bodampalli, the patel and others who are responsible for conducting the meeting of FMIS of tank and responsible for allocation of land under 'DAMOOSI' system, are owning wells, which they share with their own brothers. However, this sharing on equal terms places a limitation on the crops and the area to be cropped. As a consequence normally it is the food crops that are grown. Most of these farmers are using wells for conjunctive purposes in monsoon season. This dependency has made them to continue to conduct FMIS of tank.

The only FMIS of ground water in Bodampalli consists of three members. None of the members area a functionary in the FMIS of tank. Further, these members find it beneficial to utilise the irrigated area allotted to them during 'DAMOOSI' to grow additional food grains. This allocation of land is an additional piece of irrigated land that they will be getting to grow crops, than what they actually hold. This factor of availability of additional land irrespective of size than what one owns is the crucial factor that has helped in the continuation of FMIS of tank.

The irrigators of Bodampalli unlike in GG halli allocate larger part ones dry land holdings to a commercial crop such as groundnuts (Table 4). The production of groundnuts is also higher in Bodampalli than in GG Hally (Table 5). The prices for groundnuts being higher than any other crop with higher productivity the farmers of Bodampalli earn higher income than farmers of GG Halli.

Irrigators in GG halli, unlike irrigators of Bodampalli, grow higher quantum of ragi, and lower quantum of commercial crops like ground nuts in dry lands (Table 4). As a consequence they wish to grow paddy as a commercial crop in the irrigated fields. In Bodampalli the irrigators allocate very less area for ragi in the dry lands but allocate wet lands in the command areas for ragi during monsoon season. On the contrary, in GG halli there is less dependence on tank for food-grain production, as much of their food-grain requirement comes from dry lands. In case of Bodampalli, as very little of food-grains comes from dry lands, the irrigators had to depend highly on tank irrigated areas for food-grains. Ragi being a dry crop, by growing that in the command area, the irrigators of Bodampalli conserve water collected in the tank during monsoon months, for irrigating a crop of paddy in summer. Only those farmers who can utilise a well to supplement water to the fields in the command area only grow paddy in monsoon months. Further, those who own fields in the low lying area grow paddy, as those fields receive water on their own from the tank due to seepage. This factor in allocation of land in the command areas for food-grains appears to be crucial for the Bodampalli village to continue their FMIS of tank. In addition to this, irrigators of Bodampalli, do not utilise water in the well or tank for commercial crops, as that of villagers of GG halli.

In Bodampalli both tank and wells are not reliable,therefore, the farmers of Bodampalli continue to use both well and tank for commercial purpose. Further farmers of Bodampalli regard groundnut as the best assured crop even in draught conditions, they allocate large part of their dry land holdings to groundnuts, a commercial crop. As a result, the selection of a commercial crop appears to be crucial. In GG halli, the cultivation of groundnuts on a low scale in dry lands and high dependency on irrigated sericulture as a commercial crop, has made the irrigators of GG halli to require irrigational facilities throughout the year. Further, as the income from sericulture is substantial than paddy crop, irrigators of GG halli are more worried about the requirement of water for sericulture,than growing a crop of food grains in summer months.

In growing cotton as a commercial crop in Bodampalli by those who matter a lot in the management of tank panchayat, has been helpful. This cotton crop being a crop of nearly six months with high investments brings in a return of high amount (above Rs.1 lakh). This cotton crop is for producing foundation seeds. The seed company which lease in the lands from the farmers restrict the area to half an acre for all the participants. As this crop requires above 1250 laborers for the entire period, the growers are forced to depend highly on laborers. To maintain the labour requirement, cotton growers, utilise the 'Damoosi' in summer to provide a bonus to such families which extend labour throughout the cropping period of cotton. The bonus is by allowing such laborer to grow paddy crop in the land allotted by the panchayat to the cotton growers. In GG halli the cultivation of sericulture do also require labour, but for a week wherein the worms form cocoons. Unlike cotton, sericulture is flexible in its requirement of labour. By limiting number of silk worms to be reared one can adjust the crop to the labour available within the family. Further, even if one cannot rear worms, one can sell the mulberry leaf in the market and earn few thousands. In G.G. Halli majority of those who grow mulberry depend on family labour (Table 5). Few of them even exchange labour within themselves.

Further, those who own the wells, for which an FMIS is organised, demand labour at payment from those who receive water from the well. Even though, this is not an obligation, it is essential to maintain the contract. Thus the shift to a commercial crop and consequent requirement of labour appears to have an impact on the survival of tank FMIS. Comparatively, in Bodampalli, among irrigators it is only those who grow cotton are the ones who are dependent on hired labour to a large extent. These irrigators utilise tank for extending a favour to those who have worked with them for the entire cropping season of cotton. For the cotton growers, the small sized plot allotted to them don't matter as much as cotton crop. Therefore, by allowing the laborers to utilise the land allotted to them under 'Damoosi' ensures good labour supply to cotton crop. This dependency appears crucial for the continuation of tank FMIS in Bodampalli.

Controls on Groundwater

Since the tank is crucial to meet the subsistence requirements, the irrigators of Bodampalli, have continued to control the utilisation of wells within the command area. The Panchayat for the tank prohibits those who own a well in the command area from transporting water from a well beyond the command area. Further, in summer months, when the irrigators practice 'Damoosi', no well owner within the area identified for 'Damoosi' is allowed to draft water from the well. To compensate, the well owner is allowed to receive tank water for the prescribed area. In these type of allocations, the well owner will be receiving assured water supply probably larger than his holdings. This happens as the allocation takes into consideration the entire holding of an individual within a command area. In GG halli prior to 1987, when the panchayat was active, no well owner within the command area was allowed to draft water from the wells. All well owners were supplied with water from the tank. The panchayat had a right to the water in the wells for conjunctive use. With high investment on tube- wells, the tank-panchayat of GG Halli, felt that any restriction will affect the economics of repayment of loan, if one has taken a loan to instal a tube-well. Even if one has not taken a loan then that will affect the income of an individual who expects high returns after investing a huge sum. This relaxation has cost dearly to the panchayat of GG Halli.

CONCLUSION

The consequence of disbanding 'panchayat' of tank in GG Halli is that, those who now have to depend entirely on tank are those who are dominantly own less than an acre in the command area of a tank. Even among these farmers, it is those who own less than half an acre (Table 6). These categories of farmers are those own below five acres of dry land (Table 7). Of such farmers, to a large extent they own land less than two acres. Which means it is the poorest among the irrigators who have been left behind to depend on tank in GG Halli. The inability of these to own an alternative resource or to join on FMIS of groundwater, has severely affected their productive capability. Which in the long run can enhance inequality among the irrigators.

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Please note that the tables have not been included in this volume.

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Paper No.17

Analysis on the Sustainability System Associated with Groundwater FMIS In The lower Reaches of Yellow River, China.

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Abstract

The present paper is firstly to deal with the situation and problems existed in groundwater development of the lower Reaches of the Yellow River, which include tubewells and its utilization, unbalanced development of groundwater and prevailing groundwater FMIS as well as their action in the lower Reaches of the Yellow River. Secondly, the sustainability system associated with groundwater FMIS is analysed, which consist of economic sustainable steps, reasonable irrgation duty studying, crop pattern planning, conjunctive use of surface and groundwater as well as groundwater FMIS institutions, ect. since 1988, facing the deteriorative situtation of groundwater, both the government and local agency have taken various measures in order to alleviate the tensitive status, which include allocating subsides to groundwater development, power supply, regulating crop pattern, establishing and improving groundwater FMIS institutions. Finally, the reasonable development of groundwater in the lower reaches of the Yellow River was studied which include the

regulation of tubewell operation and management, economic sustainability of groundwater developing and planning, etc.

I The basic situation and problems in groundwater development of the Irrigation Areas of the Lower Reaches of Yellow River (IALRYR)

Established in the beginning of 1950s, the Irrigation Areas of the Lower Reaches of Yellow River (IALRYR) has the history of 40 years. The farmland area totals 500.2 hectares(ha), the present cultivated farmland area is 300 ha. The designed irrigated area amounts to 283.6 ha. The most part of the area belong to alluvial plain of the Yellow River. The climate of IALRYR characterizes in simiarid and simihumid area with annual average rainfall of 510-795 mm. The rainfall from June to September makes up more than 70% of the whole year's. The present tubewells amount to 200606, in which the equipped tubewells account to 170841. The tubewells in actual use are 111178. The present tubewell-irrigated area is 50.7 ha.

With the development of the industrial and agricultural production in the lower reaches of Yellow River, It is proved that the water resource is inadequate. But, the Unreasonable and wasted utilization of water resources exist in IALRYR. In the upper stream area of IALRYR, the trend of building canals and abandoning tubewells result in large amount of groundwater resources undeveloped and salinity problems. In the lower part of IALRYR, the overdeveloped groundwater caused the water table drawdown. The poor management result in severe deterioration of tubewell. On the other hand, the organizations of groundwater FMIS is imperfect with no systematic planning and water rival in irrigation period, which result in development and management chaos of groundwater resources. Therefore, the analysis and research must be carried out on tubewell construction and management, the organizations of groundwater FMIS and relevant policies as well as the sustainability system associted with groundwater FMIS in order to enhance social economic benefits created by both Yellow River and tubewell irrigation.

II Investigation and study on the groundwater FMIS organizations and sustainable measures

In 1990, the investigation on groundwater development and utilization on the organization of groundwater FMIS have been carried out, which shows that reasonable groundwater development depends on two factors: the first is groundwater management organizations which include sustainability from government special management organizations of IALRYR and farmmer management organizations, The village farmer management organizations are playing very important action in tubewell operation and groundwater development. The second is relevant measures made by the policy-making departments, which cover economic policies, irrigation schedule, crop pattern and water resources development and utilization policies, etc. The organization of groundwater FMIS and its sustainability system in IALRYR are analysed as follows:

(1) The organization of groundwater FMIS and government sustainability system

There are 98 Irrigation Areas with irrigated area greater than 667ha. The organizations below township level are considered as organizations of FMIS. According to the statistics, there are 986 township groundwater FMIS organazations with the total members of 3944. Averagely, each member in township groundwater FMIS organizations manage 51 tubewells. The well-irrigated area total 50.7 ha. The single tubewell can irrigate 2.53 ha averagely. Generally speaking, each township groundwater FMIS organization has 3 to 5 farmers. Some of which has 2 farmers. The management scope is based on administrative boundary. The most parts of farmers come from the villages within the township and all of them have practical experiences in FMIS and tubewell management. With the development of science and technology, their management levels are improved relatively. The farmer engineers have increased to about 30. The farmer membership in township groundwater FMIS organizations have their rewards from two aspects: the first is beneficial contract of farmland cultivation, the second is subsidies from water charge which are about 100 yuan RMB (about 19US$) per man-month. The responsibilities of township groundwater FMIS are: tubewell systematic planning and constuction in township wide. The tubewell maintenance; the tubewell equipment rehabilitation; the new technology extending and utilization; the technology training and guidance for groundwater FMIS of village level and the data collecting of groundwater etc. Under the leadership of township groundwater FMIS organization, the village groundwater FMIS organizations are established. There are 29580 villages in IALRYR. According to the analysis, it is necessary to establilsh 29000 village groundwater FMIS organizations. In fact, only 19720 village groundwater FMIS organizations exist at the present. Each organization consists of 3 to 5 farmers. The farmer membership in the organizations of IALRYR amount to 59160, Each farmer member manage 3.3 tubewells averagely. The responsibilities of village groundwater FMIS organization are: tubewell operation and maintenance within the village area; the management of tubewell facilities; installing the equipment and supplying water to water users; coordinating water use among different users and monitoring water volume, etc. Besides cultivation of contracted farmland, the village farmer management members receive subsidies of 30 to 50 yuan RMB (about 9 US$) per man-month from water charge. But, the prevailing village groundwater FMIS organizations are imperfect. A part of villages have no relevant organizations, which should be strengthened in the future.

The organization sustainable system of the government for groundwater FMIS are reflected as following: 1 or 2 state technicians are arranged in every township groundwater FMIS organization to undertake technical guidance for the groundwater development and management; some of state-owned special management agencies take groundwater development into systematic allocation and scheme of water resources of irrigation area. (e.g. chenGai Irrigation Area of shandong province); The tubewell drilling teams and the farmland water conservancy sections established in the county water Resources Bureaus have the duty of tubewell construction and groundwater management and development; on the other hand, the groundwtaer development and management agencies in prefecture and provincial level are arranged to charge the related tasks in their own scope, Besides, the Yellow River water Conservancy Commission (YRCC) and some relevant scientific research units are playing active role in groundwater development and management of IALRYR.

(2) Analysis on economic and technical sustainable system for groundwater FMIS

Besides sustainable system in groundwater development organizations, the economic and technical sustainable system from goverment is necessary. According to the present development status and problems in IALRYR, through investigation and study, the present paper made out sustainability steps for Yellow River Irrigation Areas as following:

(A). Economic sustainability. The first is to encourage the gravity irrigation area to withdraw and utilize more groundwater resources, the second is to deliver economic sustainabilities to tubewell operation and maintenance. In gravity irrigation area, it is suggested that reclaiming 1 Mu (about 0.07 ha) farmland irrigated with tubewell or changing 1 Mu (0.07 ha) farmland from gravity irrigation to tubewell irrigation may receive 0.5 yuan RMB (about 0.09US$) subsidy and may also get preference of seeds supply; fertilizer supply, Power supply as well as other economic preferences. But the systematic planning shoud be carried out in order to avoid management chaos.

(B). Water Duty and rational water supply technology. In accordance with study results, under the condition of water saving, gross water duty of irrigated crops in gravity irrigation areas can be controlled in 220 m^3/mu (3300m^3/ha.), 200m^3/mu (3000m^3/ha.) gross water duty in chenGai Irrigation Area of Shandong province was realized in 1989. The water charge method is that : calculating water use volume in accordance with the condition of water saving irrigation, water use within the planned scope will be charged in normal water supply price, water use volume beyond the planned scope will be charged in as double or treble price as normal water supply .

(C). Rational crop pattern. In recent years, many scientific research institutes and universities have done research on rational crop pattern of irrigation areas and made significant results, which lay important foundation for crop pattern planning, water allocation planning, water saving on paddy and new technology extending.

(D). The technology of conjunctive use of surface and groundwater. According to study results, the development proportion between yellow River water and groundwater use is 1.2 to 1.0 in gravity irrigation areas and 1.0 to 1.4 in lifting irrigation areas so that the water development balance may be kept. All the economic and technic measures mentioned above have been playing significant action in groundwater development and utilization of IALRYR.

III Suggestions on reasonable groundwater development of IALRYR.

Macro planning should be combined with micro management in groundwater development and utilization.

(1) Suggestion on reasonable tubewell operation and management.

Management of tubewell operation should be strengthened. The organization of groundwater FMIS should also be further consolidated. According to requirement, the organizations of groundwater FMIS should be increased from present 19720 to 29680. The farmer management members should be increased from present 59160 to 88740. Everage management tubewells per person should be decreased from present 3.3 to 2.2. Farmer management members should have reasonable responsibilities, rights and benefits in order to mobilize their activities. Tubewell project management in groundwater FMIS of township and village may be combined with surface irrigation project management to enhance farmer management members' consciousness for systematic projects and increase comprehensive benefits.

(2) Rational development and utilization of groundwater resources.

At the present, reasonable groundwater development scheme must be made in accordance with undeveloped groudwater in gravity irrigation areas and overdeveloped groundwater in lift irrigation areas. According to statistics, available groundwater resources in IALRYR amount to 10 billion m^3. But, the present actural developed groundwater amount only 3.05 billion m^3, which only makes up 30% of available groundwater. Besides, tubewell irrigation quota is very high in some irrigation areas. Everage tubewell irrigation duty is 401m^3/Mu(6015m^3/ha), the highest tubewell irrigation duty reaches as high as 490.3m^3/Mu(7354.5m^3/ha). Therefore, the first is to enhance groundwater development volume. On the other hand, water saving steps should be taken to reduce tubewell irrigation duty. According to study results, under the condition of water saving, tubewell irrigation duty can be lowered to $180m^3$/Mu($2700m^3$/ha). Therefore, if annual groundwater lifting volume reaches 5.0 billion m^3, then, the annual tubewell-irrigated area will be 28.0 million Mu (1.87 Million ha), which will be 20 million Mu (1.33 Million ha.) higher than present tubewell-irrigated area.

Ⅳ Conclusions.

Considering the groundwater situation and problems existed in IALRYR, the present research project has been carried out focusing on investigations and analysis of groundwater FMIS and has pointed out the suggestions on consolidation of groundwater FMIS organizations and government sustainable system. Analysis and research have also been done for groundwater rational development and utilization. The results may be used in water resources planning and development of IALRYR.

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Agro-well Systems - A Sustainable Alternative to Dry Zone Farming? Individual Vs. Group Managed Agro-wells in Operation

Rajindra de Silva Ariyabandu

Abstract

In mid 1980s the government of Sri Lanka considered exploration of groundwater for supplimentary irrigation in North Western and North Central Provinces to uplift the living standards of rural poor in these areas. State provided assistance to individual farmers owning land in tank commands to construct large diameter open dug-wells for cultivation. The state subsidy was essentially given for well excavation, making bricks and to purchase the water pump. Under this programme fare share of the state grant was consumed by the owner of the excavators as machinery rental. Due to the ad-hoc nature of this programme, the water pumps which were provided on a bank loan too went to undeserving cases, e.g. for ones who did not even own agro-wells. As a result of this heavy top-down approach in implementation, farmers in some instances refused to repair their well banks when they collapsed due to heavy rains. They always expected state support for all construction/restoration works. The sense of ownership towards ones own system was totally absent and as a result farmers showed scanty respect for construction and its sustainability.

It is at this point of time that the programme changed its heavy top-down approach to a more participatory approach specially at the construction stage. Under the new approach, the well excavation was totally given to the farmers, withdrawing the excavator facility. Thus, giving the farmers the cost of machine rental as an incentive for their labour. For this purpose farmers obtain the help of other farmers on a mutual basis or on attam (exchange labour) basis. This approach instiled a sense of ownership among farmers towards their own system. Hence, the participatory approach made the implementors to consider the possibility of cultivating from agro-wells on a group (organization) basis. Since then a group of 4-5 farmers has been considered as a viable unit to cultivate from an agro-well of 15-20 feet in diameter and 20 feet in depth.

The Author, in this paper attempts to compare and contract the merits and demerits of the two approahces with special reference to community participation, resource mobilizations, operation and maintenance cost and benefits of cultivation, and in nutshell, on the question of sustainability of agro-wells as a viable option to dry zone farmers of Sri Lanka who are otherwise deprived for irrigation water in yala (dry) season.

BACKGROUND

The origin of hydraulic civilization in Sri Lanka which began in 3rd century BC started to collapse by 12th century AD due to reasons yet unclear but thought to be as 1) spread of Malaria 2) foreign invations and 3) increase in trade. The abolition of the rajakariya (Kings work performed by the people) system in 1832 further influenced the general decline of O & M in irrigation works.

The 1965-1979, 15 year period saw the introduction of the Green Revolution Package. This resulted in increase in land area under cultivation and intensification of agriculture on existing land. It is believed that irrigation intensity increased from 109 to 131 during the same period (Madduma Bandara, 1984). With the phasing out of the green revolution and the gradual increase in population saw increase in demand on land and water. This situation coupled with the decline in O & M and ad hoc state intervensions in rehabilitation/ restoration of irrigation systems without proper beneficiary participation led to the deterioration of these irrigation works.

At this point of time certain scholars and bureaucrats advocated the conjunctive use of water to improve crop production in existing land where accessibility of irrigation water was fast diminishing due to poor state of irrigation systems. The viable alternative suggested here was exploring of ground water for irrigation. This alternative was not given adequate attention either by the peasants or the policy makers possibily due to favourable weather condition and lack of initiative.

However, by mid eighties, the water availability situation became a serious concern outside Mahaweli development area. thus, the turn of events began in 1986 with the cabinet memorandum by the Ministry of Agriculture development and research titled "Proposal to Grant a Subsidy to Promote Diversification of Agriculture". This cabinet memorandum made the beginning of the current large diameter open-dun well or agro-well programme to explore ground water specially in the dry zone to cultivate a successful Yala (dry season) and to supplement irrigation in Maha (wet season).

The agro-well programme

Justification. Agriculture in the dry zone of Sri Lanka depends mostly on natural precipitation. Only around 25% of the cultivated acreage in the dry zone is under irrigation (Peiris, 1990). In the rest of the land agriculture production is predetermined by rainfall. Even in land under major irrigation schemes, poor rainfall results in poor Yala season production. This results in low farmer income, under employment and total discontent among farmers. This becomes an additional burden on the government as the state had to offer welfare measures to maintain minimum living standards of these people. To avoid reoccurance of this situation the farmer income had to be stabilized. Under the present condition exploration of ground water through agro-wells can provide a stable income from agriculture by cultivating throughout the year using agro-well water. These agro-wells provide; 1) Access to water irrespective of the season 2) provides supplementary irrigation during Maha 3) maintain crops in Yala and 4) no maintenance or additional infrastructure.

Geologically, the dry zone of Sri Lanka with the exception of the Jaffna peninsula and the immediate surroundings do not offer a great potential for ground water explorations. Ninety percent of the land mass baring the North is underlined by a precambrian rock with poor perosity.

However, in recent studies it has been observed that there is still a considerable potential for development of ground water in the hard rock formation of the dry and the intermediate zones. As these agro-wells extract water from the weathered over burden [usually upto about 10 meters (m)], the potential for such extractions are possible in tank commands, specially under minor irrigation where surface water dries up in the Yala season. Madduma Bandara (1982) states that the ground water influence under major irrigation schemes spreads to the extent of the reservoir under question. This could probably be extended to minor irrigation system as well, though it has not been studied in detail.

Implementation of the agro-well programme

Since the Cabinet Memorandum of 1986, the Ministry of Agriculture[1] Development and Research (MADR) through the Provincial Councils (PC) and the Agriculture Development Authority (ADA) began to implement the agro-well programme mostly in the dry zone districts of Sri Lanka. Besides the state organizations many non-governmental organizations including the Freedom From Hunger Campaign (FFHC) got actively involved in the agro-well implementation programme.

At the initial stage Cabinet approval was sought to provide Rs. 165 million as a 50% subsidy to construct 11,000 agro-wells in the five districts of Anuradhapura, Kilinochchi, Mannar Mulativu and Vavuniya (Figure 1).

With gaining acceptance and importance given to the programme, the five initial districts were extended to cover further seven dry and intermediate districts. With increase in the programme, the MADR

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1. The Government of Sri Lanka devolved the central administrative powers to the nine provinces by the 13th Amendment to the Parliament. Hence, each province is now governed by a Provincial Council (P.C.).

MAP OF SRI LANKA

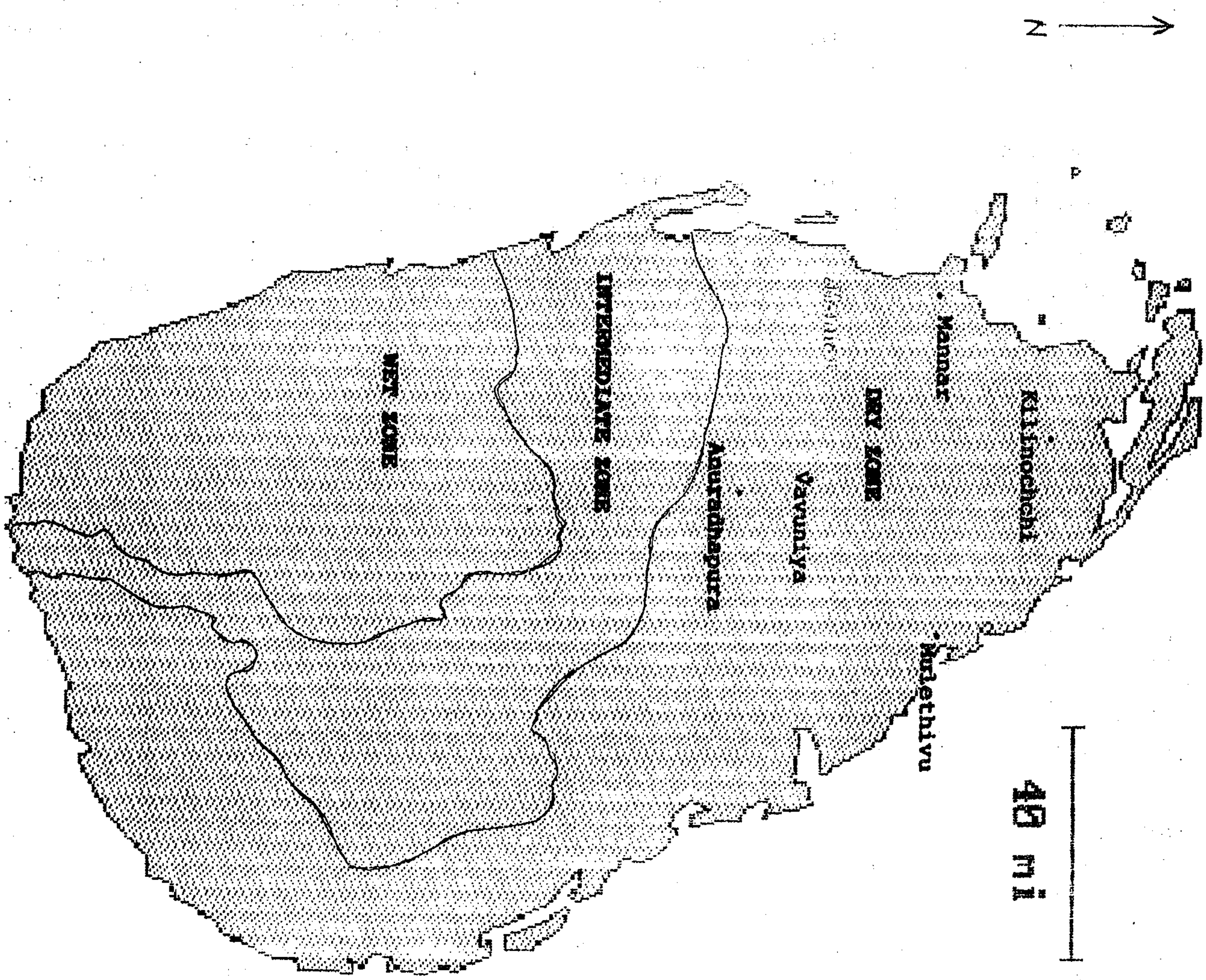

Figure I : Locations of the 1st Agro Well Programme

ventured out to request for funds from international and national donors to make the programme a success. This effort has proven fruitful as the EEC and in certain instances World Bank and various Australian and German donor agencies have offered assistance. As a result the ADA programme has extended upto 12,000 agro-wells anticipating to cultivate 20,000 - 24,000 acres of land. Besides, the Provincial Councils allocate funds for this purpose from their development budget. Though accurate census of the PC programme is not available at the first stage in Anuradhapura (one of the dry zone districts), the plan was to construct 175 agro-wells. The FFHC in it's first attempt anticipated to construct 20 agro-wells in the drier parts of the Kandy district. Funds in this case was given by the Australian and German donors. Besides these three major agencies, agro-wells are being constructed by a large number of NGOs and individuals. By 1991, this micro-irrigation technology has become so popular that Janasaviya[2] recipients were seen constructing agro-wells under their "common work" component.

Method of implementation

Basically there are two principle methods of implementation of the agro-well programme. First is individually, meaning an agro-well unit will be given to each individual farmer in a selected location. Second is collectively or by group. Under this mode a group of five farmers are given an agro-well unit. Principally these two methods are being implemented by the ADA in the former case and the Provincial Councils in the latter case. In the case of the FFHC a mixture of both have been implemented. Under individual ownership a farmer is expected to cultivate a minimum of 1-2 Ac. while under the collective ownership a group is expected to cultivate 2-4 Acs.

Selection criteria

Farmer beneficiaries. Proper selection of project beneficiaries have been one of the most important criteria for the success and failure of rural development programmes. The agro-well programme is no exception to this general rule. The three implementing agencies described earlier have their own criterion for selecting beneficiaries. However, the ADA appears to be having the most comprehensive scheme of section. In the other two, the selection criteria is rather scanty without much precision. Table 1 summarises the important criteria of the three approaches.

Many bureaucrats have argued that group management of agro-wells have been a failure. Thus, they would prefer to implement the programme individually. The main reason for the so called failure of

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2. A state assistance programme for the poorest of the poor.

Table 1 Selection Criteria of Project Beneficiaries

Agriculture Development Authority	Provincial Council	Freedom From Hunger Campaign
- should be a permanent settler of the location	- depends on the request of the farmers	- should be a full time farmer
- should be less than 55 years	- on the request of local level organizations	- willingness to participate in such projects
- should own at least 01 acre or more in the area	- on the recommendation of the Provincial Secretaries	- should not be a recipient of any other state assistant programme
- should not be a defaulter of any loan		- should be a food stamps or Janasaviya recipient
- should be in a position to pay back the loan taken for constructing the well		- should be a permanent resident of the area
- should be able to adhere to all conditions of the bank		
- should be in a position to construct the test-well by himself (without state support)		
- should possess a valid farmer ID card		

the group-managed agro wells was the wrong selection criteria or inadequate supervision of selected beneficiaries or both. At the field level the beneficiaries are supposed to be selected by a field level implementing committee consisting of officials from the state Banks, ADA, Department of Agrarian Services and Department of Agriculture. When the qualifying criterion is to have five farmers to an agro well as the case in the P.C. system, the more enthusiastic farmers would incorporate the names of four other farmers and get the agro-well for himself. Here the problem lies not with the farmers but with the selection committee. Another complaint often heard about group managed wells is that none is accountable for the physical infrastructure and pump-sets. A situation of this nature would not arise if the group is a properly selected one or preferably a group selected by the farmer beneficiaries themselves. The easy way out of this complication is to recommend individual wells to each farmer which by no means is a long term solution to agro-well systems in operation.

The selection of agro well locations too depends on the implementing agency. The ADA adopts a system whereby the beneficiary has to dig a test well of 20′ deep 4′ in diameter. If this well has a water level of 2′ then the test well can be expanded to a large diamter agro-well. The P.C. system does not follow this process, rather they have constructed most of the agro-wells in minor tank commands. Thus, ensuring adequate water for cultivation. However, certain NGOs involved in well construction have requested the villages themselves to identify suitable areas depending on their village folk wisdom. In such event, villagers have always identified locations close to paddy fields and in certain instances where there had been abandoned wells.

OPERATION OF AGRO-WELLS

Planning

In all the three implementation programmes planning is done by the policy makers at the head offices or at ministry level in Colombo and other provincial capitals. At this stage the policy makers and influential personnel can decide on the areas where the programmes are to be implemented. Thus, one could argue that the implementation programmes can be biased depending on the degree of influence one could exert at this stage. Once the area is selected the programme gets implemented at the field level through the ADA district managers or divisional secretaries as the case may be. The final selection of specific locations are done at this stage. One major draw back at this stage is non-participation of intended beneficiaries or their representatives. Hence, many complaints have been reported of undeserving cases getting the benefit of these programmes, one extreme example in this regard is in a certain programme some farmers who did not pocess wells, have received water pumps. This could be interpreted as total mismanagement and lack of accountability towards the programme.

Construction of agro-wells

Agro-well constructions are mainly done through two methods. 1) Individually, using excavators for digging and hired labour for construction and 2) As a group, using community participation for digging and construction. In the former case, which is the method adopted by the ADA, the digging operation is done by an excavator for which the well owner has to pay at the rate of Rs. 550/hr with diesel (US $14) or Rs. 660/hr without diesel (US $17) as excavator charges. Usually an excavator takes approximately 8-15 hrs. to dig a well depending on the size of the well. In one instant an individual farmer has to provide 127 liters of diesel to the excavator for digging of his agro-well. This would amount to Rs. 1,143 (US $29) for diesel alone. The same farmer pays Rs 8,512 (US $212) for operating the excavator for 15.2 hrs. Thus his total cost for digging the well amounts to Rs. 8,572 + Rs. 1,143 = Rs. 9,655 (US $241). More often than not this appears to be the case when excavators are employed. These individual farmers get Rs. 15,000 (US $375) for construction of wells. Out of which, Rs. 5,000 (US $125) is given as cash for making of bricks. With the balance Rs. 10,000 the farmers are supposed to dig the well and construct it using rubble masonary. One could observe in this case that farmers are almost left with no money to attend to construction once the well excavation is completed.

A similar situation would not be encountered in group managed agro-wells. In this case the entire digging is the responsibility of the farmer group. The Rs. 10,000 given to the excavator in this case is given to the farmer group depending on the work performed. For construction purposes a further Rs. 10,000 is given on a 10% interest. Some farmer groups who had received Rs. 10,000 for digging had saved the same to support construction.

In the construction part, most of the funds are consumed by the rubble masonary. If standard bricks are used, an agro-well of 15′ diameter 20′ depth would require approximately 18,000 bricks. In such cases some farmers have used upto 30 bags of cement (50kg each) to line the well banks. However, When large granite stones are used farmers have used upto 40 bags of cement per well lining. To reduce this cost farmers were encouraged to prepare their own <u>ling gadol</u> (bricks specifically made for constructing wells). These bricks have a special shape which tappers to a side. The shape of these bricks reduces the possibilities of collapsing of well banks. When such bricks are used the requirement of cement can be minimized due to its inherent binding character. As each well requires about 18,000 bricks, the task becomes easy when it is a group well.

Fund allocation

Each agro-well unit costs Rs. 40,000 (US $1000) approximately including the water pump and accessories. Thus, the implementing agencies have to support the beneficiaries to establish these units. Fund allocation and recovery by the three implementing agencies are given in Table 2.

Operation and maintenance

Unlike other minor irrigation tank systems, O & M of the agro-well micro irrigation is less complicated. Maintenance of such systems can be almost negligible if the initial constructions are done properly. Cleaning of the foot value and removing bottom debris will have to be done periodically to achieve the maximum well yields. The water pumps can be used for nearly five years without any major breakdown if regular services are carried out on time. Well maintenance is usually done during low water demand periods, this too can be a difficult task if an individual attempts to do it alone.

In the case of individual ownership, operations of the units become less complicated. In such event there is no case of water sharing or time of irrigation. In the case of group wells this problem may arise if the group is not selected properly. Here I refer back to the importance of the selection of the group. If the group is a well-knit cohesive group of farmers coming from the same rural background, there should not be any problem of water sharing. In fact the group cultivates as a unit of five farmers and not as five individual farmers in a group. This may well sound theoretical. But it is possible in practise if attempts are made right from the commencement of the project with lot of awareness building and dedication of the implementors. The paramount importance in this attempt is to allow the beneficiaries to select their own groups after being fully convinced of the programme. Incidentally the Author of this paper is currently experimenting on this concept in the dry zone of Sri Lanka.

Community participation

In the individual owned agro-well programme as that of the ADA, community participation can be at minimum levels. The beneficiaries do not have to unite as a community or group at planning, design or construction stages. All these activities are done for them by the implementers of the programme. The necessity of community participation surfaces only at the time of purchasing agricultural inputs, for this, individual farmers have attempted to form into organizations but evidence suggest that this was not a success as many individual farmers complain about each other for misappropriations. This is a result of lack of group cohesiveness right from the beginning and attempting to form organizations only to fulfil a particular need. The need for group formation and organization must necessarily come from the beneficiaries themselves right from the beginning and they should be party to all decision making and implementation stages. This builds up a sense of ownership towards ones own programme. Hence, at all subsequent stages of the programme, the farmers will act as a group not as individuals.

In the case of group ownership the decision making body is the group organizations. Though this concept is practised in the Provincial Council system certain improvements can still be made to make it more democratic. In the selection of farmers under this system, the final decision is taken by the implementers or the divisional secretary.

Table 2 : Fund Allocation and Recovery

Agricultural Development Authority	Provincial Council	Freedom From Hunger Campaign
* Total loan compo- for construction Rs. 15,000	* Total grant component for digging Rs. 10,000	* Total grant component cost of construction excluding the pump. Approximately Rs. 19,000.
* Preparation of bricks Rs. 5000	* Preparation of bricks not specified	* Preparation of bricks not specified
* For digging purposes Rs. 10,000	* For digging Rs. 10,000	* For digging Rs. 10,000
* Water pump-set Rs. 15,000 (Bank loan in kind)	* Water pump-set Rs. 15,000 (Bank loan in kind)	* No water pump given under the scheme
* Interest rate 12.5%	* Interest 10%	
* Grace period 3 months for water pumps	* Grace period 6 months	
* 2 years per capital costs of construction		
* Repayment of instalments 8 years (first 2 yrs only interest)	* Repayment of instalments five years	

This practice has to change and the selection of farmers in a group should be given totally to the group concerned. Beyond this the group works together as a unit in all decision making and implementation aspects.

Under the Provincial Council system, the group of five farmers become accountable to one agro-well unit for all its constructions and O & M. Hence, the responsibility of digging, lining and O & M is done by the farmer groups. The farmers dig the agro-well using their own family labour, this usually amounts to about 150 mandays. By doing this as a group, farmers save Rs.10,000 which is otherwise paid to the excavator owner. For lining the wells the farmer group prepare approximately 17,000 - 20,000 Linq Gadol per each well. This exercise become easy when five farmers get together in a group. At the time of lining the well banks, the farmers can assist the masons thus, avoiding the necessity for casual labour. The kerosine oil for the water pumps during digging and construction is a major cost. In the case of the group managed wells, this cost can be shared among five as against one in the individual managed wells. One of the most important advantages of group management is, in the event of collapse of well banks due to rain or other causes. In this event the group can get together to reexcavate. But in the individual case when it happens the owner is unable to seek assistance of the fellow farmers or even call a Shramadana (voluntary work) due to individualism inculcated in the minds of the people. Bank loan repayment becomes much easier when five farmers are accountable to a loan than one. Even the risk of non payment of loans become much less in the case of group managed wells as against individually managed wells.

Hence, the banks too should be more willing to deal with farmer groups than individuals. Attending to marginal maintenance of the wells, when shared among five can be less burdensome than when one attempts to do it individually. Operation of the pump and water sharing are two aspects which is believed to cause problems in group managed wells. The advocates of this assumption tend to think that no one would take the responsibility in this case as it is a common property. This assumption is negated in the authors experiment where the water pump is considered as a group property and responsibility of maintaining is divided equally among the members of the group. Even in water sharing the author firmly believe that once the group is properly selected, growing crops decided on concensus by the group, it will be the responsibility of each group member to maintain the crop to achieve maximum production. Hence, this approach could instil a good sense of ownership and responsibility towards ones group managed agro-well.

CROP CULTIVATION UNDER AGRO-WELLS

The introduction of agro-wells in the dry zone of Sri Lanka was to diversify farmers from paddy mono culture specially during the Yala season. As the quantity of water and extent of land (0.4 - 0.9 ha.) are limited under an agro-well unit, farmers too opted for other field crops (OFCs) than paddy. The usual crops grown under agro-wells are chillies, onions, Green gram, Cowpea, Soya beans, vegetables, beetle etc. However, some farmers still cultivate paddy from agro-wells. The reason for cultivating paddy under agro-wells was total lack of knowledge on the crops that can be grown under limited water situations. Where OFCs are cultivated the farmers use a 9 day water rotation from a well of 22′ in diameter and 15′ in depth. If paddy is cultivated, a 6-7 day rotation is required from the same well.

At the beginning of the programme, farmers were growing more vegetables than high value cash crops. Infact it was at this stage that farmers were attempting to continue on paddy cultivation using well water. This was totally due to inadequate training, poor planning and traditional practices. However, farmers soon realized that growing non-cash crops is not beneficial to them as they have to repay the loans taken to establish these agro-well units. Subsequently, with proper training, farmers have shifted from non-cash crops to high value cash crops like chillies, big onions and gherkins. It is reported that farmers have earned as much as Rs. 100,000 (US $2380) from growing a combination of crops mentioned above or a single crop in an area of two acres (0.8 ha) during a single season. Some of these farmers have repayed their loans within two years and reaping total benefits from the capital investment made by the implementers.

CONCLUSION

Agro-well system can be a viable option to dry zone farming if it is properly implemented and managed thereafter. This system can stop out-migration of farmers specially during the dry season and encourage them to a more settled way of farming. If proper selection criteria is adopted and the selection process monitored, the group managed agro-wells could be a long lasting sustainable system of agriculture in the dry zone of Sri Lanka.

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Paper No. 32

CASESTUDY OF MANAGEMENT OF THREE DEEP TUBEWELLS IN TANGAIL, BANGLADESH

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Paper for presentation at the South Asian Regional Workshop
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ABSTRACT

The operation of irrigation systems on three deep tubewells in Tangail District, Bangladesh, was monitored from 1989 to 1991. These systems used buried cement concrete pipe to distribute water from the tubewells, to irrigate diversified crops during the dry season.

This paper focuses on the management of the deep tubewells and the irrigation systems. Each tubewell was installed by the Government agency (the Bangladesh Agricultural Development Corporation) following application from a cooperative of villagers (Krishak Samabay Samity or KSS), who took out a loan to purchase the tubewell. In principle the KSS owned and managed the tubewell, but in practice it was dominated by a few prominent individuals.

The paper describes the membership of the KSS on each tubewell, their participation in the management of the system, the management structure and KSS meetings. It describes the financial arrangements made for operating the tubewell. Budgets were prepared each season, but not followed. The three KSSs varying records of loan repayments are also discussed.

The utilization rates of all the tubewells were disappointing, averaging 3.88 hours per day at a discharge of about 35 lps compared to the design of 56 lps. The irrigated areas were typically less than half the design (40 ha), and irrigation intervals were high. The reasons for this poor performance were found to be a combination of social, managerial and agro-economic factors, and these are discussed in the paper.

The management and operation procedures are compared with the recommendations of the Irrigation Management Programme (IMP) and possible improvements are discussed. These include moving to systematic irrigation of fields fed by the same branch, instead of the current erratic distribution of water under the farmer's fuel system.

This case study illustrates some of the difficulties of FMIS where farmers resources are unevenly distributed, particularly in the complex technical and management environment of deep tubewell irrigation.

The study was undertaken as part of a UK/Bangladesh research project on buried pipe distribution systems for surface irrigation which was funded by the Overseas Development Administration, UK.

INTRODUCTION

In Bangladesh irrigation water is mostly distributed by earthen open channel systems. However, in areas with undulated land topography and light textured soils earthen open channel systems are found not convenient and appropriate both technically and economically. Under such situation "Buried Pipe Distribution System" (BPDS) was considered to be a better solution. BPDS was introduced in Bangladesh about a decade ago. Since then, a number of buried pipe (BP) systems, mostly cement concrete (cc) pipelines have been installed by several organizations.

Tangail Agricultural Development Project (TADP) is one of the few organizations who have been constructing BP systems for the Krishak Samabay Samities (KSS, a farmers' co-operative). TADP with the assistance from German Agency for Technical Co-operation (GTZ) has been working in the eastern part of Tangail district for promoting irrigated agriculture using Deep Tubewell (DTW) with BPDS. Till date it constructed a total of 79 BP systems, both full and partial. Most of these schemes have been encountering leakage, operational and management problems. Unfortunately, no dependable studies so far have been made to evaluate the system performance and put recommendation for further improvement. Under the circumstances, this case-study was carried out on three BP schemes installed by TADP at Taltolapara, East Kutubpur and Shaplapara during 1989 to 1991. This study was undertaken jointly by the Bangladesh Agricultural Research Institute (BARI) and the Loughborough University of Technology (LUT), UK with funding from both LUT and the Overseas Development Administration (ODA), UK. The overall objective of the study was to carry out detailed case-study of constructional, operational and management experiences of irrigated agriculture with BPDS. The specific objectives were: i) to study the technology of BPDS, ii) to study the water management and agronomic practices under BPDS, and iii) to study the operational and management aspects.

This paper contains the study results mostly related to the third objective and a part of the second objective.

METHODOLOGY

The study area falls under Madhupur Tract which has silty clay loam soil, undulated topography, annual rainfall of about 2100 mm, mean monthly temperature of 11 to 39^{0}C and relative humidity of 49 to 88%. November to April is the water deficit period. Diversified crops were grown, mainly rice (transplanted aus, aman and boro), wheat, water-melon, soybean and banana; and the cropping intensity of the area was 233%.

Discharge from the DTW and at the outlets were measured using cutthroat flumes and 90^0 V-notch. Operational procedures were observed in the field and relevant data were obtained from the pump log-books and the block registers. Data recording in the log-book and the register were routinely checked by the project staff. Data related to socio-economic and management aspects were collected partly by interviews, partly by checking the scheme records and partly by direct field observations. Additional information was collected from TADP reports to supplement the project data.

RESULTS AND DISCUSSION

Waterusers, KSS Membership and Management

The three schemes had an average of 62 waterusers (Table 1) of whom 68% were KSS members. About 80% of the KSS members were irrigating. Another survey of TADP (Mayer 1991) on 40 schemes showed an average of 59 waterusers per scheme of whom 60% were the KSS members.

Each KSS has a six members management/standing committee, first formed at the time of registration and then elected, for the overall management of the schemes. But in practice the president and the manager act as the chief executives. Table 1 showed that on average only 40% of desired weekly meetings were held with poor attendance of the waterusers. The main issues discussed were seasonal budget, loan situation, fixation of irrigation charges, oil charges, driver's salary, etc. In most (50 to 80%) cases, manager was the chief decision maker.

Ownership of Deep Tubewell

Each deep tubewell was sunk by the Bangladesh Agricultural Development Corporation (BADC, a government agency) following the application from a KSS after downpayment, which was made out of cash or loan to buy the tubewell. The BPDS was installed by the TADP and handed over to the KSS at a subsidized cost to be paid in installments. In principle, the KSS owned and managed the tubewell and the BP system, but in practice it was dominated by a few prominent individuals.

Table 1. Information on the KSS management.

Parameters	schemes		
	Taltolapara	East Kutubpur	Shaplapara
1) Waterusers			
a) KSS member (during study)	42	44	42
b) Non-KSS member	19	19	20
2) KSS meeting			
a) desired nos.	20	20	20
b) held			
i) nos.	10	8	6
ii) percent	50	40	30
3) Member present per meeting (%)	15-26	10-56	29-56

Water Charges

All the three KSSs practiced own fuel system. Therefore, water charge included oil cost, repair & maintenance, staff salary and installment of DTW and BPDS. Usually, this total cost was distributed over the total irrigated areas and water rate was charged as Taka per decimal (Table 2). There were many defaulters in water charge payments. Maximum water charge (85%) was collected at East Kutubpur. Bangladesh Rural Development Board (BRDB) with the help of police collected this money. Police actions made the farmers anxious about the loan payments and some of them repaid it by selling out lands, which could have serious social consequences. The main reasons for not paying the water charges in time were the lack of responsibility and sincerity to the KSS, lack of coherence in the group, factional problem, crop failure and for some farmers financial inability to pay.

A survey by TADP (Mayer 1991) on 40 schemes indicated that 23% KSS farmers practiced cash payment system, 17% sharecropping system and the remaining KSSs were using sharecropping for certain crops and cash payments for other crops.

Table 2. Information on financial aspects.

Parameters	Schemes		
	Taltolapara	East Kutubpur	Shaplapara
1) Water charge			
a) system	Cash payment	Cash payment	Cash payment
b) rate (Tk./decimal)			
i) rice	2	5.50	4
ii) non-rice	1	1.75	2 and 1
c) collection (%)	70	85	64
2) DTW loan			
a) amount due (Tk)	14,3640.00	1,84,680.00	1,43,640.00
b) amount paid			
i) Tk	92,512.00	89,819.00	68,210.00
ii) percent	64	48	47
3) BP loan			
a) amount due (Tk)	31,552.80	27,700.00	26,190.00
b) amount paid (Tk)	0.00	0.00	0.00

Loan Situation

Table 2 showed that none of the schemes cleared their due loans completely. The reason for over due of loans was either farmers did not pay water charge in time or the money collected was used in personal business of the manager or both. Government policy of exempting agricultural loan upto Tk. 5000.00 was the another reason for non-payment of loans (Rashid et al. 1992). Table 2 also showed that no payment was made against buried pipe loan by any of the schemes. Whenever an installment was fallen due the management raised the question of repairing the leaks of buried pipe and avoided payments.

Pump Operation and Water Distribution

Very low pump operation was observed (12% of advised) and 3 to 4 outlets were used each day. The main reasons of this low utilization were the poor management, own fuel system, high fuel cost, smaller command area and non/under irrigated diversified cropping (as it was not obligatory to grow irrigated crops within the command area).

The very limited number of outlets (about 20-21) of two cusec capacity were found inconvenient for the prevailing field situation. This resulted in longer earthen field channels and caused higher conveyance losses (Rashid et al. 1990). The condition of most of the field channels were poor. Generally, they were undersized, uncompacted, irregular in shape and had very low banks. About half of the channels were constructed during the irrigation period on a very temporary basis. Overflow of irrigation water above the banks was a regular feature. Yet under own fuel system it was difficult to divide the flow between the farmers. No maintenance work was observed during the study. One cusec outlet operating two at a time should have been more convenient.

Because of "own fuel" system water was supplied to the farmers in order to which they arrived at the pump house. This led to frequent switching between pipelines and resulted in unnecessary losses of water in repeatedly filling of the pipelines. This problem can be solved following the line rotation. Farmers are to be grouped outletwise i.e. water supply to the farmers under a outlet should be completed and then moved

Table 3. Pump operational information.

Parameters	Schemes: Taltolapara	East Kutubpur	Shaplapara	Remarks
1) Pump Operation				advised
a) Hours/day	4.49	2.22	4.92	20
b) days/month	18	16	17	26
2) Discharge, lps				design
a) pump	31	39	29	56
b) outlet	27	31	27	-
3) Conveyance loss (lps/100 m)				
a) Pipeline				
i) tank test	0.50	0.29	0.33	
ii) inflow-outflow	0.58	0.68	0.45	
b) earth channel				
i) by inflow-outflow	8.56	6.82	7.30	
4) Leakage repaired (nos.)				
a) pipe body	28	184	10	
b) at joint	145	541	34	
c) total	173	725	44	
d) per 100 m	7.9	41.02	2.37	
5) BP repairing cost (Tk/year)	1,450	9,000	650	
6) Pump servicing cost (Tk/year)	800	10,250	4,600	
7) Water adequacy (supply/demand)	0.93	0.95	0.89	

to the next outlet. In own fuel system, different grade fuels were used which created trouble for the engine. Switching over to project fuel system may be beneficial.

Pump and Outlet Discharge

Tubewell discharges of the schemes were found to be in the range of 29 to 39 lps compare to the design discharge of 56 lps and that of outlet was found in the range of 27 to 31 lps (Table 3). These variations were due to own fuel system, low channel capacity and change in the depth to static water level. Average conveyance loss in the pipeline was found to be 0.37 lps/100 m by tank test and 0.57 lps/100 m by inflow-outflow method and the same in the earthen channel was found to be 7.56 lps/100 m by inflow-outflow method. Rashid et al. (1992) reported that the conveyance losses on eight schemes in Tangail district were 0.33 lps/100 m by tank test and 0.69 lps/100 m by inflow-outflow method in the pipelines and the same was 7.69 lps/100 m by inflow-outflow method in the earthen channel.

Irrigation Practices

No scientific or recommended irrigation scheduling was followed and the large variation in irrigation intervals was noticed. In general, practiced irrigation interval was longer than the recommendation for most of the crops. The reasons for the large interval were the use of own fuel system, high fuel cost, waiting for rainfall, the low collection of oil charge and the shortage of operating funds. Water adequacy (supply.demean) was determined for boro-rice and was found less than 1 (Table 3) which meant under irrigation. Area under irrigation by different farm category is shown in Table 4.

Repair and Servicing

Pump servicing and pipeline repairing costs are shown in Table 3. None of the schemes practiced preventive maintenance, breakdown repairing was observed everywhere, as a result pumps were performing poorly (usually running at lower speed and discharging less). All schemes experienced leakages in the pipelines. Too many leakages at East Kutubpur (41.02 leaks/100 m length of pipeline) was because this scheme had bad quality pipes (hand made) as well as bell-mouth socket and spigot joints.

TADP's survey (Mayer 1991) on 40 schemes reported that only 48% of the DTWs were serviced during rabi season; in all cases luboil was changed (average 3.8 times); fuel filters were changed in 72% cases, 60% of the DTW had atleast one breakdown during 9 days on average; 37% of the repaired was carried out by BADC, 27% by TADP (on-the-job Training Programme), 26% by the KSS themselves (local mechanics, pump operators, etc) and rest 10% by UCCA mechanics.

Table 4. Area under irrigation by different farm category.

Farm category	Cultivated land per farm (ha)				
	Irrigated		Non-irrigate		Total
	High land	Medium high land	High land	Medium high land	
Landless	0.05 (80)	0.01 (20)	-	-	0.06 (100)
Marginal	0.19 (63)	0.07 (21)	0.02 (7)	0.03 (9)	0.31 (100)
Small	0.25 (41)	0.12 (20)	0.18 (30)	0.05 (9)	0.61 (100)
Medium	0.76 (59)	0.17 (13)	0.11 (9)	0.24 (19)	1.28 (100)
Large	1.12 (34.5)	0.15 (4.5)	0.58 (17.5)	1.42 (43.5)	3.27 (100)
All farm	0.47 (43)	0.10 (9)	0.18 (16)	0.35 (32)	1.10 (100)

Note : Figures in parentheses indicate percentage.

Command Area

The irrigated command area varied considerably from year to year in the range of 9 to 29 hectares compared to that of intended command area of 40 ha. In general, this does not appear to be shortcoming in the BP system, rather this was because of poor management and inadequate extension services. The reasons for low command areas were the poor KSS management, own fuel system, non-rotational water distribution, lack of leadership in the KSS, reluctance of large farmers to cultivate all their lands and farmers preference to other businesses to agriculture.

Land Utilization and Landownership Patterns

Different uses of land under the three schemes in the rabi season of 1989-90 are shown in Table 5. Figure 1 shows the landownership pattern and the acreage owned by the different classes of farmers as indicated by TADP from their survey of 40 schemes.

Cropping Pattern and Crop Diversification

Diversified crops were grown mainly rice, wheat, water-melon, soybean and banana and the cropping intensity of the area was 233%. Under these three schemes wheat was the major crops followed by boro rice during the rabi season. However, a different picture is shown by a TADP report (Mayer 1991) on 40 schemes in the area (Fig. 2). Table 6 shows the crop diversification in the areas

Table 5. Land utilization pattern under three schemes in rabi season of 1989-90.

Parameters	Scheme		
	Taltolapara	East Kutubpur	Shaplapara
1) Irrigated cultivation			
a) Total (ha)	18.87	9.25	20.66
b) Percent	43.43	22.25	49.70
2) Non-irrigated cultivation			
a) Total (ha)	1.97	2.54	2.12
b) Percent	4.54	6.10	5.12
3) Unavailable of cultivation			
a) Total (ha)	5.33	3.90	4.39
b) Percent	12.25	9.39	10.58
4) Orchard			
a) Total (ha)	0.25	0.08	0.25
b) Percent	0.57	0.20	0.60
5) Forest			
a) Total (ha)	0.70	1.89	1.99
b) Percent	1.61	4.55	4.78
6) Pond			
a) Total (ha)	0.18	-	0.14
b) Percent	0.42	-	0.33
7) Fallow			
a) Total (ha)	16.16	23.90	12.01
b) Percent	37.18	57.51	28.89
8) Total land under scheme			
a) Total (ha)	43.46	41.56	41.56
b) Percent	100	100	100

Note : Unavailable of cultivation includes mosque, homesteads, bazar, etc.

Table 6. Crop diversification.

No. of different crops	Command area (Percent)		
	All	Lowland	Highland
0	4	0	6
1	23	80	14
5	23	20	23
10	40	0	46
12	10	0	11

Source : Mayer 1991.

Use of Inputs

TADP survey on 40 schemes showed that 64% farmers used fertilizer and pesticides, 35% fertilizer only, and 3% pesticides only; 76% of the crops grown were HYV (rice mainly); 6% of the farmers used tractors for ploughing; and 7% applied improved infield irrigation techniques (mainly field preparation for vegetables).

Figure 1. Landownership Pattern and Landholding Sizes within the Command Areas

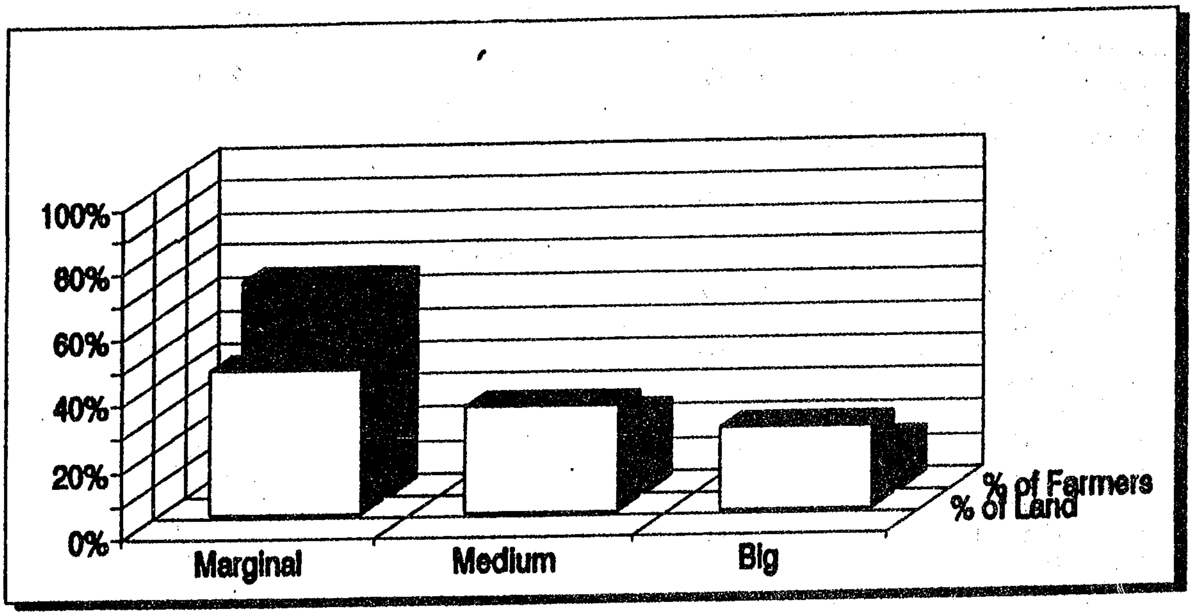
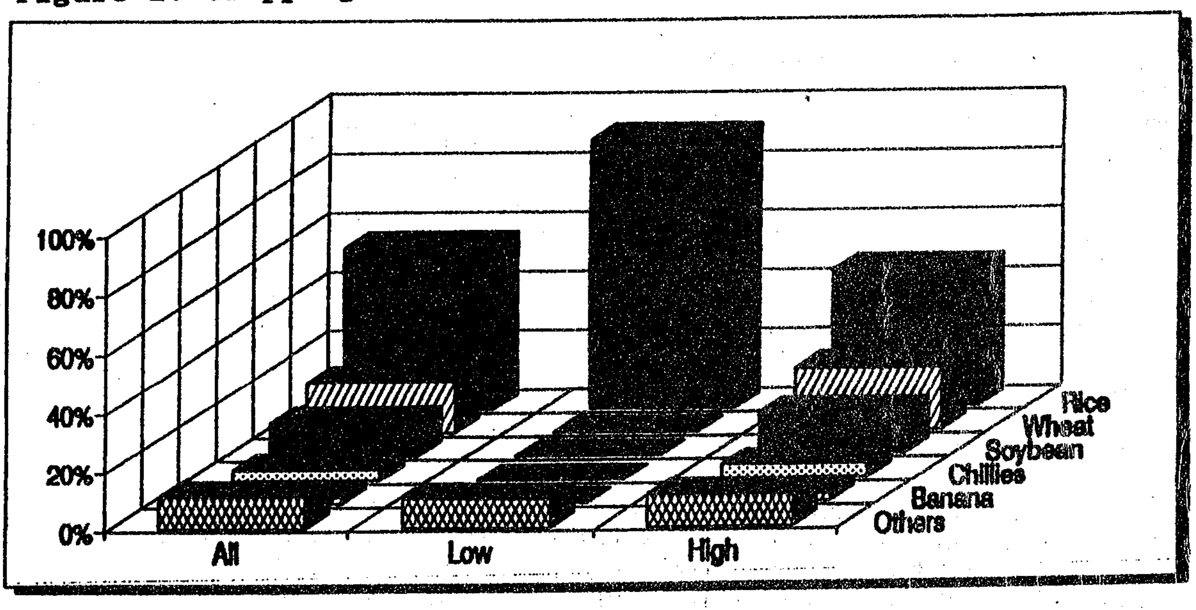


Figure 2. Cropping Pattern during Rabi Season 1990/91



Extension Services

Extension services were inadequate. Out of the government departments and the donor agency only TADP was found active in the project areas. For the improvement of the schemes effective extension services (both in agronomic and in water management aspects) and effective scheme management were judged to be essential.

CONCLUSIONS AND RECOMMENDATIONS

The study area contained varied topography and dispersed housing, under the situation BP systems were found effective for distributing irrigation water over the command area.

The average irrigated area was only about half of the intended command area. The inefficient management system and inadequate extension services were the reasons of this low irrigated area, not the shortcomings of the technology. Extremely low pump operation (3.88 hrs/day and 17 days/month) and too many fallow lands (about 40%) were observed. To improve the economic performance of the BP systems, these constraints need to be overcome.

Two cusec outlets and their limited numbers (20-21) were found inconvenient under the prevailing operational and field situation. One cusec outlets, one for each 2 to 3 acres, and operating two at a time would be more convenient.

Instead of "own fuel" system, project supply fuel and line rotational water distribution system can enhance engine life, reduce conveyance losses and increase pump operation and hence command area. Routine preventive maintenance should be practiced.

Effective extension services, both in agronomic and in water management aspects, are most essential to make the buried pipe schemes more attractive and profitable.

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FARMER-MANAGED SHALLOW TUBEWELL IRRIGATION SYSTEM AND ITS SUSTAINABILITY IN NEPAL

Narayan Prasad Upadhyay

Abstract: Nepal is a developing country with 43 per cent of its population earning below the, minimum subsistence requirements. About 90 per cent of the cultivated area is being used for growing food crops. While most of the hill districts are moving into a food deficit situation, there is tremendous potentiality for producing marketable surplus in the Terai where there is prolific demand for irrigation development. Furthermore, in the region shallow tubewells (STWs) have been very popular, successful and productive than deep tubewell (DTWs) Nearly 23000 STWs have been installed. The determinant conditions such as high potential shallow aquifer zones, small size of land holding, short gestation period, cost effectiveness of the technology etc. have induced the small and poor farmers to prefer (STWs) over DTW. In STW FMIS, farmer beneficiaries are actively involved in system development and water management. Their active involvement creates conditions which result in sense of ownership, cost savings, effective resource mobilization, need based system development, reliability, effective cost sharing, effective support from private sector and wide potentiality for developing water market which further result into better working of FMIS than AMIS. Besides, interventions in the form of subsidy arrangements, loan assistance and technical support have been playing key role in maintaining its sustainability. Although the STW ground water FMIS has become very popular, yet some technical, social and financial problems have been encountered in its way to massive implementation. Therefore, it can be concluded that the system can not be left with complete independence and some supportive interventions are necessary for its continued promotion and sustainability.

1 INTRODUCTION

1.1 Country Background

Nepal is a rugged and mountainous landlocked country with a surface area of about 147,181 square kilometers. The country is bordered by China (Autonomous Province of Tibet) on the North and otherwise surrounded by India. The country has an estimated population of almost 19.37 million, which has grown at an average rate of 2.55 percent for the years 1985 to 1990.

Agriculture dominates Nepal's economy. It accounts for 60 percent of gross domestic product and 70 percent of total export earnings, and provides a livelihood to almost 90 percent of the working population estimated at 7 million. Over 90 percent of the cultivated land is used for food grain production.

The Terai, a strip at the North of the Gangetic plain, contains 48 percent of Nepal's population and produces. 70 percent of the country's agricultural output. The remainder of the population and economic activity are largely centered in the hills.

The country is facing considerable developmental problems and challenges. Factors such as deteriorating environment, rapid growth of population, steady erosion of the forest areas, farming on to marginal lands have led to a drop in per capita food production and increasing hardship to the farming community. About 43 percent of an estimated 19.37 million people are believed to be earning below the minimum subsistence requirements.

1.2 Need for Irrigation Development

Although agriculture forms the mainstay of Nepal's economy, yet most of the Northern districts are moving into a food deficit situation while there is tremendous potentiality for producing marketable surplus in the Terai.

The total cultivated area in Nepal is estimated at 3.1 million ha. The irrigable area is 1.9 million ha. out of which 1.6 million ha are in the Terai and 0.3 million ha in the hills. The total area under irrigation is about one million ha indicating about 33 percent of Nepal's cultivated land to be under irrigation.

It is reported that His Majesty's Government of Nepal (HMG/N) needs to bring an additional 35000 ha. of land under irrigation annually just to keep up with the existing population growth. However the present annual performance level is only at nearly 18000 ha. Thus there is an urgent need to bridge this big gap to meet the present food requirement of the country, if it is to be self-sufficient in food production.

There appears to be little scope left for expanding the area under cultivation. HMG/N is committed to increase farm production, create employment opportunities and alleviate poverty through the expansion of irrigated agriculture. The major hope for boosting up agricultural production lies in the expansion and intensification of irrigation development activities.

2 DEVELOPMENT OF SHALLOW TUBEWELL GROUND WATER IRRIGATION SYSTEM

2.1 Promotion of Shallow Tubewells

In order to keep the capital cost of irrigation development low and reduce government expenditure on operation and maintenance, HMG/N is giving top priority to ground water irrigation systems with low cost and short gestation periods such as shallow tubewells (STWs) which is being managed by farmers comparatively very easily as compared to surface and deep tubewell (DTW) irrigation systems requiring huge investments, long maturity periods and long term Govt. involvement in Operation and Maintenance.

Besides, interventions such as provision of technical guidance, loan assistance and subsidy arrangements have acted as Key elements in identification, development, transfer and promotion of STW technologies to suit local geological needs and make them within the reach of the weaker sections of the farming community.

2.2 Achievement Status

Terai districts are principle areas where demand for STW exists. During the period between 1980/81 to 1989/90 about 23000 STWs have been installed in various Terai districts of the country (Table 1).

2.3 Performance of Shallow Tubewells

Pudasaini (1976) in a study of Bara district, Nepal found higher resource productivity, income and labour employment in STW irrigated farms than rainfed ones. Similarly Khoju (1980) study in the four Eastern Terai district of Nepal indicated higher levels of resource - use, yields, income and cropping in-tensity associated with STW irrigation. The study also revealed higher technical efficiency i.e. higher output per unit of each input in the case of STW irrigated crops.

3. CONDITIONS FOR SHALLOW TUBEWELL PREFERENCE OVER DEEP TUBEWELL

Along with the great potentiality for STW promotion in most of the Terai districts of Nepal, there are certain determinant conditions which create conducive environment to the farmers for STW preference over DTW and they are discussed as under:

1. Small Farm Size

The total number of holdings in the country is estimated at 1721176, the average size of holding being 0.96 ha. While 63.1 per cent of households own less than one ha of land, only 10.4 percent own land more than 5 ha. (Table 2) . The average farm holdings are decreasing in size. Hence majority of the small and poor farmers have preference for STW system of ground water irrigation over DTWs.

Table 1 Number of Shallow Tubewells Installed (1980/81 - 1089/90)

S.No.	Year	Number of STWs (ADB/N)
1.	1980/81	240
2.	1981/82	904
3.	1982/83	2575
4.	1983/84	1944
5.	1984/85	2319
6.	1985/86	2334
7.	1986/87	2322
8.	1987/88	2621
9.	1988/89	1359
10.	1989/90	1285
Sub Total		17903
Other Agencies (total)		4972
Grand Total:		22875

Table 2. Size of Holdings with Percentage of Households.

S.No.	Size of Holdings	Percentage of Households
1.	Less than 1 ha.	63.1
2.	1 - 3 ha	19.4
3.	3 - 5 ha	7.1
4.	5 - 10 ha	5.8
5.	10 - 15 ha	2.5
6.	15 - 20 ha	0.9
7.	20 - 30 ha	0.5
8.	30 and above	0.7
	Total	100

2. Fragmentation of Holding

The fragmentation of holding is very high and ranges from 1 to 8 parcels in the Terai. Nearly 53% of operated holdings fall within the fragmentation range of 3 to 9 parcels due to which farmers can make comfortable accomodation of STWs individually or in a small users' group (Table 3).

3. Land Tenure Situation

In Nepal as much as 25 percent of the cultivated land is farmed under tenancy conditions in which fixed rentals are paid to the land owners due to which the land owners have no incentive to invest on irrigation development on such lands rather they prefer to install one or more STWs on self - owned and cultivated parcels of land as per their requirement.

An impact study of STWs in Nepal (parashar 1988) found that the farmers owned maximum up to 5 STWs (Table 4). The practice of placing separate STW in owner operated scattered parcels of land and rotating one pumpset among them is common even among large holders and thus they prefer STWs over DTWs.

4. Short Gestation Period

Farmers prefer STWs because it can be installed in a very short period of time. Studies have revealed that the average time taken to install a STW is 5.4 days. The range of installation duration varies between a minimum of 2.9 days to a maximum of 9.8 days (Table 5).

5. High potential Shallow Aquifer Zones

The Terai districts have high potential shallow aquifer Zones (Figure 1) Ground water occurs under various conditions as a result of the different types of deposits that constitute the Terai geology. Because of variations in geo-hydrologic conditions, aquifer yields water to the STW at a practically useable rate making easy access to ground water supply in most of the Terai districts of Nepal. Therefore, farmers prefer to have STWs.

Shallow aquifer static water levels vary throughout the Terai and hence useable draw down also vary accordingly. The depth of STWs vary between a minimum of 6.1 meter to a maximum of 91.5 meter. The average depth (Parashar 1988) worked out at 17.6 meter (Table 5).

6. Subsistence Food Requirement

With heavy demographic pressure on land leading to small holdings coupled with fragmentation, the immediate need to mitigate the food requirement for subsistence, would determine the choice of technology.

The Terai belt covers nearly 23 percent of the geographical area occupying 65 percent of the total cultivated area of which about 90 percent is being used for growing food crops. This indicates that one of the key determinant of the choice of irrigation technology is the farmers' insistence on self-sufficiency in food which motivates them to search for and prefer technologies such as STWs which enable the water users to intensify their farm activities at the earliest possible.

7. Simple Technique

Different types of indigenous drilling techniques are practiced through out the Terai region of the country. These techniques with unique characteristics and capabilities have enabled the farmers to install very successful, productive and longer lasting wells under most hydro-geologic conditions in Nepal.

The most common methods of sinking STWs are Manual Rotary, Thokuwa, Dhikuli and Bogie. The method of sinking depends upon the type of soil, strata and also the region.

Table 3. Percentage Distribution of Fragmentation of Operated Holdings.

S.No	No. of parcels	Percentage of Operated Holdings	+	Distribution
1.	1	11.18		
2.	2	21.12		
3.	3	13.36		
4.	4-5	19.66		
5.	6-9	19.74		
6.	10-14	9.46		
7.	15 or more	5.48		
	Total	100		

Table 4. Shallow Tubewell Ownership by Number of Sample Respondents.

S.No.	Number of Shallow Tubewells	Number of Sample Respondents
1.	1	328
2.	2	68
3.	3	19
4.	4	7
5.	5	1
Total	554	423

Table 5 Depth, Gestation Period and cost of STWs.

S. No.	District	Depth of well (meter)	Period In days	Installation Cost in NRS	(US $ at1986 exchange rate)
1.	Jhapa	14.73	4.7	2954.27	147.71
2.	Morang	20.20	5.1	3263.92	163.19
3.	Sunsari	18.72	5.2	2032,07	101.60
4.	Saptari	24.70	4.2	3194.76	159.73
5.	Siraha	18.01	2.9	3266.39	163.31
6.	Dhanusa	20.00	4.6	2534.39	126.71
7.	Mahottari	26.70	4.7	2549.50	127.47
8.	Sarlahi	21.25	3.6	2221.29	111.06
9.	Rautahat	15.10	4.5	4249.07	212.45
10.	Bara	16.80	3.5	3900.69	195.03
11.	Nawalparasi	15.70	9.2	3225.00	161.25
12.	Rupandehi	12.30	9.8	2870.19	143.50
13.	Kapilvastu	16.30	7.5	5808.65	290.43
14.	Dang	12.60	7.4	6440.33	322.01
15.	Banke	17.00	5.2	3729.81	186.49
16.	Bardia	15.00	3.9	4155.77	207.78
17.	Kailali	15.40	7.0	6974.44	348.72
18.	Kanchanpur	16.00	4.4	6654.39	332.71
	Average	17.60	5.4	3890.27	194.50

Figure 1. Map of Nepal indicating high potential shallow aquifer zones with the number of STWs installed. (1980/81 - 1989/90)

No sophistication of machinery is involved. Construction, renovation as well as operation and maintenance can be easily and widely understood. Drillers do not need high cash requirements. Installation equipments required are minimum and mobile.

8. Cost - Effective Technology

The STWs are cost effective. An impact study of STWs (Parashar 1988) found that the average cost of installing a STW is Rs. 3890.27 (US $ 194.50 at 1986 exchange rate). The highest cost incurred was worked at Rs. 6974 (US $ 348.72) in Kailali district and the lowest cost being Rs. 2032 (US$ 101.60) in Sunsari district (Table 5) . However the cost determinants in installing STWs are depth, type of casing pipes/strainers used and method of sinking.

Choice is available in the selection of construction material which are readily available. Some, construction materials are commercially manufactured, some are constructed in shops and some are constructed at well - sites.

9. Ready Availability of Pumpsets

Farmers prefer STWs because they can be easily operated through pumpsets which are within the reach of the majority of the farmers and are movable. Farmers can either obtain pumpsets from within the country or import from the adjoining Indian markets. The horse power (HP) of pumpsets owned by ST owners varies from 5 to 10. Majority of STW owners possess one set and those who do not have, use in rentals.

10. Subsidy Arrangements

Provision of 40 percent subsidy on the total cost of STW installation by HMG/N also acts as motivational condition to determine the farmers' preference for STWs over DTWs.

4. FARMER MANAGED IRRIGATION SYSTEM IN NEPAL

4.1 The Context of FMIS

Water is one of the primary resources of the country. People have been utilizing this key element of agricultural production through installation and construction of irrigation systems. This tradition gave birth to the farmer managed irrigation systems. The country's irrigation systems can be broadly categorised into two types based upon the management responsibility : farmer - managed irrigation systems (FMIS) and agency-managed irrigation systems (AMIS) . In FMIS, farmers take the responsibility for installation, construction, operation and maintenance, water allocation, distribution and the overall management of the system on a continuous basis. Any external intervention to FMIS is need based and occasional. In AMIS department personnel are responsible for construction and the management of the system.

Out of nearly one million ha of irrigated land over 67 percent is presently farmer - managed and the rest 33 percent only is agency managed. Poor performance of AMIS interms of quality as well as quantity is a persistent problem in Nepal. There are three major reasons for this poor performance 1) system deterioration due to poor maintenance 2) lack of management and 3) inadequate agricultural support services.

It has been found that the FMIS works better because the process of institution development proceeds through a series of advances and consolidation of beneficiaries' thinking, expectation, confidence and skill.

4.2 Conditions for better working of FMIS than AMIS

There are certain conditions which accelerates the working of FMIS better than AMIS. The identified conditions have been described as under.

1) Demand driven systems. In FMIS irrigation schemes and technology are demand driven' and they are based on felt need of the beneficiaries where asin AMIS irrigation projects are supply-driven based on foreign aids/grants.

2) Active participation of beneficiaries. FMIS works better because farmer beneficiaries are involved in all stages of the project cycle. They invest considerable time in project activities such as project identification, selection, design, development, improvement and operation and maintenance of the system. They share informations, local skill and their rich experience in the development and execution of schemes which makes them feel to receive effective irrigation services. Attachment to the system from the very beginning plays a pivotal role in making FMIS function better. Besides, community can converge all the diverging views of the beneficiaries for a common need.

3) Sense of ownership. FMIS works better because the beneficiaries feel the sense of ownership and belongingness to the system. Awareness and sense towards creating assets of their own, by themselves and for themselves make the system work better. They are conscious about the ownership of the system and their responsibilities.

4) Easy operation and maintenance. In FMIS, schemes are operated by the beneficiaries through mutually agreed arrangements. Beneficiaries take keen interest in the timely repair and maintenance of STWs especially of pumpsets'. Spare parts and maintenance services can be obtained from the open market where as in agency managed systems project has a monopoly on all repair and maintenance work.

5) Minimum bureaucratic disturbances. Beneficiaries are independent in making decisions with regard to the system operation without recourse to bureaucratic budgetary constraints and cumbersome procedures and without suffering delays during critical periods.

6) Reliability. FMIS works better because the water users can rely more on the self-managed schemes/system which helps in building confidence among themselves as against AMIS where electrical supply or the pump repair are beyond their control which leaves them with a feeling of insecurity.

7) Timely mobilization of internal resources. Timely mobilization of internal resources such as labour, materials and funds and their effective management by the beneficiaries play key roles in making FMIS work better be cause they are conscious of their duties and rights and also they are very keen towards time-bound expectations and achievements from the system.

8) Effective cost sharing. Involvement of the beneficiaries from the very beginning of the system development to its operation and maintenance crates their interest in cost sharing mechanism. They believe that the system is being built according to their specifications and requirements.

In STW FMIS, initial investment is very less and over that 40% subsidy on initial capital investment is being provided by the Govt. and the rest is borne by the beneficiaries in the form of loan and equity as against AMIS where cost sharing calls for a large sum which is beyond the ability of the majority of the farmers.

9) Common approach to conflict resolution. Water users have tendency to identify their problems and seek solutions with group decisions. Their is increased awareness among themselves in sharing irrigation management issues which helps in solving water dispute with ease.

10). Better management of available water. In FMIS, work responsibilities are clear and distinct. Water users develop their own mechanism for water allocation and distribution which leads to distribution efficiency. Distribution efficiency depends upon the distance from source well to the field of use and permeability of the conveyance channels. Terai shallow aquifers are wide spread and indigenous boring equipments highly mobile which enable the farmers to place STWs adjacent to or within the place of use in most areas. Besides, small capacity of shallow wells coupled with small area irrigated by each well, helps the water users to minimise the number and length of conveyance channels which reduces the conveyance losses there by increasing the distribution efficiency.

Beneficiaries' consciousness and efforts towards evaporation losses, surface run off, method of irrigation and its compatibility with planted crops and under or over irrigation of crops, help to achieve better water management efficiencies than in case of AMIS.

11) Awareness towards cost control. The cost aspect becomes an important issue when we talk about irrigation development. With the farmers' participation irrigation systems have been developed at a very low cost. The studies have revealed that the per ha cost for developing farmer managed STWs is much below than that for DTW whose approximate cost is estimated at Rs. 21000 per ha (US$ 1050) at 1986 prices (Prachanda 1989).

In FMIS beneficiaries are interested in efficient conveyance and application of water for which they keep direct observation on pumpset operation and irrigation requirements of crops. This results in fewer hours of pump operation and hence farmers can lower costs for the same irrigation benefit.

In AMIS system development and its regular maintenance are heavily dependent on external resources in the form of Govt,. expenditure.

12) Willingness to pay watercess and easy cost recovery. Cost recovery is an important issue in irrigation development. In FMIS beneficiaries feel joint responsibility in cost recovery since they are involved in investment, operation and maintenance and water management decisions. Beneficiaries establish and jointly agree upon a water fee collection mechanism. They are willing to pay water charges because the system delivers water on a timely basis making the supply system more dependable. Further, they are able to pay watercharge which is fixed by the users' group decisions on the basis of their farm size and water requirements.

In agency managed systems, direct cost recovery has been very difficult. Water fees have been fixed but the collection rate is very low.

13) Strength and vitality of water user's group. FMIS works better because, beneficiaries work for common cause with common interest and hold membership of water user's group. As a group, they maintain strength and vitality to enter into useful interaction with the line agencies' support system which in turn enables them to intensify their farm productivity.

14) Flexibility. Irrigation systems managed by the farmer beneficiaries are flexible, adjusting their methods and mechanisms of system development, improvement and water management to suit their local socio-economic environment.

15) Support from private sector. Irrigation systems managed buy the farmers can derive substantial support services from the private sector. There is an increased tendency to strengthen the private sector by providing them necessary assistance such as provision of drilling equipments and pumpsets, establishment of workshops for local fabrication/manufacturing of spare parts and post installation services, import facility for spare parts and training to drillers.

16) Wide potential for water market. There is tremendous potentiality for the development of water market because majority of the farm families own less than one ha land which

means that for a large number of households owning a STW means operating at a level far below the designed capacity,

In a study (IIMI 1991) it has been found that the economics of a water market for a typical community owned STW scheme is encouraging. The community earned a net of Rs. 5950 (US$ 141 at 1991 prices) by selling water for 325 hours in one year.

17) Manageable size of beneficiaries. FMIS particularly STW ground water irrigation system works better because the group size is manageable. The number of beneficiaries varies from 3 to 5. Consequently, size of the combined land area also varies from 3 ha to 5 ha (IIMI 1991). Smaller the commend area and the size of beneficiaries better is the system management.

5. PROBLEMS ENCOUNTERED IN THE PROMOTION OF SHALLOW TUBEWELLS

Although the STWs have been highly popular and successful ground water FMIS in Nepal, yet some problems have been encountered in accelerating its massive implementation.

Some of the experienced problems are 1) reduction in the discharge of water as compared to the discharge at the time of installation due to accumulation of sand in the strainer, unsatisfactory aquifer, decrease in water table, low depth of the well and breakage/leakage of strainers 2) inadequate repair and maintenance facility for pumpsets 3) increasing cost of STW installation 4) increase in the cost of pumpsets and diesel 5) lack of money with the farmers to purchase diesel 6) under exploitation of STW water 7) reluctance of STE owners to operate it in rentals 8) inability of STW owners/drillers in the selection of suitable drilling technology 9) timely unavailability of pumpsets 10) inadequacy of trained drilling contractors 11) thick density of STWs and 12) too many parcels of land.

6. PROMOTIONAL CONDITIONS FOR INCREASED SUSTAINABILITY OF STW GROUND WATER FMIS

To sustain and promote ground water FMIS through STWs, some additional efforts have to be made such as 1) continuity in the capital subsidy as an incentive to the small farmers in the installation of STWs 2) maintaining adequate well distance to avoid reduced discharge of water due to heavy concentration 3) making provision for diesel loan to motivate STW owners to operate the pumpsets and STWs in rentals to improve the operational hours of STWs 4) providing training to STW owner and/or drillers in the selection/installation of suitable drilling techniques and operation and maintenance of STW/pumpsets 5) imparting training to water users in water distribution and management.

It has been realised that the STW is the only suitable ground water FMIS to reach the small and marginal farmers which constitute 60 percent of the country's farming population.

It is, therefore necessary to have some form of intervention in the system to create conditions conducive to sustainability and promotion of STW FMIS. Some of the additional conditions of sustainability to be addressed are 1) developing clear cut policy for rehabilitation of existing non-performing STWs 2) assisting farmers in creating water markets by motivating them to form water users' groups so that they can share water in rentals which will lead to the increased farm productivity and income with minimum cost on irrigation, on one hand and on the other it will enable the water users to make use of the optimal capacity of STWs. 3) making active and continued involvement of water users in all phases of project design, implementation, operation and maintenance and water management which will help develop an inbuilt mechanisms for irrigation system development and water management facilitating them to ventilate their hopes and expectations in their respective areas according to their need. 4) helping water users develop mechanism to solve the problems besetting water distribution and management . 5) adopting more liberal policy to support repair and maintenance infrastructure and private pumpset dealers. 6) integrating and implementing agricultural extension services effectively with the irrigation system to improve cropping pattern and increase cropping intensity for the optimal utilization of STW water which will induce farmers to come within a system of water user's organisation and make the organisation more viable and strong. 7) motivating the beneficiaries for regular check up of soil quality under STW irrigation to avoid conditions unfavorable for crop growth so that water users achieve better crop yields and maximise returns and 8) developing a long term agricultural price policy to avoid erratic fluctuations in the price of farm produce so that the farmers are induced for investment on irrigation development activities and are also protected against the increasing cost of the technology.

CONCLUSION

Under Nepaleese context, it can be concluded, that the conditions, under which STWs are preferred over DTWs and the conditions, under which FMIS works better than the AMIS, clearly, indicate that the STW system is the only popular and easily manageable ground water irrigation system to reach the poor individually or in a group. Experiences and studies reveal that the ground water STW FMIS can definitely maintain its institutional as well as technical sustainability and can provide an equitable and sustainable supply of water that will lead to increased agricultural growth along with social justice. But at the sametime, it may be worthful to note that it will be unreasonably high expectation to wish the system to function with complete independence for at least a couple of years to come. The farmer beneficiaries are in a need of creative and supportive intervention. The form and the degree of support and intervention required as discussed earlier either through governmental departments or related organisations will be of vital importance and will play a pivotal role for the system's continued promotion and sustainability.

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SUSTAINABILITY OF FARMER-MANAGED GROUND WATER IRRIGATION SYSTEMS IN DROUGHT-PRONE AREAS - ROLE OF SOCIO-ECONOMIC CONDITIONS

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Abstract

In India, using ground water for agricultural purposes is one of the oldest forms of irrigation. Traditionally dugwells were the chief means of irrigation in drought-prone areas. Farmers evolved indigenous methods to lift water from shallow dugwells. Waterlifts were mostly drawn by bullocks and also by human beings, depending upon the depth of well and area to be irrigated. Over the years economic compulsions and technological innovations seemed to have influenced to a great extent the spatial and temporal spread of ground water irrigation. The increase in population growth has necessitated the optimum utilisation of available ground water. This has led to the construction of dug-cum-borewells and tubewells. Animal-drawn waterlifts were gradually replaced by diesel and Electric pumpsets. Single-farm wells have become multi-farm wells, because of division of property among brothers and other kinship members. The emergence of all these techno-economic changes in the ways and means of ground water exploitation is believed to have posed a threat to the sustainable supply of water for agriculture. It is therefore attempted in this paper to highlight the understanding of the groundwater management problems by the farmers and methods adopted by them to handle aquifer draw-down.

Problem

Agricultural development in drought-prone areas is fraught with multiple risks emanating essentially from erratic and scanty rainfall. Farmers over the aeons have, however, searched out the environment for niches favourable to their own concept of welfare and often through centuries long trial and error, have established farming systems with technologies (such as risk-spreading multiple cropping) suited to their needs (Dillon, 1986). One such technology developed traditionally by the farmers to mitigate the adverse effects of inadequate and uncertain rainfall is ground water harvesting for agricultural purposes. Since sophisticated technology to gauge ground water potential in a given region was not available to farmers, their conventional wisdom and practical experience have been mainly responsible for the identification of appropriate sites for tapping ground water. This has led essentially to the construction of shallow dugwells by individuals or by small groups of two or three farmers whose lands were geographically contiguous.

Farmers in drought-prone areas, having experienced uncertainties of rainfed farming, tend to be cautious in using available water in wells judiciously to ensure sustainable supply. For, they could visualise the hardships if the draw-down goes beyond a level which they perceive as unsafe. Further, they are aware of the limitations of capital and technical knowhow required for deepening dugwells beyond a particular depth in a given region. Some of these factors play a crucial role in shaping up typology of wells in terms of depth, diametre, mode of water lifting and irrigation practices to be adopted, keeping in view the sustainability of the system in the long run.

In the wake of increasing population pressure and the consequent demand for more food production, the need for exploitation of ground water has increased over time. This has necessitated the technological innovations to be introduced to tap ground water. Keeping this in view, government has sponsored institutional credit programmes to encourage dugwell irrigation. This seems to have led to an apparently paradoxical situation; for, on the one hand the technological revolution and institutional credit facilities enabled the construction of deep wells and on the other, it tended to jeopordise the traditionally established sustainability. Given this situation it is important to know as to how farmers manage ground water systems keeping an altruistic view, namely, 'live and let others live' in mind. What kind of strategies they evolve to manage ground water systems? How do they perceive draw-down conditions and plan for suitable farming systems? How do they share water scarcity? What kinds of interventions from the government are necessary to promote sustainability in ground water exploitation? These are some of the questions that need to be examined to understand the dynamics of ground water exploitation.

With a view to examine some of these issues a few farmer-managed ground water schemes from I.V. Palli, a village in Anantapur District of Andhra Pradesh, India, have been selected. The issues and problems analysed in this paper are essentially based on the experiences and views of farmers selected for this study; yet they are representative of the general conditions in the region.

The Study Region : A Background

The study village is situated in an economically backward, semi-arid and frequently drought-prone region where annual rainfall ranges between 500 - 600 mm, mainly in the south west monsoon spread over June to September. Rainfall is not only low in the region but also highly uncertain. Therefore, shallow dugwells were the main sources of irrigation. There are a few tanks located in the neighbouring villages from which the village selected for the study does not get any direct benefit by way of surface irrigation. But it is benefited indirectly as the tanks contribute to the recharge of ground water aquifers which in turn enables rise in water level in the wells. Since rainfall is low in the area the chances of tanks getting filled frequently are less. It was reported by the local people that the cyclonic storms in Bay of Bengal, the frequency of whose occurence is as uncertain as rainfall itself, are some times blessings in disguise for this area; for, it ensures adequate rainfall enabling innumberable tanks in the region to receive full storage. Farmers experience tells that if the tanks are filled to full capacity in one year there will be no scarcity of water in the wells at least for two years even if rainfall is low. During such years they go for water-intensive crops without much problem. It indicates farmers' ability to judge draw-down possibilities based on monsoon conditions in a given period of time.

Red soils with rocky formations are predominant in the region. This is one of the characteristic features of soil profile in the Deccan Plateu, where the hard rock area forms about 90 per cent of the geographical area (Dhawan, 1986). This could perhaps explain the reasons for dugwell technology to be prominent in the region, leaving little scope for the introduction of tubewell technology. Hard rock bottom does not permit deep dugwells. However, during the last two decades the number of dugwells has increased, the externalities of which would be examined elsewhere. Paddy was the chief crop under dugwell irrigation. Aquifer draw-down in successive years seemed to have effected substantial changes in cropping pattern under well irrigation. Farmers have been using cropping pattern as one of the important means to ensure sustainable supply when ground water becomes scarce.

Ground Water Systems (Dugwells) Selected for the Study : Salient Features

The ground water systems selected for this study are traditionally - built shallow dugwells, which are mostly a century-old. The details are presented in table-1.

Table 1 : Salient Features of Farmer-Managed Ground Water Systems Selected for the Study

System Number	Depth of Well (in feet): at the time of first construction	Depth of Well (in feet): Present	Whether converted into dug-cum-bore well	If yes depth of bore (in feet)	Area irrigated (command area in acres)
1	20	30	Yes	100	11.5
2	22	26	Yes	120	6.3
3	18	22	Yes	60	4.6
4	18	24	Yes	80	8.2
5	12	24	Yes	90	8.0
6	26	26	No	-	5.7

The present owners of the six systems, the details of which are presented in the table, are second and third generation people. Therefore, none of them are able to say the year of constructing the well. Almost all the wells were deepened two to three times depending upon the draw-down status of aquifers over years. Further, it was reported that desilting of the wells once in five years or so, depending upon water level in the wells, is undertaken to keep the aquifers active without allowing any clogging. This practice perhaps was followed to ensure sustainability. During the last 20 to 30 years a number of new wells have come up in the area. This has affected water availability in the old wells. All the farmers, therefore, were forced to construct borewells. The dugwells under reference have been converted into dug-cum-borewells, for, the dugwell technology, as mentioned earlier, does not permit deepening of well beyond a certain depth. Further, hardrock strata in almost all the wells seems to be the major constraint to deepen the wells. Even so, some farmers (1 and 2 systems) did attempt to deepen wells through blasting the hard rock bottom, but of no avail. Some of these natural constraints have been responsible for integrating modern tubewell technology with the traditional dugwell technology to ensure adequate supply of ground water. Therefore, dugwells have been converted into dug-cum-borewells.

Another interesting feature is that the number of beneficiaries per well has increased over the years making them as common properties. For, single/twin-farm systems have been converted into multi-farm systems. This change tends to influence water use and management strategies which might affect the sustainability. The following table gives the details (Table-2).

Table 2 : Number of Beneficiaries Per System, Status of Their Relation and Type and Number of Waterlifts.

System Number	Number of Beneficiaries: At the time of construction	Number of Beneficiaries: At present	Relationship	Type and Number of Waterlifts per System: At the time of of construction — Moht	Type and Number of Waterlifts per System: At Present — Electric Pump
1	1	7	Kinship	2	3
2	2	4	Non-kinship	1	2
3	1	2	Kinship	1	1
4	2	4	Non-kinship	2	1
5	3	8	Non-kinship	2	2
6	1	4	Kinship	2	-

It is observed from the table that the number of beneficiaries (owners) has changed over time. This shows that the ground water systems, though start with single ownership, assumes common property nature in course of time. This happens essentially due to two reasons : (1) patrilineal right to inherit property leads to division of land among brothers and hence becomes common property; and (2) the sale of land by the original owners to others outside the kinship circle. It is interesting to note that out of the six systems under reference, three systems (50 per cent) have owners who do not belong to the same kinship. This shows the prevalence of cooperative culture for exploiting ground water, may be in a small way. It appears that this kind of cooperation emerged out of economic compulsions. For instance, small farmers with tiny holdings find it uneconomical to have an independent well (Reddy, 1988). Further, raising funds independently to construct a well may be a difficult proposition. Therefore, two or three farmers whose parcels of land are geographically contiguous used to come together and construct a well and share the costs and also water on prorata basis of the land they own. In such cases land will be owned individually and irrigation well becomes a common property. The individual rights to use water in proportion to their land are registered and guaranteed under law. Any attempt to prevent a member from using his/her share of water could be challenged in court of law.

Practical Problems Faced by Farmers

The depletion of ground water table year after year, caused partly by the additional wells in the study area and mostly by less precipitation, made farmers realise the importance of modern technology. While attempting to adopt modern technology, namely, tubewell technology, farmers seemed to have faced many problems. The most important problem, as reported by many is the selection of appropriate site for tubewell. They used their practical wisdom and also sought the help of local 'water diviners' in selecting appropriate site. Both the methods are not scientific and therefore, striking a potential aquifer is a chance factor. For instance, the farmers of system one (table-1), wanted to drill a deep bore in the hard rock to augment water supply in the well. Even after drilling to a depth of about 80 feet the rock stratum did not go and they got disapointed. However, second attempt has been made to identify another site with the help of a water diviner to drill another bore, a few feet away from the first one, to a depth of about 100 feet. This time also it was not possible to clear the hard rock strata and thus left the hope of striking deep aquifer and tried to manage with available water. In both the times the investment had gone waste. Had appropriate technology been available to strike potential aquifers the wasteful expenditure incurred by the farmers could have been avoided. The demonstration effect of such failures tends to leave an adverse impact on other farmers willing to adopt modern technology. Though finance is another major constraint for deepening wells, farmers are able to overcome it if there is guarantee of getting plentiful water.

In the case of other four systems under reference (2 to 5th) the situation is different. They also had the same problem of indentifying the right site to install bore. But by trial and error methods they could successfully strike active aquifers, especially the systems four and five have copious supply of water after constructing the borewell. The discussion so far of the nature of ground water systems and their transformation from traditional to modern technology to ensure sustainable supply of ground water leads us to examine the management strategies adopted by the farmers.

Technological Progress and its Impact on Sustainability

The transformation of ground water irrigation from low-cost traditional dugwell systems to cost-intensive modern tubewell technology and the changing ownership pattern seem to have influenced farmers' attitude towards water use and management. Practical wisdom and field experiences of the beneficiaries over a period of time have enabled them to asses the availability of water in the wells depending upon the temporal and spatial intensity of rainfall in the region. Accordingly they plan cropping pattern. For instance, it was reported that when rainfall is good where tanks and ponds in the area get filled in a particular year, farmers are sure that ground water aquifers get recharged and water in the wells will be plentiful. In such years water intensive crops like paddy are grown on a large scale. If the rainfall intensity is less semi-dry crops are cultivated, so that water scarcity does not occur. Majority of the farmers are aware of the fact that excessive draw-down in successive years leads to drying up of the aquifer. Therefore, cropping pattern is used as an effective measure to ensure sustainable supply of water. This has been the age-old practice in the study region. With the result, in none of the wells under study, as reported by the beneficiaries, water levels have gone below critical levels, say about 2 feet. Even if water occasionally depletes to the bed level of the well farmers manage in such a way that it reaches sustainable safe level as perceived by them by practising utmost economy in water use for the crops. These practices are more true in the case of single-owner systems, though the systems with more than one owner also adopt such measures.

Besides the introduction of tubewell technology and extension of institutional credit, supply of electricity on subsidised rates appears to have changed the outlook of farmers' towards sustainability. It may be recounted here that traditionally 'Moht'* was the chief device to lift water. This was replaced by diesel pumps in the study region in late sixties. Later, when the villages were electrified in late seventies, diesel pumps were replaced by electric pumps. It is interesting to note that as long as Moht was the chief means to lift water from wells there seemed to have never been scarcity for water. Because, farmers were extremely cautious in using water; for, it was a laborious job involving both manual and animal labour. The introduction of diesel pump technology has made farmers relatively more liberal as for as on-farm water use was concerned. However, the high cost of diesel oil had a built-in check on over use of water. But, the introduction of electric pump technology, particularly the introduction of fixed tariff (demetering), based on horse-power (HP), seems to have consolidated the sense of liberalism among farmers which has left its own impact on sustainable use of water from wells. Since power tariff is based on HP irrespective of the quantity of electricity used, farmers tend to use more number of pumping hours than actually required resulting in wasteful use of water which was not the case under Moht irrigation. This practice seems to have led to draw-down in all the wells under reference, necessitating their deepening more than once.

Further, technological progress in ground water lifting (diesel and electric pumps) while bringing attitudinal changes among farmers in water use has also encouraged proliferation of single-farm dugwells in the study region contributing to the fast depletion of ground water. Before the advent of pump irrigation dugwell irrigation was practiced predominantly in the farms adjacent to the village. Because farmers generally avoid dugwell irrigation in the farms any from the village. For, it requires transportation of water lifting equipment namely long and thick rope, a big leather bucket and also animals (either bullocks or in some cases buffaloes) daily from the village to the farm. Families with single male-member cannot afford this; because it requires at least 3 male persons (adults) to operate Moht for lifting water from well (two persons to lift water with the help of two pairs of bullocks and one person to water crops on the field). Therefore, families with at least 2 to 3 male members used to venture to go for dugwells, that too in the farms close to the village.

With the introduction of pumpsets (diesel and electric) the scenario of ground water systems has changed in the study region. Dugwells were constructed even in farms away from the village. The competition to use ground water has increased. This has resulted in depletion of water table and created water scarcity in some of the older systems where plentiful water was available.

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* Moht is a system used to lift water from shallow dugwells. A long and thick rope and a big leather bucket are used and it is operated through animal labour (Bullocks or Buffaloes). In local parlance it is called as Kapila.

For instance, in system one (see table 1), as reported by the present owner cultivators, water seems to have never been a problem. It was irrigating about 11 acres (one acre = 0.405 Hectares) of land with 300 per cent crop intensity (one semi-dry crop followed by two paddy crops in a year). The well was known for plentiful supply of water in the region. Ten years ago when a neighbouring farmer had constructed a dugwell just about 100 metres away from this system the availability of water in the older well has drastically come down. Further, when the new dugwell was converted into dug-cum-borewell, the aquifer draw-down seems to have gone beyond the reach of older well. With the result, the older well has dried up completely inspite of the best efforts by the farmers to deepen the well. Unable to strike any other aquifer farmers of older well have switched over to rainfed farming. While this is only an illustrative example of the externalities of new technology contributing to over-mining of aquifers endangering the sustainability of ground water systems in the region, many farmers have fallen into a perpectual debt trap by resorting to dugwell irrigation with out understanding the limitations of ground water availability. It is in this context that the role of government becomes important in regulating ground water. Appropriate norms to maintain spacing between wells need to be stipulated and farmers should be educated about the limitations and disadvantages of indiscriminate mining of ground water aquifers.

Water Distribution - Methods and Practices

It is obvious that single - owner systems do not have problems of sharing water. The management strategies adopted to regulate draw-down and ensure sustainable supply of water for irrigation were, as mentioned already, essentially linked with cropping pattern and its intensity (high water-intensive crops followed by higher intensity of cropping when water is plentiful and less water-intensive crops and lower intensity of cropping when water is scarce). But it would be interesting to know as to how water is shared between the farmers when a system takes the form of common property in course of time for reasons expalined earlier. As seen from table-1, the systems under reference are small in scale in terms of area irrigated and also number of participants. Before we discuss water sharing methods adopted by the group-owned and managed systems let us look at the status of water lifting devices in the ground water systems under reference (refer table-2).

Traditionally Moht was the chief source of water lift from dugwells. If a system is owned by two persons they used to provide for two Mohts, so that each partner can use independently or some times interchangeably depending upon the location of farm plots. As long as water supply in the well is abundant unrestricted use is allowed to aprtners, though legally water right is linked to area owned by a farmer under a given well. In times of scarcity strict measures are adopted to share available water equally between partners by fixing rosters based on time sharing if watering is to be completed in a single day and if watering is spread over a week or a mutually agreed period the roster will be based on sharing days. In either case the share is linked to area owned or any other norms of entitlement. In olden days since it was difficult to share the time in terms of hours, farmers followed the Sun's movement. For instance, if there are two partners, one is allowed to use water upto sun rise and the other from sun-rise to sun-set. The order will be reversed in the next day or for next watering, so that the advantages or disadvantages, if any, are shared equally. If there are more than two partners, the rostering would be upto Sun-rise, Sun-rise to noon and noon to Sunset. This roster goes on changing. In case water is very scarce where the entire area cannot be irrigated in a single day, they resort to a roster where each partner uses a full day. This again is based on pro-rata basis of each partner's entitlement for water in a given well. These rosters change also according to cropping pattern. If it is for paddy the roster is invariably based on time sharing in a day, for, paddy needs every day watering. If it is semi-dry crops the roster is based on sharing of days in a week or in a stipulated period of a roster. This kind of strict rotations have a built-in check on excess use of water. It also ensures economy and efficiency in water use which in turn contributes to sustainability.

With the advent of pump technology Moht has become redundant. It is found from table-2 that the increase in number of pumpsets is not commensurate with the increase in number of partners in each system. This shows that one pump is shared by two or three farmers. As reported by the farmers, to have a pumpset independently for each tiny plot is not economically viable and also many cannot afford it. Therefore, they are in a sense compelled to think of collectivism. Since each one of them understands local dynamics well it is easy to arrive at mutually agreeable terms and conditions in operation, use and maintenance of collectively owned pumpset. Water sharing from the common source has, however, remained more or less on the same lines as it used to be under Moht irrigation days.

Water use methods and land preparation for irrigated farming have changed after the introduction of pumpsets. For instance, it was reported that farmers were very particular about uniform levelling of land while Moht system was in operation to enable smooth and quick spread of water with minimum wastage. Under pump irrigation they seemed to be not very particular about this aspect. They do not bother much even if it takes more energy, time and water. The liberal attitude developed by the farmers towards water use has led to draw-down conditions necessitating periodic deepening of wells, where some are successful in striking potential acquifers and some not. While nature plays its own role in recharging the ground water aquifers, man has greater responsibility to maintain the balance by resorting to judicious use of ground water. Unplanned growth of wells has resulted in depletion of ground water level the externalities of which had affected many resource-poor farmers adversley. They had to abandon the shallow wells and be out of irrigated farming. In effect area under irrigation has not increased commensurating with the increase in wells. It shows that additional area claimed to have been brought under irrigation by the new wells is not addition in real terms. The gain of new entrants is the loss of old ones or the gain of resourceful farmers is the loss of resource-poor farmers. This raises the question of equity the answer for which may be difficult to find under the existing socio-economic conditions.

Tragedy of Commons

Many of the ground water system, as seen above, acquire common property nature over time. Though the ground water systems have had established norms and practices to share water without affecting sustainability, it is well known that common properties, whether it is land, water, forest or any other resource, are fraught with several crises associated with their operation, maintenance and use by the members, leading some times to temporary or may be permanent disuse. This phenomenon is generally known as tragedy of the commons (Hardin, 1968). It was reported that majority of the systems under reference were the victims of tragedy of the commons at one time or the other. Many farmers take it as a natural process that might some times last for two to three years. Established social authority and rural ethos help finding solutions for such problems.

While it may be true that the tragedy of commons relating to a system's operation and use of water is taken care of by the existing ethos in a village, certain other problems are some times left uncared for, which affect the sustainable supply of groundwater. For instance, system six in this study is totally abandoned due to conflicts among partners. This would have been resolved, as stated by the local farmers, if it were to be a problem of conflict resolution. It is a different issue and more partinent one in the context of sustainable ground water recharge. There is a long bund diverting a rivulet just upstream of the well under reference (6th one). A few years ago because of heavy rains the bund got breached and the revulet now flows straight into well. This has caused silting up of well. To reconstruct the breached bund several other farmers are involved, who do not show much interest, though they are also affected by the breach. Before the breach took place the bund was enabling water storage in a fairly big pond which was in a sense percolation tank to recharge ground water. Because of this breach, water supply in system one and also in other wells adjacent to the pond belonging to farmers of a nearby village has greatly been affected. Since the cost of reconstruction is high and many farmers are involved it is left un attented to. With the result, water supply is affected in some wells and some others in the downstream are abandoned. In all, about 15 to 20 acres of hitherto irrigated land has gone out of irrigation. Inspite of the attempts made by some of the affected farmers it is not repaired till to-day. If the breached bund is restored to facilitate water storage as it used to be before breaching, a minimum of six wells will be benefited by it, and about 40 acres of land gets assured irrigation.

While this is a single microlevel example of how the tragedy of commons affect ground water levels a serious view of the ramifications of such tragedies at macro level is necessary. It is in such matters government's intervention becomes more important. Government not only should take up such repairs but also must educate farmers to preserve traditional ponds and tanks which are the main sources of percolation in drought-prone areas.

It is often recommended that government should stipulate stringent measures to ensure equity and sustainability in ground water exploitation. One should appreciate the limitations to regulate ground water through appropriate spacing between wells (Dhawan, 1990). In a democratic polity where a major proportion of land is owned by private individuals, it is not possible to regulate spacing between wells. The indirect means such as not providing institutional finance, electricity for pumpsets and so on would not be effective checks, for, many farmers can raise their own funds or borrow from private money lenders to construct wells. Similarly diesel pumps can substitute electric pumps if electricity is not supplied. Therefore, the only option open for government is to educate farmers about the ways and means to regulate ground water use, encourage community wells to extend ground water irrigation for small and marginal farmers and promote watershed management to recharge ground water aquifers.

A Resume

The discussion so for brings out certain interesting findings. Traditionally, dugwell irrigation was popular in drought-prone areas. When dugwell technology was the prerogative of a few farmers whose lands were located nearer to the village, plentiful water was available even in the shallow dugwells. When dugwells number has increased over time the necessity to strike deep aquifers arose. The limitations of deepening dugwells beyond a particular depth have made farmers to look out for an alternative technology to tap the ground water. The emergence of tubewell technology enabled a few rich farmers to convert traditional dugwells into dug-cum-borewells. The negative externalities of modern technology on traditional dugwell irrigation were many. Farmers in the traditional systems were careful and judicious in using ground water. They used to maintain minimum depth of water in wells to keep aquifer active. A judicious combination of crop-mix suitable to water levels in wells has been used as one of the means to sustain water supply. The emergence of tubewell and pump technology has encouraged the liberal use of water resulting in wastage. This has necessitated deepening of wells at regular intervals, which has increased the cost of irrigation. Though farmers have evolved strategies to manage ground water by appropriate methods of irrigation and sharing of water, the tragedy of commons strikes often resulting in temporary or some times permanent disuse of irrigation systems. Government should take initiative to construct percolation tanks and encourage watershed management to ensure sustainable recharge of ground water aquifers.

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The Development of Groundwater Resources and the Farmer-Managed Irrigation Wells in Shandong Province, China

Sun Fu Wen

Abstract

This paper introduces the situation of the development of groundwater resources and the organization structure of farmer-managed irrigation wells to ensure the increase of the production yield in Shandong province, China.

In order to develop and utilize the groundwater resources scientificly and reasonably, an overall investigation should be made first to make clear the distribution and deposits of aquifer, law of movements so as to assess the available groundwater resources. On the basis of the investigation, unified planning and reasonable layout should be made. The following model is applied to control the groundwater table: pumping - recharging by diverting Yellow River - pumping (drawdown - recharging - drawdown). With this model the groundwater storage capacity can be enlarged, the regulating ability can be raised so that more surface water goes into the aquifer and becomes reclamation resources. Thus a stable water aquifer is sustained.

With the deepening of the agricultural reform in the household-contract responsibility system, the agricultural economic system, production group, distribution method, and the understanding and requirement on the irrigation projects are changing. The farmers think well-irrigation has many advantages — less investment, short construction period, instant effect, less influence from the outside, reliable water source, flexible application and convenient management. The farmers call it "self-responsible water " or " self-managed water" . The management ways of irrigation wells are mainly as follows: 1) Contract system under the unified management of the village committee; 2) Contract system with reward under the unified management of the production group; 3) Household contract system; 4) Responsibility system with a piece of land as payment.

The above-mentioned ways permit the direct participation of farmers in the flexible management, ensuring the timely irrigation and the increase of production yield.

The Development of Groundwater Resources and the Farmer-managed Irrigation Wells in Shandong Province, China

Sun Fu Wen

The reasonable development and utilization of groundwater resources is a kind of work with high technique, for which it should be made clear that the distribution and recharge of groundwater, the runoff and the exploitation conditions.

I. General Survey

In 1973, a general survey of groundwater resources was carried out in 8000 sq. km. of Shandong. Drilling method was used in combination with survey, using exploitation, geophysical exploitation, chemical analysis, pumping test and dynamic observation etc. It is preliminarily made clear that the movement law of groundwater in places suitable for well drilling. The 1:50,000 maps of counties and 1:100,000 map of prefectures and cities are drawn which are as follows:

1) Depth of the Bottom Surface of Shallow Fresh Water;
2) Depth of the Top Surface of Deep Fresh Water;
3) Thickness of the Sand Layer with Shallow Fresh Water and the Distribution of Water Quality;
4) Chemical Varieties of Shallow Fresh Water;
5) Depth of Groundwater Table (Dry period, Wet period);
6) Characteristic Value of Groundwater Table;
7) Hydrogeologic Section;
8) Zoning of Groundwater and Exploitation Conditions;

Information from the general survey and the production practice show that shallow groundwater has the following advantages: large area, quick permeability, convenient management, while the deep groundwater does not have the above-mentioned points which can not be used so much or only as reserved source. Therefore making full use of the shallow groundwater is a principle which should be followed in the development of groundwater resources.

II. Unified Planning and Reasonable Zoning

Surface water and groundwater is a transferable integrated body which needs unified planning, reasonable zoning and comprehensive utilization, so as to gain maximum efficiency. The present situation of Shandong is that places with sufficient groundwater are also rich in surface water. There are two sets of irrigation facilities with higher irrigation guarantee. However in places short of groundwater, some of the irrigation projects for surface water are not equipped with complete sets and water resources can not be fully utilized. Therefore, it is very necessary to study and work out the various zones which are technically feasible and economically reasonable.

1. Well Irrigation Zone

In the pre-mountain alluvial plains and the old river beds where there is rich water resources, wells are the main facilities for irrigation and anti-drought.

2. Well Irrigation Zone in Combination with Canals

In places with relatively rich water resources, the engineering structure of wells and canals is adopted. The wells play the major role with canals as an auxiliary measure so as to raise the regulation ability and ensure the water use of farmland.

3. Canal Irrigation Zone in Combination with Wells

In places short of groundwater, surface water should be fully utilized. Canal irrigation plays the major role and well irrigation is auxiliary.

The above zoning is based on the quantity of the local groundwater resources, meanwhile surface water is used as major or auxiliary measure. Optimum benefit is made possible through this combined and alternate use of water resources.

III. Controlling the Groundwater Table to Improve the Storage and Regulating Ability

In the irrigation district of Yellow River diversion, water quantity diverted from Yellow River is bigger than the groundwater exploited. In some parts of the district, water table becomes high due to the irrigation recharge of Yellow River water, and regulation ability is low. For example, in Weishan irrigation district, water table before irrigation is about 2.5-3 m below surface. One time of irrigation can raise the water table by 1.67m on the average and maximum by 1.81m. The observation data show that there are 21,395 sq.km. of area with water table less than 2m (42% of the total area), among which 6,765 sq.km. last for 120 days and 6,888 sq.km. last for 60 days. The high water table is the main cause of surface salinization.

On the contrary to the above example, the area from Jiazheng to Xueyan of Guanxian County used to be saline soil. For the past ten years, wells have been playing the major role in irrigation. Annual groundwater use is 120-150 thousand m^3/sq.km., water table is kept between 3-6m and 6,700 ha of saline land are brought under control. According to the measurement of Jiazheng rainfall station, when daily max. precipitation is 141 mm, three-day max. precipitation is 154 mm and flood-season precipitation is 688 mm, there is nearly no runoff. Most of the rainfall is converted into groundwater.

A solution can be drawn from the above two examples that when water table is controlled at an optimum level, storage capacity is enlarged, more water is recharged to aquifers and the regulation ability is improved.

How to control the groundwater table is a complicated problem concerning technique, economy, management, policy and legislation. However, from the point of view of technique, long-term and steady development of groundwater can be ensured by taking the following measures: 1) Adopting the engineering structure of shallow wells and canals; 2) Combining drainage and irrigation with storage and recharge; 3) Unified dispatch of the "three water"; 4) Applying the model of pumping-irrigation by diverting Yellow River-pumping (drawdown-irrigation recharge - drawdown).

What kind of water source is used in applying this model depends on the groundwater situation ; In general well irrigation is used in spring to lower the water table for bigger storage. When the water table drops below 7m, it is proposed to divert surface water for irrigation. When water table stays between 5.5-7m, 60% of the area is allowed to be irrigated with diverted water. When water table stays between 4-4.5m, only 30% of the area is allowed to be irrigated with diverted water. When water table is less than 4.0m, diversion is forbidden and only well irrigation is allowed. In this way, surface water plays the double function of irrigation and recharge, precipitation recharge is enlarged during the flood season and it can help reduce evaporation and gathering of surface salinity. The multiple purposes of anti-drought, salinity treatment and increase of regulation ability are reached, which provides the reliability for long-term, steady and balanced exploitation of groundwater resources.

IV. Organization Structure of Farmer-managed Irrigation Wells

The farmers think irrigation wells are less influenced by the outside than other kinds of irrigation projects and need less investment. It can be done by several households joint together. The well is drilled, equipped with completed sets and used within the year. Production yield is increased within the year too. The farmers call it "self-managed water" or "self-responsible water".

There are four types of farmer-managed irrigation wells:

1. Under the Unified Management of the Village Committee in Combination with Contracts

All the facilities of the irrigation wells are owned by the village under the unified management of the village committee (the basic administrative unit in the rural areas of China). This type of management accounts for 27% of the total irrigation wells.

Under the village committee, an irrigation service team is set up, within the team, individual wells are contracted. For example, in the rural areas of Yantai city, an irrigation service team is set up in most of the villages, responsible for irrigation construction and management of the whole village. It implements " four unified management", that is unified planning for well drilling, unified management of facilities, unified distribution of irrigation water and unified standard of water charges. Within the service team, wells are contracted to the persons. "Five fixes and one reward" responsibility system is implemented, that is fixing personnel, fixing irrigation task, fixing consumption of fuel and electricity, fixing repair fee and fixing salary. At the end of the year, reward is given according to how the target is fulfilled. This type of management is further developed by the farmers of Haiyang county. First, an irrigation management organization is set up in the village consisting of a village cadre, an operator, an electrician and a cashier, whose task is to operate and manage the irrigation projects and collect water charges. Second, projects' account of properties is set up. Independent accounting is practised to be self-responsible for the benefits and losses. Third, reasonable water price is set based on the cost. Fourth, through the discussion among the farmers, the depreciation fee and part of the profit is taken out for the repair and reabilitaion of the projects so as to have long-term benefit.

2. Under the Management of the Production Group and Implementing the Responsibility System of Contract and Reward

The irrigation wells and the pumping facilities are owned by the farmers of the whole village. The production group is formed by farmers whose land is within the effectively controlled area of the well. The well is used and managed by the production group. Contracts of duties and rewards are made to the persons. This type of management accounts for 48% of the total wells.

The detailed issues are discussed and determined by the farmers of the production group, such as irrigation priority, water cost for one-time of irrigation per mu, repair cost and payment of the contractor. Most of the production groups chose the average value of the past three years' expenditure to call for tenders. A contract is made between the production group and the contractor. The money saved belongs to the contractor and the money over spent is assumed by himself. If work is well done, amount of money is raised by the farmers at the end of the year to reward the contractor. If the irrigation task is not fulfilled without any special reason, the contractor should compensate for some of the losses.

3. Contract System by Specialized Households

The village committee repairs and makes everything ready, such as the well, pumping equipments, engine house, water tank, canals and commonly used instrument. Reasonable requirement are made according to the well discharge, pumping situation, soil quality, water price and irrigation area to invite tenders among all the farmers. The households chosen sign the contracts with the village committee. Some of the households collect water charges according to the price made, some according to the irrigated area and some according to the watering period. A certain proportion is given to the village committee as depreciation cost and the rest belongs to the contractor. This kind of management accounts for 22%.

4. Responsibility System with a Price of Land as Payment

The irrigation project belongs to the whole village. The cost for the operation, repair and depreciation are paid by the farmers of the whole village. An operator with high sense of responsibility is entrusted by the village committee for management, taking care of the wells, engine house, pump equipments, water tank, canal and irrigating the land in time. A piece of land of 0.1-0.2 ha around the well is delimited as the payment of the management person, who cultivates the land with irrigation free of charge. The income from the land is the salary of the management person. The farmer user can inform the operator for irrigation at any time and the costs of electricity and fuel are paid by the user.

Through many years of practice, all the types of farmer-management irrigation wells have gained good result. First, the management person is active, responsible and high efficient. Second, the management person has detailed and clear responsibilities. He can repair and maintain the equipments in time, put the instruments in order and keep the pumping equipments in good and safe condition, so as to start the engine at any time. Third, the core of the responsibility system is that working is directly linked with payment. More work, more salary and the savings belong to himself. Therefore, the management person is thrifty and hardworking, waste is reduced, energy is saved, cost is lowered, steady and high yield is ensured and the farmers' income is increased year by year. Our experience shows that if the farmers are organized properly, there will be a bright future for the farmer-managed irrigation wells.

Annex: General Situation of the Development of Irrigation Wells in Shandong Province

THE SUSTAINABILITY OF GROUNDWATER FARMER MANAGED IRRIGATION SYSTEMS

Manuel Olin

ABSTRACT

The sustainability of a GW based FMIS cannot be guaranteed, but if the necessary conditions are not provided its demise is assured. A GW WUA will be unsustainable if it cannot raise sufficient funds and manage its money, if it cannot obtain quality maintenance and repair (M&R) services on site, if the necessary spares are not available, if the tubewell (TW) suffers frequent breakdowns in midseason, or if the energy supply is unreliable.

Subsidized financing of M&R by the government are in the long run detrimental to the WUA as they are unsustainable. Eventually government priorities change. Provision of these services by the government prevents the spread of expertise and the development of a market for M&R services. Thus there is no backup source when government ceases to provide them.

This paper describes a concept of sustainability, the approach for achieving it and the conditions necessary for sustainability. Application of this approach is being tested in the Bhairawa-Lumbini area of Nepal.

1. Introduction

There are many reasons why a groundwater based farmer managed Irrigation system (GWFMIS) may not be sustainable. Clearly, a basic set of conditions for sustainability must exist. There must be a reliable source of water, a reliable source of energy, the mechanical and physical design must satisfy engineering and equitability criteria (water must reach all users) and other basic requirements must be satisfied. However, even if all of the above are met, the system may still not be sustainable.

There are two issues which I believe are critical. An effective response to them is a necessary condition for irrigation system sustainability. This paper describes both issues, but focuses on the one which I consider to be less familiar and more in need of discussion. In this paper I describe an approach to creating the necessary conditions and how it is being applied in the Bhairawa Lumbini Project in Nepal.

The two issues are:

* The high cash requirements of GWFMIS
* The need for a reliable maintenance and repair (M&R) support service

Only the latter issue is elaborated in this paper.

Experience with FMIS has been mainly with gravity surface water (SW) schemes. There is a tendency to try to apply the SW experience to GWFMIS on the assumption that all FMIS are the same. While there are certainly similarities between all types of FMIS regardless of the water source, ignoring the differences may prove fatal to the GW system, at great cost to the government which promoted the scheme and to the farmers who invested effort, money and hopes in the enterprise.

In this paper I propose a plan of action for making GWFMIS sustainable. I also indicate as a corollary, the circumstances under which GWFMIS are unlikely to be sustainable and therefore should not be promoted.

2. Differences Between Surface Water and Groundwater FMIS

There are some basic differences between groundwater (GW) and surface water (SW) based irrigation systems. The major ones relevant to this discussion are:

* GW systems based on tubewells (TW) are cash intensive since they require the purchase of goods and services for operation and for M&R. Energy (electricity or diesel fuel), spare parts and skilled labour for M&R must all be bought for cash. SW systems are normally labour intensive since members normaly supply the bulk of the labour inputs. In most cases, the major input in SW operation, M&R is relatively low skilled labour.

* In the absence of preventive maintenance, GW systems are unforgiving. Unmaintained GW systems are prone to total failure. Poorly maintained SW systems perform poorly but do not normally break down totally. (I do not refer here to natural catastrophes such as floods which may wash away the intake.) Preventive maintenance is indispensable to the good functioning of the pumping and distribution equipment. Break downs occur when the equipment is operating; any stoppage when the pump is operating is critical, as the entire investment in the crops up to that time, as well as any potential profit from its sale, is at risk.

* The fixed location of the TW determines that the M&R service be mobile. The M&R service must reach the site of the TW; most of the equipment cannot be brought to the workshop for repair or requires expert dismantling and reinstallation of the component.

* M&R of pumping equipment require highly specialized skills and familiarity with the equipment. Relatively low skilled labour can repair a SW system. M&R for TWs is totally dependent on specific skills not available to the users of the irrigation systems (knowledge of mechanics and electricity and more particularly, familiarity with the equipment installed).

* Equipment repair requires a stock of spare parts, usually imported. While SW systems require few spares, TW M&R is dependent on spare parts and in particular on imported spare parts, since the pumping equipment is imported. Ordering of spare parts when they are already needed to carry out a repair, would normally put the pumping equipment out of commission for the remainder of the season and possibly longer.

3. Necessary Conditions for the Sustainability of GWFMIS

As a prelude to the discussion, the term "sustainable" must be defined. Sustainability is the ability to continue in existence indefinitely and the ability of the water users association (WUA) to irrigate continuously from its TW, without directed intervention or support from exogenous forces. Stated simply, sustainability means that the irrigation system will continue to function even after the lenders or donors have pulled out.

While there is no way to guarantee that a GWFMIS will be sustainable, it is clear that it will NOT be sustainable IF:

* The irrigation system does not generate sufficient cash income for its members to cover the costs of operation, M&R.
* The group does not have an organized, accepted, understandable and equitable system for generating the funds and sharing the costs of operation, M&R among its members.
* A reliable service infrastructure to maintain and repair the equipment, obtainable in the nearby vicinity, is not available.
* A supply of skilled labour familiar with the equipment installed is not available.
* A sufficient stock of commonly required spare parts is not available.

Obviously, the converse of the above are necessary conditions for sustainability. ALL OF THE ABOVE must be provided as necessary conditions of sustainability. It is essential then, that every GWFMIS project include these components in their plans and their implementation programs.

The above may be divided into two basic fields of action:

* The water users
* The service sector

Assisting the water users is a recognized field of action to all familiar with the FMIS concept. In the case of GWFMIS the field of action must be broadened to deal with and emphasize training and assistance in all the fields related to cost sharing and money management. Due to lack of space in this paper, the approach to this issue will not be discussed.

The service sector is a less common field of action. This paper makes an argument for the participation of the private sector in GW irrigation system development. While the need for farmer participation in irrigation projects is already accepted, broader community participation is required in the case of GWFMIS.

4. Traditional Delivery of M&R and the Sustainability Problem

Commonly, M&R are provided through a project authority (PA) or through a government service. They are financed by the government or by outsiders such as a foreign non governmental organization (NGO). The M&R services are generally provided free of charge to the WUA or at nominal cost.

Because the M&R services are provided free of charge or at highly subsidized rates, no private sector M&R service can develop; there is no market demand for it. A single supplier is the sole source of the service and the sustainability of the GWFMIS is dependent exclusively on it. If it should cease to exist, the irrigation systems will eventually cease as well.

Once project financing comes to an end, there is no longer any source to finance provision of the M&R services. What is worse, whatever experience was gained over the years is normally lost as the employees of the project move on to other government services, as they look for and find other work, (Government employees are rarely entrepreneurial types and do not often set up their own businesses.) or as the service continues to be provided in name only. Spares are not purchased, fuel for vehicles is rationed, the vehicles are not repaired or replaced and eventually only salaries are paid. Under these circumstances, no M&R services are provided and ultimately all tubewells break down. Furthermore, literature on the subject indicates that even before collapse of the government provided M&R service, it is rarely satisfactory. (See for example Jackson, R. 1991 and Pant, N. 1984).

Subsidized financing of M&R, and nonmarket provision of M&R services are in the long run detrimental to the WUA as this type of service is unsustainable. Eventually government priorities change, funds from international loans run out and NGO energies are diverted to the latest international crisis. Provision of these services by a PA or government organization prevents the spread of expertise and the development of a market for M&R services. With no demand for the service, no supply develops. There is no backup source of M&R when government ceases to provide it.

5. Creating the Necessary Conditions

A M&R service must exist in the vicinity of the GW irrigation systems. The service should be provided by private workshops which would be accountable to the users for the quality of their work. M&R work paid for by the users would assure that the workshops are accountable to them. The M&R service must be profitable to the suppliers of the service so that they will continue to provide it. There should be a sufficiently large number of workshops and/or tradesmen to keep prices at a reasonable level and to provide backup if some workshops should go out of business. A sustainable solution must be financially sound and locally based.

How are these conditions to be created?

The concept is to stimulate the development of workshops by local entrepreneurs.

As in the case of farmer participation, the approach to the service sector should be initiated at the beginning. The service sector should be informed from the outset of the planned irrigation development. Their interest and their active participation should be sought and encouraged.

The failed approach of "handing over" completed irrigation projects to the farmers after everything is in place, is likely to fail in the service sector as well. Establishing a M&R service and "handing over" to the private sector (that is, privatizing it) is not likely to succeed. It will not be designed on a scale manageable by small entrepreneurs and its systems will be incompatible with the way things are done in the village.

The private sector should be offered an "in" from the outset. A project M&R service should not be set up. No government monopoly or insurmountable competition should be introduced. Instead, private entrepreneurs willing to undertake to do the M&R should be encouraged and assisted to do so, if they meet certain criteria, undertake to make certain investments, agree to train in the maintenance and repair of the equipment.

The steps proposed are as follows:

* Spreading the word in the villages and nearby urban centres and creating interest
* Offering training courses in all aspects of equipment M&R
* Advising on the tools and equipment needed to provide M&R service
* Advising on recordkeeping and on how to run a workshop
* Assisting in obtaining loans to purchase tools, equipment and spares
* Assisting the entrepreneurs to make the contacts with the equipment suppliers
* Accrediting workshops to carry out the M&R work
* Offering contracts to do the necessary M&R work during the commissioning period

For the commissioning period when the project is responsible for maintaining and repairing the pumping equipment, the project authority would pay a private workshop the price of the service. While commissioning is normally only one year, it may cover a fairly long period if there are many TWs in the project starting up over a number of years. Furthermore, even in one year, much experience can be gained.

The WUA must, as a condition for receiving the the TW, agree that for a fixed period (say five years) they will contract with an approved workshop to have their pump serviced. This would simultaneously create a market for the M&R services and assure good maintenance at least during the first years. It would also establish a tradition of good practice which, it is hoped, would continue beyond the minimum time agreed to.

WUAs should be free to select the workshop of their choice from among a group of say, three workshops which would serve each area. They could switch from time to time if they are dissatisfied with the service.

It should be the role of the PA or the government service promoting irrigation development to take the necessary actions to create the M&R service as it is to promote farmer participation in the project.

One of the more problematic issues is the need for preventive maintenance. This is never obvious and might seem to the WUA to be a waste of money. The PA must promote the idea to the WUA in all ways and at all times. Sound principles of preventive maintenance must be inculcated from the beginning and continuously promoted.

6. The Bhairawa Lumbini Project and Application of the Approach

A few words of description of the Bhairawa Lumbini Groundwater Irrigation Project (BLGWP) in Nepal and what is being done there is in order here. The consultant for the project, Tahal Consulting Engineers Ltd., is applying the above approach there.

BLGWP in the Western Region of Nepal has already installed 64 tubewells (TW) in the Stage I area, all of which are already operational. Another 38 in the Stage II area are in the process of installation and will be operable shortly. During the coming years, 78 more TWs are planned for development in an area denominated Stage III. All TW are operated by electric power. A typical TW in Stages I and II serves about 120 ha with about 80 families.

By the year 2000 a total of about 180 TW will be operational. Over 14,000 families farming about 22,000 ha will be served by TWs in the area.

Stage I had no farmer participation component. It was designed and implemented in the traditional way with all decisions being taken by professionals employed by BLGWP. All investment costs and until this year all operating and M&R costs were covered by the PA. Until now, M&R have been the responsibility of BLGWP. At an advanced phase of Stage II, elements of farmer participation were introduced. Stage III will be based completely on farmer participation principles.

Analysis has shown that the costs of operation and of M&R can easily be borne by the farmers enjoying the benefits of irrigation. Both the plans and impact studies made in the field have shown that increased production which result from higher yields per crop, from greater intensity of land use and from a transfer to higher value crops leave the farmer with a sufficient cash income and surplus. Moreover, the farms are easily accessible, thanks to good roads developed in the framework of the irrigation project so that crops can easily be sold.

Calculations have shown that costs of operation, M&R would be roughly US$50 per ha, of which US$40 are for operation (electricity and pump operator) and US$10 for M&R. These are average figures and considerable variation may be expected among the TW units. In practice, the charge for water which the WUA will levy from its members will not be divided by area but by actual consumption.

The M&R activities of BLGWP are classified into the following categories:

* Routine Preventive Mechanical and Electrical Maintenance
* Heavy Preventive Mechanical Maintenance
* Mechanical Repair
* Electrical Repair
* Pipeline Distribution System and Outlet Repair
* Civil Maintenance and Repair (Buildings, structures, canals and access roads)

The latter two, pipeline distribution system and outlet repair, and civil maintenance and repair, require trades such as plumbers and masons, skills which are generally available in the surrounding areas. Many farmers are themselves familiar with this type of work. Routine preventive maintenance (the first item above) is now included in the duties of the pump operator. Accordingly, less emphasis is placed on these subjects in the program to develop a private sector M&R support service. The program focuses primarily on mechanical and electrical M&R and sets out to create a source of such M&R services.

An activist approach to the development of an M&R support system has been adopted to stimulate the private sector in this field, as the capabilities will not develop unaided. The program includes: providing information, offering training courses and disseminating the knowledge and the lessons of experience and assistance in obtaining credit. The program includes training as many tradesmen as show interest, in order to assure a sufficient supply and to provide for competition among them. Accreditation of workshops satisfying requirements for M&R will also be done. Handbooks on routine mechanical and electrical maintenance and on civil maintenance that can be handled directly by the WUAs or the pump operator will also be prepared.

While promoting the development of an M&R support system, it is recognized that many WUAs may not observe the prescribed procedures without the necessary coaching. Therefore, information on the importance of preventive maintenance and its benefits will be continuously disseminated to WUAs through an intensive program of meetings.

The PA will undergo a role revision in the field of M&R. Its new role, in addition to promoting the creation of a private sector M&R service will be to define maintenance activities and their frequency, to plan equipment, tool and spare parts requirements, to define training requirements, to prepare manuals and handbooks, to accredit workshops, to provide M&R services by means of contractors during an interim period and to supervise the quality of M&R carried out by contractors. It will cease to provide M&R services by means of its own employees.

7. Problems Encountered and Foreseen

The fact that BLGWP has already been operating for about eight years under a different concept makes the change difficult. This is due to the discomfort that WUA feel about taking responsibility and about having to cover the M&R costs, to skepticism in the private sector about the change in approach and to internal professional interests against the new approach.

A transition period is planned as the change cannot be abrupt: in the absence of an existing private M&R support service, BLGWP is the only body capable of providing the necessary services at present.

Close monitoring of the process is planned. This is a new approach and corrective actions may be necessary and should be taken with a minimum delay whenever problems surface.

8. Conclusions

The approach presented above has been developed in order to assure the long run sustainability of the irrigation systems. It was adopted simultaneously with the adoption of the farmer participation approach and is still in the early stages of development and application. The approach is still being tested and the team is learning and improving on the approach as work progresses.

The basic concept of private sector M&R support service promises long run sustainability of GW based irrigation systems. Unfortunately, government provided M&R services do not promise long run sustainability and even in the short run they are often unsatisfactory.

For long run sustainability, GW irrigation systems should not be dependent on government or NGO support, as ultimately such support is inevitably withdrawn. Active assistance in the development of a private M&R support system and abstention from establishing government run M&R systems are the essentials of this approach.

As a corollary to the analysis in this paper, GW irrigation systems are unlikely to be sustainable in the following situations:

* In projects which do not offer a high cash return to farmers for their produce
* In remote areas far from urban centres capable of providing the necessary M&R support
* In a cluster of TWs not large enough to offer economic opportunities to the private sector

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Paper No. 48

COMPARATIVE ASSESSMENT OF FARMER-MANAGED AND AGENCY-MANAGED GROUND WATER IRRIGATION SCHEMES IN NEPAL

N. ANSARI

1. ABSTRACT

Nepal's national development plans have been targeting to turn the rainfed farmlands to irrigated agriculture in order to meet the food production needs. As surface water is not available everywhere and in required quantities all year round to increase the cropping intensity, responsible agencies of the Government has been engaged in the development of ground water irrigation schemes in the terai (plain) and some inner valleys which have quite a rich and rechargeable aquifers. However, various constraints are encountered in the implementation and management of groundwater development through Deep Tube Wells (DTWs). On the other hand during last two decades a lot of shallow tube wells (STW^s) have been installed by farmers themselves with the assistance of Agricultural Development Bank of Nepal (ADB/N). The farmers draw water for irrigating their non-monsoon crops and even during monsoon period when rains fail. The performance evaluation of these privately operated STW^s has shown that national average is only 2.0 hectare (ha) of irrigation per well as against 4.0 ha potentiality. It is because land holdings are smaller and neighboring or small land holdings do not have reach to these private STW^s. However some operators do sell water to the neighboring farmers. Table 1 shows present irrigation status of Nepal.

The Agency built and operated DTW^s on large project scale are performing better than the Jointly managed DTW^s on small scale but the issue is the operation and maintenance (O&M) cost recovery . It is so little that sustainability of such schemes are at risk. The Government policy is that at least O&M cost must be borne by the users but the users are not willing the compensate this. Hence the agency has made a strategy to turnover the O&M of these DTW^s to the organized water users group (WUG^s) gradually in stages. The sustainability issue and lessons learnt has changed many irrigation activities in Nepal. Now DTW^s or community STW^s are being undertaken on sectoral approach where 25 percent (%) of the cost is shared by the users and the O&M is their full responsibility.

2. GROUND WATER DEVELOPMENT FOR IRRIGATION

2.1 Need to Exploit Groundwater

Surface water is not available everywhere for supplying water to the potential irrigable areas. Also existing gravity irrigation schemes are not able to meet the irrigation needs for cultivating multiple croppings. The climate is favorable for farming all year round for increasing cropping intensities. The existing surface schemes mostly fulfill the irrigation need as supplementary irrigation during rainy season (monsoon) which is June to September. Thereafter the discharge of supply canals drops such that only a part of the command area are irrigated for growing crops in other seasons. In this situation groundwater is inevitable to be exploited. Fortunately, the terai region and some of the inner valleys have rich and rechargeable aquifers both shallow and deep. In such areas groundwater has to be harnessed for conjunctive use as well. In the areas where surface water has no access, groundwater will be the main source of irrigation. It is fully recognized that greater use of groundwater for irrigation would substantially raise the cropping intensities and income of the farmers. Now the farmers are been encouraged to install tubewells for supplementary irrigation of monsoon crops and full irrigation of dry season crops. Diversified cropping are being introduced in tubewell schemes as water is in assured supply within one's control.

2.2 Historical Perspective

Surface FMIS has got prominence in Nepal having long history of their evolution. Varied type of irrigation systems of all sizes have been built since centuries ago. They are being operated and maintained by the farmers own cooperative efforts. More than three decades ago groundwater use for irrigation was unknown except some localized dug-wells for growing vegetable crops. But during last two decades, the need to increase cropping intensities, has induced the farmers to install STWs of their own where shallow aquifers are found. There are some open dugwells also where static water table is high. Here farmers extract water by <u>suction</u> lift (centrifugal) pumps to irrigate their desired crops. Side by side of these private STWs Government Agencies have also developed quite a number of DTWs on a large scale project as well as on small scale.

3. AGENCY AND FARMER-MANAGED GROUND WATER IRRIGATION SYSTEMS

3.1 Farmer-Managed Ground Water Irrigation Systems

Such systems mostly consist of installation of STWs whose maintenance and operation is done by the individual farmer or a group of farmers. The ADB/N has played a pioneering role in the promotion of STW irrigation by providing financial assistance in the form of rural credit and technical assistance to a limited extent. ADB/N in accordance to its mandate has been involved in irrigation development since 1970s. It has provided credits to individual farmers, small group of farmers and communities mostly for installation of STWs and procurement of pumpsets. Besides, treadle pumps, rower pumps and dugwells are being propagated in the terai belt. Now thousands of hectares of farm lands are being irrigated utilizing the immense groundwater resources of the country.

3.1.1 <u>Process of STW schemes</u>. The Government has fully encourage the tubewells irrigation program by providing subsidy to the farmers. The subsidy is administered by the ADB/N along with their lending of the credits. A short description of the program is given below:

- On the request of a farmer or a group of farmers, technical and geo-hydrological data is collected. Groundwater Development Board (GWDB) under DOI is responsible for ground water exploration and the groundwater resources evaluation. For any area if sufficient data is not available then layer testing for shallow aquifers are done to assess the prospect of STWs.

- Then the applicant have to place all the documents and clearances for providing collateral for availing the loan sanction. After loan sanction, loan agreement is drawn between the farmer and the ADB/N.

- Pipes and other materials are supplied from the stock to the borrower farmer. If the field office do not have stock, then coupon is provided to acquire materials from the dealer. After successful drilling the value of materials is automatically converted into loan. If the farmer wants, he is given additional loan for the pumpset.

- Specified drillers carry out drilling work on work order from the ADB/N. Mostly hand rotary drilling process is used. Depending on physical conditions of terai area average time taken is generally 5-10 days. One year's guarantee is provided by the driller during which period ten percent of the payment is retained. In general drilling is tried at three places after which it is considered a failure case.

3.1.2 <u>Community STWs.</u> In Small Farmers Development Program (SFDP) areas, small farmer groups are provided loan for STWs as community schemes. Farmers in one locality having at least 4 to 5 ha attached to each other should form a group and approach SFDP office for loan and technical assistance for a STW unit. SFDP loan is provided on group collateral itself and the entire loan is recorded in the name of the beneficiary group. The group repays the loan and the interest.

3.1.3 Group STW schemes. In area where SFDP is not implemented, farmers with small landholdings form into groups and take loan for STW schemes. The process of allotting loan is same as an individual borrower. The collateral of each member is evaluated and loan share is divided among beneficiaries in proportion of the land being irrigated. Loan amount is recorded separately for repayment. There are cases when a loan is taken in name of one member of the group which he divides among members as internal arrangement but the ADB/N deals with one individual only.

3.1.4 Subsidy in groundwater schemes. Since the implementation of groundwater tubewell schemes started, subsidy has been provided by the Government in various forms. In the initial days only drilling cost was being subsidized. But since last few years 40% of the total cost of the STW schemes including pumpset is subsidized in case of individual schemes and 75% in the community schemes. Earlier the subsidy was being reimbursed by the Government to ADB/N each year but now subsidy amount for irrigation is allocated in the national annual budget which is administered by the ADB/N and other agencies who implement the schemes.

3.1.5 Technical characteristics. The depth of STW^s vary in districts and localities. Within 21 districts where STW irrigation schemes have been developed the range of depth of wells vary between 8 to 50 meters (m) with an average of 20 m. The size of boring is generally 4 inches (10 cm) diameter having black casing pipes and strainers. They tap shallow unconfined and semi-confined aquifers. All the STW^s are drilled by simple indigenous methods like manual rotary, sludge and bogie. In case of DOI sunk STW^s, rotary drilling machines were invariably used. The method of sinking a well depends upon the type of soil strata and depth upto which one has to go. All the cluster of wells are operated by diesel centrifugal pumps whose horsepower varies from 5-10 BHP (average of 6 BHP). In place where electric power is available farmers are desirous to electrifying their units. In most districts the static water table drops down during dry season when STW^s are operated. But at the end of the rainy season it is recovered to original status. It is estimated that by now more than 22,000 installed STW^s are installed. Table 2 shows further details of STW units installed all over.

3.2 Agency-Managed Groundwater Irrigation Schemes

In public sector groundwater exploitation for irrigation started from 1970^s. During 1975-77 in the middle eastern terai of Birganj area some 28 DTW^s were installed with electric driven pumps in the northern part of Narayani Irrigation Project which is devoid of gravity water supply of the canal. This included rehabilitation of 14 DTW^s drilled earlier and equipped with diesel engines. Earlier in 1968-69 during Minor Irrigation Program some DTW^s were drilled equipped with diesel run turbine pumps in Sarlahi and Sirha districts and some artesian wells in Bhairahawa district. Birganj DTW^s are equipped with submersible pumps with 25-30 meter lifts capable of pumping 50-80 l/s. The net irrigable command area is 2792 ha. All the main distribution canals are lined and have several division boxes.

On a large scale tubewell irrigation scheme called Bhairahawa-Lumbini Ground Water Project (BLGWP) was taken up during 1976-83 in the western terai where 64 DTW^s including pumphouse and for each independent partially lined distribution channels were constructed. The total irrigated area is 7,600 ha. On an average each unit commands a net irrigable area of 120 ha. All the units are equipped with electric pumps capable of drawing 83 to 140 l/s. The depth of wells vary from 120-200 m. The water is discharged into a tank from which water is distributed into canals. The canals are lined in approximately 400 m length. Along the canal there are about 20-25 wooden slide gated turn-out structures each irrigating 5 ha block. The cost of the project was Rs.256.22 millions (USD 15.6 mill) in 1984 financed by an IDA loan. This gave a per ha cost of Rs.33,000 USD2050). Under the second phase of BLGWP some 38 DTW^s have been recently brought under operation making altogether 102 DTW units in the project area. Under the third phase distribution of water will be done through buried pipe circuits.

Another large groundwater project was started in 1971 with Japanese assistance in Janakpur zone under the banner of Janakpur Agriculture Development Project (JADP). Under this program, exploitation of groundwater concentrated only in three districts namely Dhanusa, Mahottari and Sarlahi. Actual works on tubewells (TW^s) started from 1985. The initiation for a TW irrigation was solely done by the JADP authorities including site selection and the number to be drilled in an area. Although sites were proposed by the Japanese technicians but in practice the Ministry dictated site locations and plans of DTW^s. The users came only in picture when question of land for pump houses and canals came which were to be provided free of compensation. Due to dictated site fixations, drilling of DTW was mostly done at places where utilization is not maximum. Influential people got TW^s in their land and common farmers had no voice in any decision makings. By the end of 1990 some 81 DTW^s have been installed capable to irrigate about 4200 ha.

Another high potentiality for groundwater development is Kailali & Kanchanpur districts of far western terai where DOI has installed 82 DTW^s. By now some 400 DTW units are already installed in terai districts capable of irrigating 28,000 ha. The details of their distribution is given in table 3.

4. MANAGEMENT AND PERFORMANCE

4.1 Farmer-Managed Groundwater Schemes

During last two decades very heavy public expenditures have been incurred to motivate farmers in installing private STW^s and pumpsets. Sample surveys of their performance and management have revealed that utilization and areas actually irrigated is much less than their potentialities. Generally pumps have been operated between 100-200 hrs and irrigated only 2-3 ha. varying considerably between locations. Therefore, the social returns do not commensurate the Government's expenses supporting this agricultural infrastructure (STW^s). Also benefits from these supports do not equitably reach to the poorer rural communities as they have small hand-holdings or are even landless.

4.1.1 Condition of the systems. The STW units are mostly located at higher elevations of the service area in order to facilitate distribution mostly through earthen field channels. Some farmers have permanent channels whereas others dig during irrigation need generally for winter and dry season crops. During paddy season field to field irrigation is practiced which is definitely inefficient. Even the sandy channels are not lined. Generally pumps are not installed permanently in sheds and do not have fixed foundations. They are brought to the STW^s at the time of pumping. However, some farmers have constructed pump houses and division boxes. The discharge available from the most wells is between 6 to 25 l/s. In some areas the discharge decreases during dry season. But during monsoon season the static water label increases by 1.5-2 m resulting more discharge from a well. It is observed that a STW giving a discharge of 10 l/sec can irrigate 6.0 ha of farm lands if it is operated on an average of 12 hrs per day during peak demand of paddy growing period.

4.1.2 Irrigation practice. In most cases it found that the STW operators use water to irrigate winter and spring crops (wheat, maize, vegetables etc) and rice seedbed. They use STW when monsoon fail or rains do not occur for a long time.

In localities where supplementary gravity canal is not able to serve the full command or do not supply water during lean period, here farmers are also motivated to use STW^{s} as conjunctive use. These reasons of the low total annual hours of operation of a STW. The sample survey of (1988) has shown that the average STW operation was 120 hrs whereas survey of 1991 shows an operation of 168 hours annually. In the former case the cropping intensity had increased by 19% whereas the latter shows an increase of 54% mainly due to expansion of area during dry season (wheat, maize, vegetables). The average irrigation per unit STW was 2.18 and 1.85 ha respectively during the two surveys.

4.1.3 Operation and maintenance. Operation and maintenance of the systems are carried by the individual owners including general maintenance of the pumpsets. Where the STW^{s} are installed by ADB/N assistance, the some owners have taken maintenance training. However for major defects in pumps, they have to go to mechanics. In most systems the water use efficiency can be increased by making permanent field channels, controlling leakage by lining etc.

4.2 Agency Managed Groundwater Irrigation Systems

Two types of DTW irrigation schemes are under operation and management by the Government agencies. DTW^{s} on large project scale is a more structured approach of Groundwater development for irrigation. The experience of this type from BLGWP indicates that it can generale relatively high benefits because of specific agricultural support programs and water management activities. Thus it has promoted to achieve the targeted production and utilization of command area. Also the operating costs are minimized by use of electricity. However high per-ha cost influence against widespread adoption of this approach. The other type is DTW^{s} on small scale model. Localized single DTW units have been developed and also can be done in future. Such units serve 60-120 ha and is equipped with permanent pump house and distribution system. This can also generate benefits comparable to large project scale DTW^{s}. However difficulty here is a very low utilization of command area as the farmers are not willing to bear the operating costs.

Agency operated and maintained DTW^{s} are scattered in different districts of terai. The O&M of these DTW^{s} are being carried by different agencies in different ways. Some of the large project's DTW^{s} are fully operated and maintained by the concerned agency where as some of DTW^{s} are operated jointly by users and the agency. Most of the small project's DTW^{s} are operated by the beneficiaries but maintained by the agency. Taking into account these factors; management and performance of some of DTW projects are narrated below.

4.2.1 Performance and management of the systems. The performance of the systems are summarized in terms of actual irrigated area by seasons, annual operating hours and irrigation intensities.

1) The 28 DTW^{s} under Birganj GWP is being fully managed and operated by the Narayani Irrigation Development Board (NIDB). Earlier the water service charge was levied based on hours of pumping a farmer needed. But few years ago a flat rate of Rs.400 (USD 10) per ha per year was fixed. A farmer may use pumped water any time and any quantity; only he has to request the operator to supply water. Still the cropping intensities has not increased as anticipated. The total command area is never irrigated. The net irrigation has been nearly 70% in case of old (but improved) and 75% in case of new DTW^{s}. The corresponding perunit operation of the DTW^{s} averaged 600 and 450 hours. It is to be noted that average discharge of old wells is between 50-80 l/s whereas new wells have 80 l/s. The payment of water charge is below 50% and in one way the O&M is being subsidized.

2) All the DTW^{s} under BLGWP stage I (64 units) and stage II (16 units) are fully operated and managed by the project itself. Here also a flat water charge of Rs.400. (USD 10) per ha per year is levied. Upto last year it was Rs.200

(USD 5) only. The performance evaluation of BLGWP stage I has shown that 89% of the holdings in the command area are getting water for partial/full irrigation, remaining 11% is under rainfed. The percentage of irrigated area is slightly higher in larger farms. Efficient and controllable water management with effective agricultural support built directly into the project has made the stage I area to achieve full development within four years. The cropping intensity, yields and extent of crop diversification into high value crops has exceeded the appraisal estimates. Appraisal estimated that cropping intensity would increase from 118% to 165% and yield of paddy from 2.0 T/ha to 3.5 T/ha. Now the figures achieved from the project are 190% and 4.0 T/ha respectively. In the stage II area the 38 DTWs are being provided with PVC buried pipe distribution system to overcome shortcomings in open channel system. At present all WUGs are actively involved in the distribution and allocation of water while the O&M is the responsibility of the project.

The payment of water charge last year was negligible due to the rise of rate to Rs.400/ha/yr although this amount is only a fraction of the actual O&M cost. The Government cannot go on bearing the full O&M cost for ever and therefore it is the policy of the agency to turnover the O&M of all the DTWs to WUGs. In the beginning, it is planned that users should pay only the electricity bill and Govt will provide operators and maintenance cost.

3) The JADP DTW systems are being managed jointly with the beneficiaries. The very approach to provide a DTW system in a community was to organize farmers to take the responsibility of managing it after completion. But the community were not consulted in bringing the system to their area. Politicians took lead. WUGs could not be evolved to take up O&M of the systems which have been turned over to them after commissioning. WUGs are told to manage water distribution, conflict resolution, adopt cropping pattern, provide diesel & mobil, hire operators & watchmen and do minor maintenance works. However it is not effective because the implementation process did not embrace any norms to promote WUGs as institutions of the farmers creating feelings of belongingness right from the beginning.

JADP has equipped the DTW systems with Japanese diesel driven engines EBAR and FIAT. They consume 10 and 6 liters diesel per hour which cannot be borne by all farmers in all seasons. Hence, there is very poor utilization of the wells. They use it in dire needs only mainly to supplement during critical times. On an average about 30% of the users of a system irrigate once in wheat season and once at time of paddy seed-bed preparation. The WUGs feel that they would be able to operate the system in full when the DTWs are run by electricity.

The operation of DTWs and the O&M also is done by the project. However, water charge is levied in two ways. In one system Rs.16 is paid by the user prior to pumping which a fraction of fuel cost. In the other system Rs.10 is payable for mobil and the required quantity of diesel is brought by the user.

4) The SIRDP and Kailali-Kanchanpur DTWs are now being operated jointly but maintained by the groundwater project of the DOI. The development approach of these DTWs was not participatory. Except for site selections, the farmers were not interacted or informed for any matters during implementation. The project did not ask for any help or contribution nor the farmers did anything for the project. This was so because of the tradition of DOI to do irrigation works unilaterally. The officials did not know that the O&M of these DTWs would be transferred to the users nor the users knew about it. Now, the project has organized WUGs in each units and asked them to operate it by themselves. Farmers are getting organized and developing norms to operate the systems. At some places users have generated funds to hire operators. All the wells are equipped with diesel driven and battery operated engines which are either of Japan or India origin. Japanese engines consume 6-8 l/h where as Indian ones consume 4-6 l/hr. The average discharge of the DTW is 30-60 l/s. The record of utilization

is not kept systematically. The method of operation is bring diesel and give a nominal charge for mobil (upto Rs.5 per hour) and get water. Farmers feel it very costly and they irrigate once in wheat season and once in paddy seed-bed preparation and may be whenever rains fail. On an average only 30-40% of the command area is irrigated. The field offices have nothing at their disposal to promote and facilitate the utilization.

5) There is a successful example of jointly developed DTW^s but operated and maintained by the users along. This is the case from Dang Tubewell Project. Three DTW^s have been installed on the request of the farmers and on commitment of full O&M responsibility. The WUG^s were actively involved in all the activities of implementations and during this process the ownership feeling developed in them. They have now electrified DTW units with pucca pump houses. However their main distribution canal is still unlined for which they want to contribute their share (25%). They have approached the DOI to get it done. The DTW^s are fully operated and maintained by the WUG of each unit and all the beneficiaries are getting water with great satisfaction. Last year, the winter crop (mustard) produced 4 times more yield with just one irrigation. During paddy growing period they has pumped water as and when needed mostly at peak season. They have hired their own operators and pay electric bills which they raise on pro rate basis.

5. NEW APPROACH FOR SUSTAINABLE GROUND WATER IRRIGATION

The performance of agency managed DTW^s based on large projects is better than DTW^s of small project. However the recurrent cost recovery is so meager that their sustainability is endangered. Government solely can not go on providing funds indefinitely for the O&M of these systems. Also it would be injustice to a large number of farmers who are operating their STW^s along with sharing a part of the capital cost of construction. Hence, the new policy of irrigation development specifies to transfer the O&M of the DTW^s to the WUG^s who have to be organized and registered under the prevalent rules. The transfer of this responsibility will occur gradually in stages. Initially the electricity bill or fuel cost shall be borne by the users. When their capacity are buildup, the full responsibility of O&M will be turned over to these WUG^s. At present, the BLGWP is working on this policy where increasing role are entrusted to the WUA^s for the water management, distribution and adoption of cropping pattern whereas primary responsibility of O&M remains with the project. A full program is launched to promote WUA^s and their institutions and capabilities in order to convert all the DTW^s to Farmer Management. However, there is great reluctancy in taking over the system as the farmers have had the privilege of being free-riders from the beginning.

5.1 Sectoral Approach for Ground Water Irrigation Development

In retrospect, the irrigation activities have now changed main focus towards the issue of utilization and sustainability. Now all TW schemes are taken up based on local felt needs and demands as against the traditional supply driven. Here, the users are deeply involved right from the initiation of the scheme including contribution of a part of the capital cost of construction of TW and related structures and also on the firm commitment of taking the responsibility of management and O&M. Since last three years STW^s, medium tubewells (MTW^s) and DTW^s are making headway in western terai under Irrigation Line of Credit (ILC) program assisted by World Bank. Here, a cluster of TW^s are initiated based on the genuine demand of the farmers in areas where rich groundwater aquifers exist. Farmers have to form a WUG for each unit. For a group or cluster of TW^s a Farmer Irrigation Association (FIA) would have to be established and registered to get legal status. Through an agreement between the DOI and the FIA, the responsibility and obligations of each party is clearly spelt and fixed. The users most contribute towards the construction cost of the well and distribution system. The share amount is fixed so as to ensure their commitment to construction and ownership responsibility and onwards O&M of the completed TW^s. Under this program a STW users have to provide pump and construct the distribution channel with materials provided by DOI whereas the TW is installed by the DOI as subsidy. In case of MTW^s and DTW^s contribution consists of an "upfront" cash deposit (usually 5%) and labor and land required for the distribution system. If access road is desired in the cluster of wells, then the land for this road is provided by the FIA free of cost. They arrange compensation if non-beneficiaries' land is acquired.

In case of STW^s' which require machine drilling e.g. deeper than 20 m, it will be taken up under this program. Shallower STW^s which can be installed by hand drilling will be normally diverted to ADB/N-STW program.

In coming years quite a large development of conjunctive use of ground water with surface water is going to take place because larger surface schemes would take quite sometime before their implementation.

6. DISCUSSION

Culturally, by irrigation water people of Nepal knew gravity canal water. They do not have much knowledge and experience of pumping ground water for irrigation. One of the reasons of not making faster progress in exploitation of groundwater is the expection of farmers that the pattern of TW utilization should replace those normally adopted in surface water. In fact, there is vast difference between irrigation practices used by farmers having surface water and those who have to meet full cost of TW irrigation water. Hence awareness need to be aroused not to conjoin TW irrigation with gravity canal water which is less costly but abundantly used. In general, TW irrigation development has greater chance of success if it is based on real local felt needs and demands. That is why all the STW^s are working well that are installed at the initiation of individual farmers. MTW^s installed on group demand and cost-sharing basis has an in-built element of ownership sense. All the TW^s of these type are farmer-managed and hence better utilized in growing even diversified croppings, vegetables and cash crops.

The DTW^s on large and small project scales generally came in an area as top-down process. The agency personnel worked as carrier of irrigation development targets. So engineering approach was decisive factor of planning and implementation and not the sustainability factors. Beneficiaries were not involved from the beginning as well as WUA^s could not be evolved pari passu as a body to operate and utilize the system created.

STW^s are preferred and would perform better where shallow and rich aquifers are available upto 20 m depth and also shallow static water table which enables farmers to pump required discharge by a suction lift pump only. Generally an individual farmer should initiate to own and operate a STW. If his landholding is not large, then a few farmers need to form a group to own a STW. Such STW^s are encouraged where farmers are growing cash crops, vegetable and multiple croppings and where market is available. Also in condition of non-fulfillment of water from gravity canal and where enterprenear farmers want to grow crops in non-monsoon seasons, there STW^s are being encouraged. The factors such as relative management burden, ease of implementation and cost effectiveness and availability of rich aquifers, motivated farmers of terai Nepal for wider of use of STW irrigation. STW is attractive even for a farmer having 1.0 ha. land. However group ownership is needed to expand the per unit service area in order to permit small holdings to be benefitted from STW irrigation thereby its wider adoption.

Table 1. Total Irrigation Coverage (Net in '000 ha)

Region	Total Cultivated Area	Rainfed Area	Irrigated Areas			
			DOI-Managed Schemes (AMIS)	Agency Assisted but FMIS	Farmer Managed Schemes (FMIS)	Total
Mountains	227	193	-	15	29	34
Hills	1,055	867	15	28	153	188
Terai	1,359	638	252	161	308	721
Total	2,641	1,698	267	204	490	943

Table 2 Characteristics of STW units

Valleys	Sample survey (1987-88)	Sample Survey (1990-91)
No of STW[s] units	554	30
No of pumpsets owned	352	30
Districts covered	18	6
Depth range in m.	8-50	8-35
Average depth in m	60	47
Size of boring (casing)	10 cm	10 cm
Pumpsets	centrifugal (diesel)	Centrifugal (diesel)
Horsepower range	5-10 BHP	5-8 BHP
Method of drillings	Manual rotary & rigmachine	Manual rotary, Sludge, Bogie
Time to drill	5-10 days	5-10 days
Crops grown	Paddy, wheat, maize and vegetables	Paddy, wheat, maize and others.
Hours of operation (hrs)	119 hrs	168 hrs
Average irrigation per unit	2.18 ha.	1.85 ha.
Discharge litre/sec	6-25	6-20
Cropping intensity	156% (19% increased)	241% (54% increased)

Table 3 Ground Water Potentiality and Exploitation

Region	District	Potential of Tubewells Nos		Tubewells installed by 1990-91					
		STW	DTW	By DOI	By others	Total	By DOI	By others	Total
Eastern	Jhapa	10,546	12	6	1,533	1,539	4	-	4
	Morang	8,950	60	18	1,346	1,364	1	-	1
	Sunsari	3,400	153	53	1,762	1,815	-	na	-
	Udaipur	1,900	-	130	710	840	-	-	-
	Saptari	3,204	24	1,540	1,162	2,702	9	-	9
	Sirha	6,158	12	1,055	1,043	2,098	9	-	9
	Dhanusa	2,376	83		1,096	1,096	-	54 (JADP)	54
	Mahottari	3,344	88	16	625	641	24	-	24
									15
Central	Sarlahi	3,780	139	-	1,321	1,321	15	-	-
	Rautahat	2,952	171	20	795	815	-	-	28
	Bara	2,971	242	..	1,357	1,357	28	-	-
	Parsa	2,598	154	-	200	200	-	-	-
	Chitwan	Investigation under progress		-	17	17	-	-	-
Western	Nawalparasi	2,112	45	2	194	196	11	-	11
	Rupandehi	3,204	227	-	1,222	1,222	110	-	110
	Kapilsbastu	3,967	46	49	244	293	41	-	41
									4
Midwestern	Dang	1,510	40	461	10	471	4	-	5
	Banke	1,788	19	-	718	718	5	-	
	Bardia	3,798	141	-	836	836	-	-	-
Farwestern	Kailali	4,860	79	497	1,160	1,657	68	-	68
	Kanchanpur	2,392	79	603	831	1,434	68	-	14
						22,632			397

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Paper No. 52

GROUNDWATER AND ELECTRICITY COMANAGEMENT:

GENERATING NEW OPTIONS

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ABSTRACT

Ground water overdevelopment is a problem throughout northern Gujarat. Horsepower based electricity charges encourage inefficient water and energy use in overdeveloped areas. Pumping accounts for 30% of electricity consumption in Gujarat and underlies the state's power crisis.

The social conditions necessary for farmers to manage ground water overdevelopment are difficult to meet. User group and resource boundaries are poorly defined, information is unavailable, private well ownership complicates free rider control, and large heterogeneous groups utilize aquifers. Government regulatory attempts have not been successful. Institutional structures need to be created which address ground water problems at the required scale, meet necessary social conditions, and rectify pumping incentives.

Cooperatives have been proposed as a response to the state's electricity crisis. Electricity to village level organizations will be metered. They can then meter membership consumption. Since pumping is often the primary end-use, unit charges should create incentives for electricity and water conservation at organization and end-use levels. As a result, the organizations could provide an appropriate nucleus for water management activities. Defining management entities using the electrical system could address many of the free rider, user-group, and information issues complicating emergence of farmer based ground water management systems.

INTRODUCTION

This paper presents an overview of ground water problems in Gujarat (India), their linkage with energy supply issues, and potential management alternatives. The paper argues that new institutional approaches are required to address emerging ground water problems. Electricity and water co-management is presented as one possibility. The paper is organized linearly. Ground water problems are identified first and then linked with power supply and pricing patterns. Specific power supply problems are discussed next. Attention is then re-directed to existing management alternatives and the social factors influencing user groups ability to manage ground water. Following this proposals to create electricity cooperatives are described and their potential utility for ground water management is examined. Conclusions are drawn in the last section.

GROUND WATER OVERDEVELOPMENT

Ground water resources are overdeveloped in many hard rock and arid sections of India. Isolated problem areas such as Mehasana District in Gujarat are well known (Figure 1). The extent of overdevelopment is, however, poorly documented and potentially greater than estimates suggest.

Ground water maps prepared by the Central Ground Water Board (CGWB) for the period April 1979 to May, 1987 show drops of >2m throughout most of Gujarat excluding canal command areas. In large areas the decline was >4m and water levels in the unconfined aquifers were >20m in depth. Water quality in most areas with shallow water tables was poor with TDS > 1000 mg/l (often > 3000 mg/l) and bicarbonate > 500 ppm. Although May 1987 was a drought period, the decline is long-term in extensive areas. For example, depth to the water table declined from 4-16m in May 1978 to 8-28m in May 1990 in Ahmedabad, Sabarkatha, Mehasana, and Banaskatha districts (High Level Committee, 1991).

Official ground water availability estimates (the primary guide for development finance) paint an optimistic picture. According to them, only 31% of utilizable recharge to unconfined aquifers was extracted in 1986 and a further 3.2 million hectares could be sustainably irrigated from ground water (Government of Gujarat, 1986). Extraction exceeded recharge in only 5 out of 182 Taluks and was greater than 65% of recharge in a further 14. These estimates are unreliable (Moench, 1991ab, Dhawan, 1991). CGWB and the Gujarat Water Resources Development Corporation (GWRDC) scientists note that extraction estimates are based on old well census statistics, poorly known crop water duties, and well yield - irrigated area assumptions.[1] Recharge estimates are based on Taluk (not hydrologic) boundaries, water table

1 S.C. Sharma (GWRDC); K.C.B Raju (CGWB), and others.

fluctuations, assumed infiltration levels, and specific yield estimates (GOI, 1984; Narshiman 1990; Moench 1991a,b). Senior scientists indicate that they are as uncertain as the extraction figures.2

Official estimates suggest that ground water in confined aquifers is approaching full development throughout North Gujarat. Extraction exceeds 70% of recharge in Ahmedabad, Gandhinagar, Sabarkatha, Mehasana, and Surendranagar districts and is over 40% in Banaskatha (See Table 1). Of the remaining five districts having significant resources in confined aquifers, three are high rainfall and irrigation is rare in the remaining two.

Table 1

District	Estimated % Development Unconf	Estimated % Development Conf.	Water table Decline in meters Unconfined 79-87	Water table Decline in meters Unconfined 78-90	Water table Decline in meters Confined 78-90
Ahmedabad	23	97	2->4	4-8	to 20
Gandhinagar	30	97	2-4	4-8	to 20
Banaskatha	33	40	2->4	4-8	to 20
Sabarkatha	43	97	0->4	4-8	to 30
Surendranagar	37	72	0->4	na	na
Mehasana	66	88	2->4	4-8	to 40

Column 1 & 2, from Government of Gujarat (1986).
Column 3 From Maps prepared by the CGWB
Column 4 & 5 From High Level Committee (1991) text & maps

Officially estimated levels of ground water development in unconfined aquifers are at odds with observed water table declines and high levels of development in deeper aquifers. While the extent of overdevelopment is unknown, it appears to be widespread. The current focus on development must evolve into a management focus. How is the question.

WATER-ELECTRICITY LINKAGES

Estimates for 1990-91 suggest that agriculture accounts for roughly 32% of all electricity consumption in Gujarat.3 GSEB officials state that 30% of total power production now goes for pumping.4 These percentages are much higher that the official 18.4% agricultural consumption figure reported for Gujarat in 1986-87 (Dadlani, 1990).

Agricultural pumpset efficiency is very low. Surveys by the Institute of Cooperative Management indicate typical efficiencies

2 Discussions with Dr. K.C.B. Raju and T.N. Narishiman.
3 Discussions with World Bank officials
4 Note prepared by C.S. Chatper, GSEB headquarters, 1/1/92.

of 13-27% in farmers pumping systems (S.M. Patel, 1991). Efficiencies of >50% could be achieved with readily available and affordable technologies. Electricity for pumping is, however, priced at an annual rate according to pump horsepower. According to GSEB officials, current charges equal 0.15 Rs/kwh ($0.0054/kwh) while generation costs are 1.18 Rs/kwh ($0.0421/kwh).5 Given the pricing structure and subsidies, farmers have little incentive to invest in pump or water use efficiency.

In Gujarat, unlike the rest of India, official figures suggest that the number of diesel pumps is double the number of electrical ones (CGWB, 1991, Tables 34 & 35). Pump numbers give a misleading picture of the importance of electricity in pumping. Virtually all pumping from confined aquifers uses electricity to run submersible pumps. In addition, farmers prefer electricity for pumping because of its low cost. Diesel pumping costs have been estimated at Rs 1.9/kwh equivalent ($0.068/kwh), much higher than the Rs 0.15/kwh ($0.0054/kwh) farmers pay for electricity.6 Many farmers have both types of pumps and use diesel only as a backup when electricity is unavailable. As a result, where sufficient connections are available, electricity is the primary motive power for pumping.

Power sources influence water management practices. Due to insufficient generation capacity utilities generally practice power shedding. Electricity is often rotated so that farmers receive it at night. In response, they leave pumps on so that irrigation starts whenever power comes. Uncertain power availability and night rotations make careful irrigation management difficult. Farmers tend to apply as much water as possible when they can. Diesel powered irrigation is, in contrast, carefully managed. According to farmers, the cost of diesel can account for 90% of crop profits. Most of those using diesel claim to apply water as carefully as possible.

The cost of power also influences water sale rates. Field work in Mehasana District indicates that farmers having electric pumps generally charge 1 rupee/hr/hp during the dry season. This is often halved in the monsoon to maximize profits relative to fixed electricity charges. Since most costs of electrical pumping are fixed, maximizing water sales maximizes profits. In contrast, diesel pump owners charge seasonally uniform water rates.

Overall, the cost of pumping appears to influence farmers water use and pricing decisions. Flat rate electricity charges encourage extraction and create disincentives for efficient use. Unit prices do the reverse.

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5 A.H. Dhebar, GSEB office, Sabrimati on 12/31/91.
6 Discussions with World Bank officials

POWER PROBLEMS

A variety of problems affect the rural electricity system. Voltage fluctuation is common and often causes pump damage. Rural lines are overloaded and the GSEB is often only able to provide connections 4-5 years after applications are received. In rural areas about 9% of total power generated is lost to theft and collections are a major problem.7 The GSEB shifted from metered rates to annual charges due, in part, to theft and collections losses.

The above problems have led to near financial collapse for the GSEB. As a result, the organization is now "actively considering" the involvement of private companies or cooperative agencies in generation, transmission, and distribution.8 Metering and rate increases are also contemplated. Given diesel pumping costs, ability to pay is not a major issue for many farmers. How to enforce metering and collections is the main issue facing the GSEB.

GROUND WATER MANAGEMENT QUESTIONS

Ground water management responses to depletion must address efficiency incentives. As long as strong incentives for inefficiency remain, little basis exists for management. Power subsidies mask water costs and constrain management system evolution. Since (excluding well investments) it costs no more to pump from deeper levels, individuals have little incentive to conserve or participate in management.

Even with incentives for efficiency, the evolution of effective management systems would be difficult. In many cases, management will make little difference to well water levels unless it functions at an aquifer scale. Aquifer characteristics are often difficult to determine and vary greatly between areas. Where ground water availability and movement are topographically defined, "village" management systems may make a significant impact. In the large aquifer systems that characterize many geologic environments, management must cover extensive areas to address depletion.

GROUND WATER MANAGEMENT ALTERNATIVES

Regulation is the primary ground water management approach being considered in India. The central government circulated a model bill to the states in 1970 (Dave, 1983). Only Gujarat has passed legislation and that has yet to be enforced. Gujarat's act allocates power to license tubewell construction, regulate

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7 Note prepared by C.S. Chatper, GSEB headquarters, 1/1/92.
8 Personal Communication, GSEB officials in Baroda.

ground water use and prevent waste (Sinha & Sharma, 1987). Acts proposed in other states, create "authorities" staffed by individuals from state organizations (Moench, 1991 ab). These authorities are given regulatory powers within notified areas. Enforcement is through fines, search and seizure provisions, and (in some cases) electricity denial. None of the acts allow inclusion of local representatives in the management structure or devolution of authority to local groups.

Regulation is unlikely to be successful. In Mehasana, for example, declining water tables led to the closure of ground water development financing in 1976 (Ghosh & Phadtare, 1990a, p. 319). New wells are also regulated via limiting electricity connections. Neither financial nor electricity limitations have proven effective. Private financing is available and illegal electricity connections can be obtained. Drilling companies in Mehasana estimate that over 2000 wells are drilled in the district each year.

Existing regulations have probably limited ground water access for those who can't afford private financing or don't have the pull to obtain illegal connections. They have done little to slow use by the wealthy. Since most wells are privately owned, regulations are difficult to enforce. They also have strong equity implications. Depending solely on regulation for ground water management is not feasible.

The primary alternatives to regulation are indirect management through economic levers or development of local institutions capable of evolving socially feasible management systems.

Energy pricing is the main economic lever directly influencing pumping. Numerous discussions with farmers suggest that they will be unwilling to pay higher rates unless voltage and supply timing issues can be remedied. Theft will also remain a problem. In addition, differentiating between the needs of management areas through electricity pricing will be difficult. Depletion necessitates prices which encourage conservation. Where water logging is present, prices should encourage higher pumping rates. Politically it would be very difficult to charge high unit electricity rates where water is scarce and low annual rates where it is plentiful. Finally, it is far from clear how much impact an approach based solely on economics would have. In the Western U.S., energy prices are a factor in farmers willingness to invest in water conservation but play a minor role in crop choice and therefore the overall water use decision (Moench, 1991c).

Local institutions tend to require certain conditions to establish effective management systems. Management often occurs when: 1) user group and resource boundaries are clearly defined; 2) resource use and condition information is available; 3) free riders can be controlled and management decisions enforced; and

4) broad support exists for management (Moench, 1986). These conditions become difficult to meet as group size and heterogeneity grow. In a study of 93 ground water management groups, Nagabrahmam (1989) found average sizes from 3 to 21 members. Several groups identified small size as a factor in their success. Group homogeneity (economic and caste) also influences community well management success (Ballabh & Shah, 1989).

The above considerations suggest that farmer based ground water management institutions will face significant difficulties in addressing depletion problems. Aquifer boundaries are often poorly known making resource and user group boundaries unclear. Condition information is difficult to obtain since local water levels may indicate little about the overall water balance. As a result, it may be difficult to establish of broad support for management. Free rider control is also likely to be difficult. Wells are generally private and use rights strongly entrenched. How user groups could enforce extraction limitations is open to question. Finally, management scale is likely to be a major issue. Unless resource use patterns can be managed at an aquifer scale, depletion problems will be impossible to address. Physically appropriate management areas will often contain large, heterogeneous, user-group populations.

In isolation none of the management alternatives identified above can address emerging depletion problems. These problems threaten the viability of many communities. Institutions must be evolved that meet social requirements for management, are able to address the physical scale of resource problems, and rectify water use incentives.

ELECTRICITY - GROUND WATER CO-MANAGEMENT OPTIONS

Electricity Coop proposal

The formation of cooperatives has recently been proposed as an answer to electricity supply problems by the National Dairy Development Board (NDDB).9 This proposal, widely supported in Gujarat, faced Central Energy Authority opposition.10 The idea is being revived following recent encouragement of private participation in the power sector. It should be noted that electricity cooperatives, while new to India, are common elsewhere. They are, for example, one of the main sources of rural electricity in the U.S.A.

The NDDB proposal, developed for Kheda District, envisioned electricity supply through a nested series of cooperative organizations. Village cooperatives would buy electricity from

9 This section is based on Tata (1991) and interviews with Mr. Sen and Dr. Kurian at NDDB on March 4, 1992.
10 Dr. Kurian, Personal Communication.

an "Apex Rural Electricity Cooperative Society." The "Apex Society" would have society unions at substations and a peak generation organization. This structure should provide regional representation for villages. Local societies would: 1) maintain low voltage supply lines; 2) distribute electricity; 3) keep connected load within line capacity; and 4) collect dues. The Apex Society would have one meter at each village and charge unit rates. Village societies could meter members, impose flat tariffs, or follow other pricing systems.

The primary incentive for farmers to form electricity cooperatives would be improving the quality and timing of power supplies. In Kheda District from 1981 to 1987, rural non-monsoon electricity supply averaged 15-16 hours/day and was less than 9 hours/day in some months (TATA, 1991). Voltage fluctuations also necessitate frequent pump repairs. Problems with power availability, quality, and access to connections are a constant refrain from farmers. High quality power supply to cooperatives would be essential.

The GSEB is interested in rural electricity cooperatives for financial reasons. Low electricity charges, theft, and non-payment of dues in agricultural sector underlie the GSEB's precarious financial position.11 Without some new institutional structure, metering and electricity rate increases may not be possible. Selling bulk power to user groups would greatly reduce the number of meters requiring monitoring. Since local groups would have primary responsibility for collecting electricity charges, theft and non-payment problems should also be reduced.

Local distribution organizations could provide avenues for increasing efficiencies. Metering supplies to village groups and, if done, to individuals should create incentives for efficient use. Furthermore, line capacity limits possible connected load. Readily available pump improvements can reduce connected load by about 50% (S.M. Patel, 1991). Local organizations could, thus, increase connections through pump rectification. They could invest directly or grant connections if individuals rectified other's pumps.

Ground Water Management Linkages

Electricity cooperatives could provide a flexible means of rectifying ground water use incentives and a potentially appropriate institutional structure for management.

Electricity distribution by user groups could enable rate manipulation in response to ground water conditions. User groups would have to freedom to experiment with different rate structures. Unit rates or increasing block pricing would establish, respectively, uniform and rising marginal costs for water and could be used to create differing incentives for

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11 Discussions with GSEB officials in Baroda.

conservation in shortage areas. Where water logging is present, uniform annual charges would establish declining average costs and encourage extraction. Efficiency arguments advanced in the preceding section for electricity would also apply to water. Irrigation service is the "real" end-use of pump energy. Individual or institutional investments in water conservation could reduce energy consumption and connected load required. They could be used to reduce power costs or increase connections.

Eestablishment of farmer based institutions for electricity distribution could create options for managing ground water through pumping economics. It is important to recognize, however, that encouraging water use efficiency is unlikely to solve depletion or other complex management problems. Rectifying the incentive structure may be a necessary precondition for the establishment of management systems but it is probably not a sufficient one.

Management Institutions?

Farmer based electricity distribution organizations could form an appropriate institutional nucleus for ground water management. Local institutions should have incentives to ensure water use efficiency and, thus, become involved in water management. Incentives to initiate management could also exist where ground water problems are a major local concern or threatened the institution's viability.

Managing ground water through electricity distribution organizations could have advantages over institutions created specifically for that purpose. First, access to electricity is a much more tangible and immediate benefit to individual users than managing a nebulous "ground water resource." Second, user group boundaries are clearly defined (those having connections), information on use patterns is readily available (metering), and there are avenues for free rider control (connections). These factors address some of the management limitations suggested by experiences with other common property resources.

The "union of cooperatives" concept put forward for managing electricity at the substation level could be utilized for ground water management. Cooperative unions along individual or multiple branch lines could undertake management over large areas. Alternatively, local institutions could form and participate as members in larger organizations with a specific ground water focus. This approach parallels that used in the Western U.S. There, management agreements are often negotiated between institutions representing large memberships who's primary concern is not water (Moench, 1991c). The approach allows local representation but limits the number of individual actors. Through it, individual compliance with regional management agreements can be ensured via local enforcement.

CONCLUSIONS

Ground water resources are overdeveloped in many arid and hard rock sections of India. Existing management options -- regulation, economic manipulation, and the creation of local organizations for ground water management -- face theoretical and practical difficulties. Socially viable approaches are required that can address complex ground water problems at the required scale.

Ground water and electricity use are intimately connected. Low use efficiencies, highly subsidized electrical rates, and theft are problems in the electrical system. Electricity cooperatives have been proposed as one possible solution. These organizations could establish rate structures rectifying incentives for inefficient electricity and water use. Over the long run they could also form an appropriate nucleus for initiating ground water management. This idea is not new. Districts in the Western U.S. often combine power and water management activities. Substantial experience in electricity and water co-management exists.

Establishment of local electricity cooperatives in Gujarat is still at the discussion stage. Their value for managing ground water remains conceptual. Exploring these concepts is important. Ground water depletion threatens large rural areas. Existing management options stand little chance of generating solutions. New approaches are needed.

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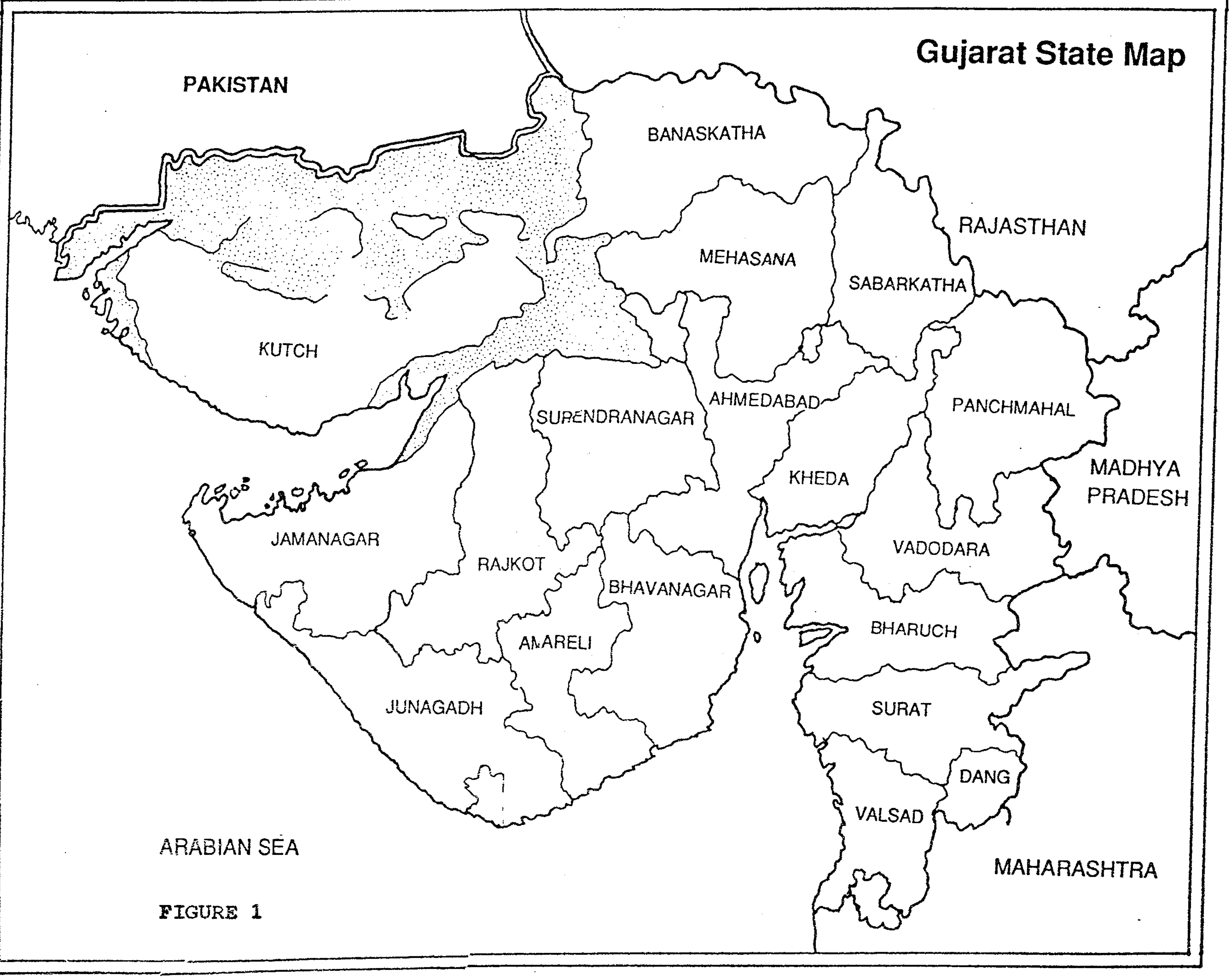
Gujarat State Map
PAKISTAN
RAJASTHAN
MADHYA
PRADESH
MAHARASHTRA
ARABIAN SEA
BANASKATHA
MEHASANA
SABARKATHA
PANCHMAHAL
KUTCH
AHMEDABAD
SURENDRANAGAR
KHEDA
VADODARA
JAMANAGAR
RAJKOT
BHAVANAGAR
AMARELI
BHARUCH
JUNAGADH
SURAT
DANG
VALSAD

FIGURE 1

Paper No.53

MINOR IRRIGATION DEVELOPMENT: A KEY FOR SUSTAINABLE AGRICULTURAL DEVELOPMENT IN BANGLADESH

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ABSTRACT

In Bangladesh, optimum use of water resources and especially irrigation water should be an important strategy for increasing and sustaining increased agricultural production. Minor irrigation covered about 93 percent of total irrigated area in Bangladesh during the years 1989-90 and according to government projections would cover about 90 percent by the end of fourth five year plan, 1994-95 (Ghani and Rana 1991). About 58% of total irrigated area during 1989-90 was and 63% of the irrigated area in 1994-95 will be covered by groundwater. Minor irrigation systems are almost entirely managed by the farmers/beneficiaries. Public intervention is only at the time of developing irrigation facilities (renting of LLP and installation of DTWs). Therefore, about 90 percent of the irrigation systems will continue to be farmers' managed irrigation system in Bangladesh. But these facilities are operating at about 50% of their rated capacities. Improvement in the management and utilization levels of minor irrigation systems in the country, therefore, can bring significant improvement in overall irrigation sector. Studies in the Ganges-Kobadak (G-K), North Bangladesh Tubewell Project (NBTP), Kahalu area of Bogra and Rajshahi areas during 1989 and 1990 dry seasons indicate that water use values for rice cultivation are 0.32, 0.18, 0.96 and 0.39 ha/lit/sec (or 3.13, 5.56, 1.04 and 2.56 lit/sec/ha) respectively. Productivity of water are 3.6, 3.8 and 5.5 kg/ha-mm for G-K, NBTP and Rajshahi area respectively.

In G-K and NBTP, irrigation facilities are operated and maintained by government agencies whereas in Bogra and Rajshahi study areas operation and maintenance are done by the farmers. From the water use and productivity figures it can be concluded that farmer managed systems are performing better. However, it has been observed that even these systems fall short of the desired levels. Performance of minor irrigation systems can be improved by adopting water management strategies like improvements in reliability of water supply, provision of improved operation and maintenance, fixation of irrigation target per unit of irrigation delivery and diversified cropping plan. These practices could lead to the accrual of additional benefits from the irrigation facilities.

Paper to be presented at the South Asian Regional Workshop on Groundwater Farmer-Managed Irrigation Systems and Sustainable Groundwater Management to be held at Dhaka, Bangladesh, during May 18-21, 1992.

INTRODUCTION

Bangladesh is located in the low lying delta of one of the largest river systems in the World and is subject to alternating annual periods of extreme excesses and deficits in rainfall, recurring floods and cyclonic storms. The major portion of the water resources are available during the monsoon months (mostly June to September) causing flooding over about 57 percent of the total area of the country (Planning Commission 1990). Over the 10.36 million hectares (ha) of rice land the flood regime stands as; 36% under less than 0.3 meter (m) depth, 35% under 0.3 to 0.9 m depth and 2% under over 3.0 m water depth during the flooding season. (BARC and MOA, 1988). Therefore, 71% of the rice area or about 62% of the net cultivable area can be brought under year round cultivation if irrigation facilities are developed. However, only about 30% of the cultivated land has access to some form of irrigation, whereas the irrigable area is about 84% and the irrigation potential of the country based on available water resources is about 76% (MPO 1991). Due to skewed distribution of available water (river flow) and annual rainfall only about 40% of the cultivable land (9.03 million ha) is cultivated during the winter months.

Water resources of Bangladesh exist in two forms - streamflow mostly coming from catchment areas outside of the country, rainfall and surface runoff from within the country and groundwater. The country does not have much control over surface water and most of this flow (about 121 million ha-m) comes during June-September which causes flooding. Most of the streams remain dry or nearly dry during November to May, therefore cannot be used as a reliable source of irrigation unless some form of augmentation facilities are created. Therefore, dependable irrigation source is the groundwater extraction. About 58% of the total irrigated area during 1989-90 was and 63% of the irrigated area in 1994-95 will be covered by groundwater (Ghani and Rana 1992). Minor irrigation (irrigation using low lift pump, deep and shallow tubewells, hand tubewells and doon and swing buskets) has been in the past and is expected to stay so in near future, the driving force behind irrigated agriculture in Bangladesh. Improvements in management and capacity utilization of minor irrigation systems, therefore, will have a significant impact on the agricultural growth of the country. This paper will focus on different management types of irrigations systems in some selected areas of Bangladesh, their utilization levels, water productivity status and their impact on further improvement.

METHODOLOGY AND MEASUREMENTS

Studies were conducted in the Ganges-Kobadak (G-K) project, North Bangladesh Tubewell Project (NBTP), Rajshahi area (within and outside Barind Integrated Area Development Project, BIADP) and Bogra area (Kahalu) to establish management type and status and water use status. Study sites and relevant measurements are briefly described as follows:

Ganges-Kobadak Project

The Ganges-Kobadak (G-K) project is the first and still the largest irrigation project in Bangladesh. It pumps water from the Ganges river and distributes over the project area through gravity canal network (main, secondary and tertiary canals and field channels). Pumping capacity is 153 cubic meter per second (cms) and irrigable area is about 141,700 ha. Three secondaries, three tertiaries and fifty observation plots were selected to represent the head, middle and tail reaches of main, secondary and tertiary canals respectively. Studies in G-K area were started since 1981 but only 1989 and 1990 data have been used in this paper for comparing with NBTP, Rajshahi and Bogra findings.

North Bangladesh Tubewell Project (NBTP)

Twelve deep tubewells were selected to study input use, management practices and improved allocation and equitable distribution of irrigation water and increasing irrigation efficiency, service area per unit volume of available water and for increasing production. This study was also initiated in 1981 but data of 1989 and 1990 will be used for this paper.

Deep Tubewells in Rajshahi Area

Sixteen deep tubewells were selected in Rajshahi area for water management related studies. Out of 16 sample deep tubewells 7 were under BIADP management, 3 deep tubewells under each of IFAD, Rental and Private management categories.

Deep Tubewells in Bogra

Bogra is the most intensive tubewell irrigated area in Bangladesh. Ten deep tubewells were monitored for discharge, irrigated area and operating hours and fluctuation of water levels. All of these tubewells were installed by the Bangladesh Agricultural Development Corporation (BADC) but are managed and operated by farmers.

RESULTS AND DISCUSSIONS

Average water use status under different irrigation systems are presented in Table 1. Water use status in Bogra area is much higher than other areas. G-K project data has been presented to compare status of gravity irrigation with deep tubewell irrigation systems under different managements. Utilization status in terms of area coverage per unit discharge in Bogra is 3 to 5 times higher than that in Rajshahi and NBTP areas. In Rajshahi area tubewells are under government agency and private management whereas in NBTB all the sample tubewells are under government agency management (Bangladesh Water Development Board). It is clear from this table that agency managed system are irrigating much lower area than the potential. One of the major reason of low irrigation coverage may be low operating hours (Table 2) which is 6.12, 5.05 and 10.3 hours on an average for NBTP, Rajshahi and Bogra areas respectively. The operating hours per day in the dry season should be higher (16 to 20 hours), for best utilization of the expensive equipments and for bringing more area under cultivation.

Productivity aspect of the irrigation water was analyzed and for G-K, NBTP and Rajshahi areas, and on an average, the corresponding values are 3.6, 3.5 and 5.5 kg/ha-mm, respectively (Table 3). It was also revealed from Table 3 that water productivity was higher under private managed tubewells than agency managed irrigation systems. In real sense irrigation systems in Bangladesh are either partially or fully managed by the farmers/beneficiaries. In agency managed minor irrigations, only the equipment is managed by the agency personnel whereas distribution and management of irrigation water and cropping plan is entirely done by the farmers. Government agricultural extension department offers some limited advisory service to the farmers. In large lift-cum-gravity irrigation systems operation and maintenance of the main systems and water distribution upto tertiary level are managed by agency personnel and distribution and utilization of water at farm level are managed by the farmers.

Irrigation coverage, operating hours and water productivity figures in the study areas reveal improvement potential. However, planning at the project and national levels do not show any sign of improvement. It can be observed from Table 4 that major contribution in increase in the total irrigated area will be through minor irrigation.

Percent increase in total irrigated area during 1994-95 as compared to 1972-73 is projected to 412% (total irrigated area would thus be 4.8 million ha). Shallow tubewells will cover the maximum (47%) irrigated area during 1994-95. Most of the increase in total irrigation coverage will be through increased number of irrigation facilities (Table 5). It can be observed from Table 5 that percent increase in number of irrigation equipments during 1994-95 over 1977-78 would be 104, 370, 3859 and 650 percent for LLP, DTW, STW and HTW, respectively. That shows a significant increase in numbers. However, irrigation coverage per unit of these irrigation modes over the period indicates practically no change in per unit irrigation coverage under LLP and DTW during 1977-1995, and in shallow tubewells during 1984-1995 (Table 6). These observations point to the fact that irrigation development strategy of Bangladesh is still based on the creation of new facilities rather than improving performance of the existing and newly created facilities.

CONCLUSIONS

Irrigation facilities in Bangladesh are highly under utilized. Irrigation coverage per unit discharge is low. Facilities are operated for less number of hours even during dry season which can easily be doubled. Present operating hours of deep tubewells vary from about 5 to 10 hours per day which could easily be increased to 16-20 hours/day. Water productivity and yield levels are also low, and could be increased with locally available technology. Efforts should be made to irrigate entire flood free area and target cropping intensity for this area should be about 300%. Production target of 10 ton/ha grain should be fixed for flood free irrigated areas for justifying investments in irrigation and for making the country self-sufficient in food production.

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Table 1. Average water use status (ha/lps) in the selected locations in Bangladesh during dry seasons of 1989 and 1990.

Sample Location	G-K	NBTP	Rajshahi	Bogra
1	0.28	0.09	0.56	0.87
2	0.33	0.18	0.35	1.00
3	0.32	0.11	0.09	0.56
4	0.34	0.17	0.33	0.82
5	0.40	0.15	0.24	0.85
6	0.09	0.17	0.40	0.79
7	0.51	0.18	0.24	1.44
8	0.31	0.12	0.33	0.96
9		0.30	0.48	0.68
10		0.26	0.61	1.66
11		0.15	0.39	
12		0.33	0.22	
13			0.61	
14			0.54	
15			0.45	
Average	0.32	0.18	0.39	0.96

G-K : Ganges Kobadak Project, Kushtia, Bangladesh
NBTP : North Bangladesh Tubewell Project, Thakurgaon

Table 2. Average daily operating hours of the deep tubewells in NBTP, Rajshahi and Bogra areas in Bangladesh during dry season of 1989 and 1990.

Location	NBTP	Rajshahi	Bogra
1	4.2	6.5	9.0
2	5.0	7.4	12.6
3	5.0	2.0	9.1
4	4.6	8.0	16.5
5	10.2	4.2	4.8
6	8.3	7.6	10.4
7	6.8	3.7	11.8
8	5.8	5.3	10.3
9	5.8	5.0	8.0
10	7.3	4.5	10.4
11	2.9	5.8	
12	8.1	3.1	
13		4.6	
14		4.0	
15		4.0	
Average	6.12	5.05	10.3

Table 3. Productivity of water (kg/ha-mm) during dry season in the selected sites in Bangladesh during 1989 and 1990.

Location	G-K	NBTP	Rajshahi
1	2.95	3.95	3.4
2	3.01	3.76	3.5
3	3.44	3.93	5.8
4	3.15	4.13	4.4
5	3.25	4.07	3.1
6	3.75	3.79	4.3
7	4.85	3.70	6.9
8	4.78	3.84	6.9
9	3.22	3.60	3.8
10		3.80	7.5
11		3.53	5.1
12		3.13	5.5
13			4.9
14			5.4
15			4.9
Average	3.60	3.77	5.5

Table 4. Irrigation achievement and target of irrigation coverage under different systems in Bangladesh (in % and total in thousand hectares).

Program	1972-73	1977-78	1979-80	1984-85	1989-90	1994-95
Gravity	5	6	6	8	7	10
LLP	45	48	41	29	25	23
Trad.	43	32	29	14	10	4
DTW	6	12	17	17	16	15
STW	1	1	6	31	40	47
HTW	-	1	1	1	2	1
Total	936	1133	1413	2484	3090	4790
% increase over 1972-73	-	21	51	165	230	412
% HYV Rice coverage	-	-	-	27	38	46

Source: Third Five Year Plan and the Fourth Five Year Plan (draft)

LLP : Low Lift Pumps; DTW: Deep Tubewells; STW: Shallow Tubewells;
HTW : Hand Tubewells; Trad: Traditional methods like doon, swing busket etc.

Table 5. **Irrigation development status under different programs (number of units) in Bangladesh as percent increase over 1977-78 position.**

Program	1984-85	1989-90	1994-95
LLP	31	63	104
DTW	128	303	370
STW	1119	1484	3859
HTW	400	650	650

Source: Third Five Year Plan and the Fourth Five Year Plan (draft)

Table 6. **Irrigation coverage (ha) per unit in Bangladesh during the reporting period.**

Program	1977-78	1984-85	1989-90	1994-95
LLP	14.9	15.0	13.0	14.5
DTW	18.2	24.3	16.7	20.0
STW	0.8	5.0	6.3	4.5

Source: Third Five Year Plan and the Fourth Five Year Plan (draft)

Groundwater development | Credit policy
Shallow tubewells

Paper No.55

SUSTAINABLE GROUNDWATER DEVELOPMENT AND MANAGEMENT IN NEPAL: MAJOR ISSUES CONFRONTED BY A DEVELOPMENT BANK IN NEPAL

Ujjwal Pradhan
Ganesh Thapa[1]

ABSTRACT

Groundwater extraction and use in Nepal with newer technologies is very recent in Nepal as compared to some other South Asian countries. The Agriculture Development Bank/Nepal (ADB/N) has been intimately involved in groundwater development for the past two decades. It is very probable that in the future the functions of the bank will be limited only to lending activities without the technical support. Were it to be so, the bank will need to find avenues for filling in the newly created vacuum if irrigation development is to be fully realized.

Therefore this paper assesses the institutional capacity and the adequacy of irrigation support services to STWs by the ADB/N by analyzing several systems supported by the bank. The economic performance of these selected STWs is also presented. Suggestions are made for enhancing the bank's institutional capacity regardless of whether it retains technical support as one of its functions.

The paper also addresses the issue of subsidy and its impact on groundwater development. The paper concludes with issues that confront STW development and sustainability in Nepal keeping in view of the positive contribution that ADB/N can make towards these goals of irrigation development in Nepal.

INTRODUCTION

Groundwater development potential in the Tarai of Nepal is estimated to be 250, 000 ha. In addition, there is a potential for groundwater development for conjunctive use in the surface command areas in some 150, 000 ha. Total area irrigated using groundwater in the Tarai is estimated to be about 110, 000 ha of which about three-fourths is under farmer-managed tube-wells and the rest is under agency management. Thus, the present groundwater development constitutes only a small fraction of the total potential.

About 70% of the total irrigation coverage in Nepal is under farmer-managed systems. Several government agencies have provided technical and financial input for irrigation development. The approaches and procedures guiding their public interventions have varied. Agencies have been either amalgamated, separated, or fragmented within and between ministries. ADB/N involvement is in the farmer-managed category and that too through the provision of loans and subsidies. However some grant assistance is provided for technical and managerial support. ADB/N is mainly involved in small surface irrigation, shallow tubewells and other types of technologies. While the other major irrigation institution, the Department of Irrigation (DOI), is

[1]Names are in alphabetical order. Ujjwal Pradhan is a social scientist with IIMI Nepal Field Operations and Ganesh Thapa is an economist with the Ministry of Agriculture, Nepal and also a Research Specialist with Winrock, Nepal.

involved in all types of surface irrigation and groundwater systems through grant assistance or through donor loans. While it would be useful to compare and contrast the impact of the grant and loan/subsidy systems on irrigation performance and implementation process, the focus of this paper will be on the impact of loans/subsidies on the economic performance of some of the selected ADB/N STWs as studied by IIMI.

IRRIGATION INSTITUTIONS AND POLICIES: THE CONTEXT FOR NEPAL

Ever since the Third Five Year Plan, the government has accorded high priority to irrigation development. However, it was only since the Sixth Plan that the government has emphasized equity and access to resources for the welfare of small and marginal farmers. New approaches and policies with the objective of improving irrigation planning and implementation were introduced in the Seventh Plan.

In 1988, the government formulated working policies on irrigation development for the fulfillment of Basic Needs (HMG/MOWR 1988). Salient features of these policies were: (i) Farmer participation made compulsory for all stages of the project cycle ,operation and maintenance, and capital costs were to be shared by the beneficiaries and the government, (ii) National Irrigation Development Committee formed to formulate working procedures, establish priorities, fix targets and coordinate all the agencies concerned with DOI and ADB/N as the main implementing agencies, (iii) ADB/N was allotted 227, 000 ha (28% of total) to be further irrigated by the end of the century, (iv) cost for construction was to be shared by the beneficiaries and certain subsidies were to be provided for groundwater systems, and (v) the operation and maintenance of small and medium scale surface systems, STW projects and deep tubewells were to be undertaken by the beneficiaries.

This new policy was to be implemented by means of two Action Plans-- one for turning over some systems constructed and presently managed by DOI to farmers for operation and the other to increase participation of farmers in the management of jointly managed systems.

The scenario regarding irrigation development by the government was that there were several agencies drawing from different sources of funding and a multiplicity of approaches regarding the implementation of projects. Project financing was in the form of outright grants, or partial loans with substantial grant component, or a combination of grantees' contribution usually in the form of labor. Varying input levels -- financial or otherwise-- were required from the beneficiaries. The degree of beneficiary involvement during the projects differed from one agency to another and even from one project to another within the same agency. Different agencies approached the issue of maintenance and operation of the systems after completion differently. Some handed the systems over to the users, while others continued to control with minimal farmer input.

In view of such a fluctuating yet dynamic irrigation scenario and experience in Nepal, the various objectives and Action Plan documents are currently being consolidated into a new irrigation policy document. The objectives of the proposed new irrigation policy (still in draft form) are:[2]

i) to promote farmer organization participation in the irrigation sector through cost-effective, economical, and environmentally sustainable investment of irrigation development that contributes to a reliable increase in agricultural production and productivity

ii) to integrate all support services crucial to irrigation expansion

iii) to reorganize the management and technical units of DOI so as to support irrigation development objectives

iv) to maximize the involvement and participation of beneficiaries so as to decrease government responsibilities in irrigation implementation and thereby promoting local resource mobilization and self-reliance

v) to support personal and community efforts in irrigation development

vi) to support and strengthen the capacity of other non-government and government agencies in irrigation development

vii) to support and enhance research capabilities of national institutions in irrigation technology and management.

It is with this evolving policy backdrop that we now turn to the analysis of ADB/N and the performance of the STWs that it has help install.

ADB/N'S IRRIGATION LENDING POLICIES

ADB/N reviews and appraises the borrower and the enterprise in accordance with policies and regulations approved by its Board of Directors. The salient features of the lending policy cover i) eligibility, ii) borrower participation and loan limit, iii) security, iv) interest rates, and v) approval procedure.[3] ADB/N may finance 100% of project investment costs of irrigation and lending to small farmers.

Originally, the bank tried to overcome capital constraints in the private sector for irrigation development through financing. <u>It was realized that credit for irrigation development alone is not enough and therefore the bank provided technical support in irrigation sector both in the identification of suitable technologies and system development (IIMI, 1991).</u> Now, ADB/N is a major institution in irrigation development in Nepal. In search of newer and appropriate technologies, ADB/N has propagated shallow tubewell, dugwell, rower pump, and treadle pumps in the Tarai in thousands of hectares utilizing groundwater potential.

ADB/N's STW Implementation Process[4]

By 1990, more than 20, 000 shallow tubewells covering nearly 80,000 ha of irrigated area was financed by ADB/N. IIMI's report notes that in actual

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[2]As of March 30, 1992.

[3]See IIMI, 1991 for details.

[4]For more details on this see IIMI, 1991.

implementation however the availability of materials, availability of drilling contractors, etc. are determinant factors.[5] ADB/N provides both financial as well as technical assistance for installing STWs in the form of appointment of driller technicians, supply of materials, and regular follow up and supervision of the performance of the units.

In SFDP areas, the members are provided loans for STW as community schemes. A pre-condition for a community scheme as laid down by ADB/N is that the members should have their lands contiguous to one another. Prior to approaching SFDP for loans, the interested members have to acquire a group recommendation for the loan through group decision. This decision is furnished to SFDP and since the loan is provided on the basis of group collateral the group itself should have credit-worthiness based on past performance. The whole group is at stake with the loan and the whole group is responsible for loan repayment. The group then decides each members repayment shares.

In the non-SFDP, those who want loan have to first form a group and are treated as individual borrowers with collateral also on an individual basis. The repayment is on the basis of the land in the command area of the scheme. Sometimes the loan is taken out in the name of a single member of the group and the beneficiaries decide among themselves each individual's share. The bank treats these as individual loans thereby reducing transaction costs.

The bank also provides 40% subsidy of the total cost and also for pump sets. In community schemes, 75% subsidy is provided.

Economic Performance of ADB/N STWs

Six clusters of shallow tubewells (STWs) comprising 24 STW units were selected for the IIMI study, with two clusters each from eastern, central and western Tarai. Each cluster included 2 to 5 units of STW. The area irrigated by a unit of STW varied from 1.07 ha to 2.62 ha, with an average of 1.85 ha (Table 1).

Average cropping intensity increased by 54 percentage points following STW development. This increase mainly came from the expansion of area under dry season crops like wheat. Another important consequence of STW development has been the substitution of rice-based cropping patterns for maize-based patterns in the eastern Tarai and substitution of high-value crops like vegetables for low-value crops in the central and western Tarai sites.

Significant yield gains in wheat 42% and rice (41%) were achieved in STW sites after irrigation development. Yield gains were less dramatic for maize (21%). Among vegetable crops, potato showed the biggest potential for yield increase. The adoption of modern varieties of rice, maize and wheat and fertilizer application rates increased in most scheme areas.

Table 2 summarizes economic and financial rates of return to STW irrigation in the sample sites. The internal rate of return (IRR) was higher than 25% in all six sites, indicating high benefits to society from investment

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[5]For example, in 1989/1990 there was drastic drop in STW installation due to the India/Nepal trade impasse and the general turmoil in the country.

in this technology. STWs are also financially attractive to farmers as shown by the average benefit cost ratio (BCR) of 1.33. The estimated financial IRRs are high even though there seems to be considerable under-utilization of STWs. The average utilization of 168 hours per year is considerably lower than recommended utilization of 800 hours per year. This indicates that there is a high potential for greater utilization of STWs, with corresponding increases in returns.

Subsidies and its Impact on Groundwater Development

Subsidies are essential if private returns do not justify an investment which is otherwise socially beneficial. They may also be required to induce farmers to adopt a new technology. However, results of financial analysis show that investment in STW is financially attractive to farmers even without the 40% subsidy provided by the government. The average BCR of 1.33 and IRR of 41% are comfortably above the threshold of private incentive. In computing financial rates of return the opportunity cost of labor was assumed to be equivalent to the market wage rate. The BCR and IRR would be even higher than the computed values if a lower value for the opportunity cost were assumed. Thus, subsidies on STWs are not justified on efficiency grounds.

The proponents of irrigation subsidy argue that subsidies on groundwater development are essential to benefit small farmers. However, available data show that the groundwater program has so far benefitted mostly large farmers who are in the least need for such subsidies. For example, a 1986 survey of 248 STWs owners distributed throughout the Tarai indicated an average landholding of 6.9 ha, and that pumpset owners fell within the top 10% of Tarai farmers by farm size (World Bank, 1990). Thus, if the groundwater program is to meet the equity objective, careful targeting of subsidies will be crucial. This also calls for an active promotion of group ownership and use of STWs.

A more serious adverse consequence of the continuation of subsidies on STWs is on the availability of funds for groundwater development. Limited funds available from the government for irrigation subsidies restricts the potential for groundwater development as annual allocations of subsidy are exhausted within a few months. This situation of fund scarcity also appears to have led to a disproportionately larger share of the rich and influential in the access to subsidy.

The level of subsidies varies among different agencies involved in irrigation development. The groundwater systems developed by the Department of Irrigation (DOI) require farmers to share only part of the operation and maintenance costs. In contrast, farmers who borrow from the Bank for groundwater schemes shoulder between 25 to 60 percent of the construction costs and maintenance costs are farmers' responsibility. Thus, the implicit level of subsidy is much higher in DOI schemes than in the Bank supported projects. In view of the economic analyses of the Bank supported schemes, there is a need for critical review of government policies on subsidies for the irrigation sector.

A related subsidy issue is an assessment of the real rate of subsidy on STWs and the likely distortions on account of subsidy. Many respondents in the IIMI survey expressed the opinion that subsidy should be measured relative to world prices and not based on domestic prices, which are generally distorted. It was found that many domestically manufactured pumps and accessories were more expensive than similar products marketed in India and other countries and hence farmers were receiving a lower subsidy than they would have received under a free trade regime. Comparative data shows that a STW installation (including pumpset) using Indian equipment costs Rs.6,361 less than what it costs using locally manufactured pumps and accessories. The Bank's requirement to finance only locally manufactured pumps and accessories implies that inefficient domestic industries are subsidized at the cost of farmers and government. The price differential between imported and domestically manufactured pumps and accessories leads to lower level of subsidy (23%) than the intended one (40%). The policy implication is that farmers should have a choice in the selection and purchase of equipment.

ASSESSMENT OF ADB/N SUPPORT TO STW

Though ADB/N provides technical support for groundwater development, the IIMI research found out that the number of technical staff is extremely inadequate to cover the large area under its program. The bank also provides technical and financial supports to the private sector by providing loans for establishing workshops, importing spare parts, purchasing boring equipment, leases out pump sets to boring mechanics, and also provide trainings on STW installation to interested mechanics.

The STWs are owner operated and in the case of community schemes they are managed through mutually agreed arrangements. The beneficiaries are also responsible for repairs and maintenance. It was observed that where there was a lack of specialized mechanics many less skilled local mechanics cropped up often aggravating the pump's condition rather than repairing them. There was better private sector support and access to it for repair and maintenance of STW in areas near larger commercial towns.

Major Findings of ADB/N STWs

The economic analysis shows that there is greater pay-off to society from investing in surface, shallow and sprinkler systems, i.e., most of the irrigation projects undertaken by the bank.

A summary of the major findings specific to STW as reported in the IIMI study are:

i) Financial returns to STW schemes indicate that STW's are highly profitable to farmers,

ii) ADB/N's STW program has benefitted small farmers also by providing STW units to groups of small and marginal farmers under community irrigation schemes,

iii) The utilization rate of STW's is low in terms of area irrigated, hours operated and range of crops irrigated,

iv) The absence of competition in the pump set market has effectively reduced the subsidy provided to the farmers by the government and also has led to poor after-sale services,

vi) ADB/N's present level of technical manpower is inadequate to support its groundwater development program,

vii) The present level of training support to farmers on STW operation is generally inadequate.

PROPOSED STRUCTURAL CHANGES WITHIN ADB/N AND POSSIBLE AGENDA

In a recent MOU between ADB/N and ADB, Manila for the proposed sixth Agricultural credit project from the Manila Bank, the ADB/N is to undergo structural and functional change with a movement away from the prevailing technocratic institutional culture towards a "proper" banking culture focusing only on lending activities. As a condition for the loan as well as disbursement, ADB/N is to cut all non-banking functions, including all technical advisory functions (other than those fully funded, including overhead costs, by other donor agencies) and farmer training from its purview and will concentrate its efforts and funds only on its primary banking functions. These non-banking technical services division include the Surface and Groundwater Irrigation Sections. Technical staff, if retained by ADB/N are to be assigned as loan officers.

It would therefore be essential for ADB/N to reorient its programs and its method of project monitoring and evaluation. The technical expertise, previously in-house, will now be undertaken from outside (mainly from the private sector) since the bank will henceforth only concentrate on lending activities. In light of this new development, the capacity of ADB/N staff will have to be enhanced in its lending programs in irrigation development. The following institutional development activities will be important:

i) develop methodologies for appraising loan requests from farmers for specific irrigation subprojects;

ii) assess the capacity as well as draw up the necessary qualifications and competency of the agencies in the private sector who are potential project implementors;

iii) develop an appropriate, participatory monitoring and evaluating system for the project, including indicators of project performance (which will be partly based on farmers' own performance criteria), reporting systems and formats, etc.;

iv) develop a procedure for monitoring the project and its implementor (i.e., NGO or private sector) in terms of project performance and recommend timely corrective action on irrigation management and farmer participation.

Thus to develop such in-house capacity it would be important first to : i) inventory and assess international and local NGOs and private firms that can provide services to ADB/N either in training to other agencies or as implementors themselves; ii) determine the necessary qualifications and training for such agencies of the private sector to fulfill objectives of irrigation development and draw up guidelines for selection of implementors for ADB/N, and iii) carry out the above mentioned activities in a couple of pilot areas (covering different irrigation technologies and topographies) to field test the procedures developed.

Unless this type of in-house capacity to assess and monitor the private sector, a vacuum that was previously filled by ADB/N would be created. As was pointed out, the ADB/N STWs performed economically well, they could have still received more technical support from ADB/N. In fact that was one of IIMI's recommendation: enhance the technical support to be provided by ADB/N for sustainable support to STWs for sustainable development of STWs. Again, a donor has "forced" a structural and functional change on a borrowing institution but the fact remains that if technical assistance is to be relegated to the external, this must be managed and monitored by ADB/N. It wasn't as though ADB/N did not start out only as a lending institution. It was realized that in the very beginning that technical support was very important if ADB/N's loans were to be effective. If the present ADB/N administration feels that it should only be a lending institution, then it must also consider the replacement of technical expertise somehow so that the loans can continue being effective.

If the proposed or constricted role of ADB/N from a development bank to a commercial bank (to support privatization and private sector) focussing on rural enterprizes is to be adopted, at least at the initial stage the market has to be managed rather than expect the market forces to fill in the gap. Within the bank itself there should be that in-house capacity to monitor and assess the private sector's technical expertise and also should facilitate enhancing the private sector in the technical roles that previously the bank undertook.

CONCLUDING REMARKS

This paper examined ADB/N's support to STWs and the economic performance of those STWs in terms of sustainable support to STWs and the sustainability of STWs. It was found that the current level of subsidies needs to be reduced to distribute benefits to a larger section of the society and the need for targeting marginal farmers as the real beneficiaries. Suggestions have been made for a new role for the bank if indeed its technical component is to be phased out.

Table 1. Summary of Performance of STWs at Selected Locations

Scheme	Region	Area irrigated (ha)	Hours of operation (Hrs/hr)	Cropping intensity		Yield (mt/ha)					
				Before	After	Rice		Maize		Wheat	
						Before	After	Before	After	Before	After
Belbari	Eastern	2.62	193	220	245	2.1	2.4	-	-	-	1.6
Baijnathpur	Eastern	2.30	271	197	257	1.5	2.2	1.0	1.8	-	1.6
Chandranighapur	Central	2.28	149	213	297	1.6	2.3	1.8	2	1	1.6
Gunjanagar	Central	1.71	128	216	222	1.5	2.6	1.9	1.8	1.3	1.4
Mahadevpuri	Western	1.07	120	149	240	1.4	2.5	1.4	1.9	1.4	2
Puraina	Western	1.33	138	180	238	1.8	2.4	0.7	1	1.1	1.9
Average		1.85	167	196	250	1.7	2.4	1.4	1.7	1.2	1.7

Table 2. Summary Estimates of Economic and Financial Returns to STW Irrigation

Scheme	Economic Returns		Financial Returns			
			At full cost of investment		Excluding subsidy in investment	
	BCR	IRR (%)	BCR	IRR	BCR	IRR
Belbari	2.33	112.2	1.24	33.2	1.49	62.2
Baijnathpur	2.06	104.4	1.56	65.7	1.77	108.0
Chandranighapur	2.47	137.0	1.55	61.5	1.82	108.4
Gunjanagar	1.35	36.6	1.29	36.4	1.57	70.4
Mahadevpuri	1.54	47.8	1.23	31.4	1.48	57.4
Puraina	1.28	28.3	0.89	7.3	1.14	25.9
Simple Average	1.84	77.7	1.33	40.60	1.59	73.0

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COMMUNITY SPRINKLER SYSTEM IN SULLIKERE VILLAGE, BANGALORE URBAN DISTRICT, SOUTH INDIA

* D.S.K. RAO

ABSTRACT

During the last three decades there has been a substantial increase in well irrigation in many parts of India. This has resulted in sharp increase in ground water draft, leading to decline of water levels in many areas, particularly in the low rainfall hard rock (LR HR) areas, such as, the Eastern Dry Zone (EDZ) in the south eastern parts of Karnataka State. Water level decline has depressed well yields and increased well failures, particularly in respect of bore wells (BWs). This has also led to steep increase in the cost of well construction, affecting seriously the viability of wells. As a result, many small and marginal farmers are denied access to well irrigation.

The above situation has prompted a group of 16 marginal farmers, owning a contiguous piece of 13 hectares (ha) of land in Sullikere village of Bangalore district (Urban), to form a cooperative society (CS). The State Government (SG) has given a grant to the CS for 3 BWs, 3 submersible pumpsets (SPs) and for installing sprinkler system. The above farmers are practising community BW and sprinkler irrigation for the last two years, cultivating a judicious mix of perennial and field crops and deriving a steady flow of income.

INTRODUCTION

Sullikere village in Bangalore Urban district is located in the EDZ which is one of the ten agro-climatic zones of Karnataka State (Figure 1). The EDZ is drought prone and the annual rainfall of 768 millimetres (mms) is received mostly during the southwest monsoon season (**CGWB,1987). It is an undulating terrain and covered by red loamy soils.

The EDZ is occupied by hard rocks which lack primary porosity. Storage and transmission of ground water in these aquifers take place through secondary porosity, caused by weathering and fracturing (Raju 1985). The weathered residuum extends to depths of 5 to 10 metres (m) followed by fractured zone, up to 50m depth (CGWB,ibid). However, occurrence of fractures below 50m also is reported in a few areas.

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** Central Ground Water Board (CGWB) is the apex organisation in India for exploration of ground water.

KARNATAKA

Agroclimatic Zones

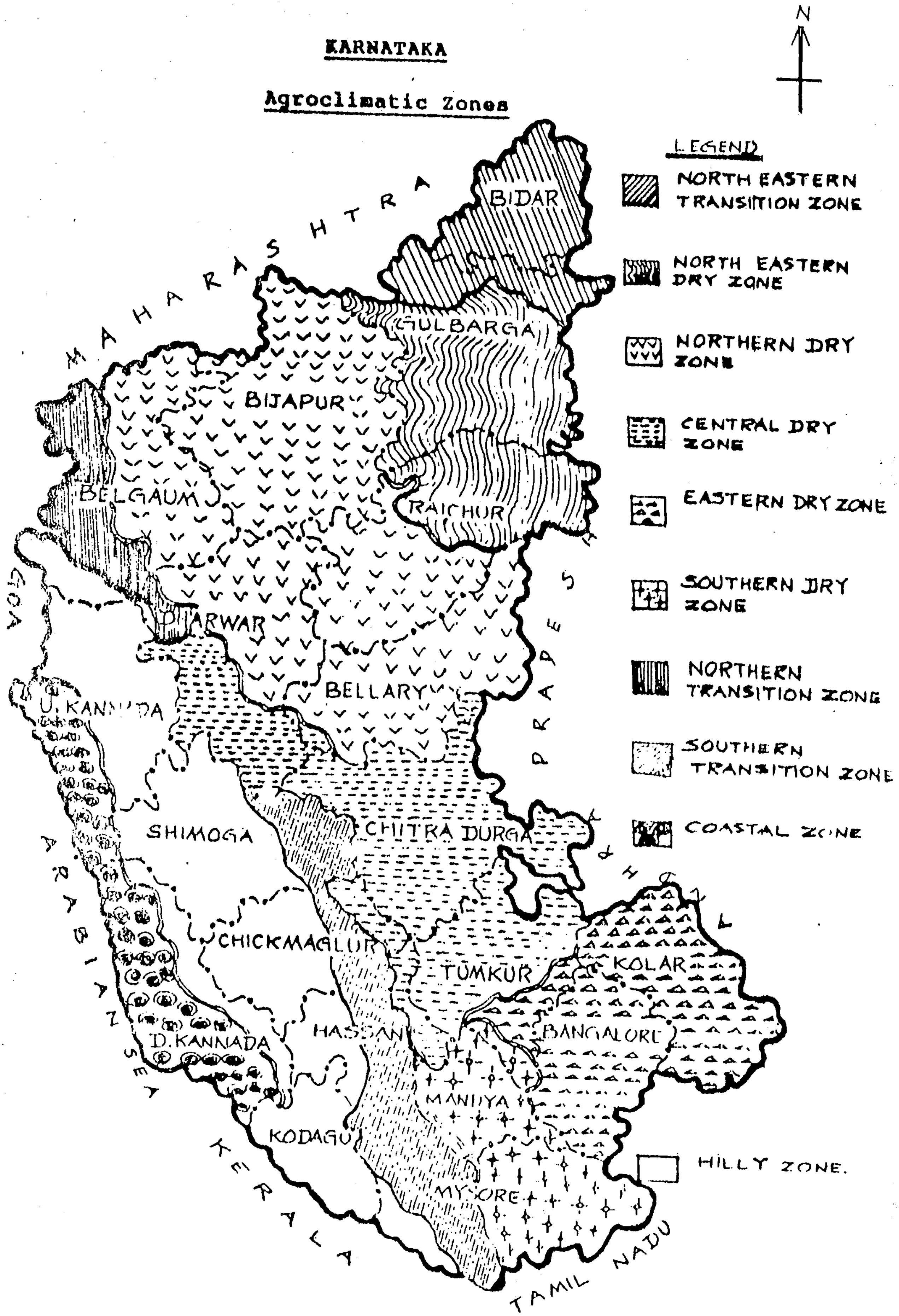

Figure 1

EVOLUTION OF WELL STRUCTURES

Irrigation well structures in the study area of Sullikere village, as in other parts of *EDZ, have undergone an interesting evolution during the last thirty years. The first phase which lasted till the early 1960s was dominated by large diameter (cross-sectional area up to 100 square metres) dug wells (DWs), rarely exceeding 10m in depth. These wells were mostly operated by bullock power. Ground water draft from these wells was extremely low (0.30 hectare metres per year) and the low discharge realised could hardly irrigate 0.5 ha of less irrigation intensive crops.

Sharp Increase in Pumpsets

The second phase of development was marked by centrifugal pumpsets, which became extremely popular because of their low cost, high efficiency and easy maintenance. Installation of a pumpset (diesel or electric) enhances the discharge and consequently the command area of a well by three to four times. Moreover, it became imperative to draw more water from wells, because during this period farmers switched over increasingly to high yielding varieties of seeds and heavy doses of chemical fertilisers which demand intense irrigation.

Even while well owners were switching over to pump irrigation, new wells were coming up simultaneously in increasing numbers. Various Government sponsored programmes, subsidising wells and pumpsets and easy availability of institutional credit gave a fillip to well construction (Rao 1991). There was more than three fold increase in the number of wells in a span of two and half decades, increasing from 1.35 lakhs in the year 1960-61 to 4.90 lakhs in 1985-86 (Figure 2).

Construction of wells and installation of pumpsets were more vigorous in the EDZ. It has 12% of the net sown area of the State but accounts for 32% of the total agriculture pumpsets (figures of the year 1990-91). This can be attributed to the heavy dependence in this area on well irrigation due to lack of good net work of canals. Deterioration of tank irrigation also contributed to the spurt in well construction (Van Oppen, et al.1983)

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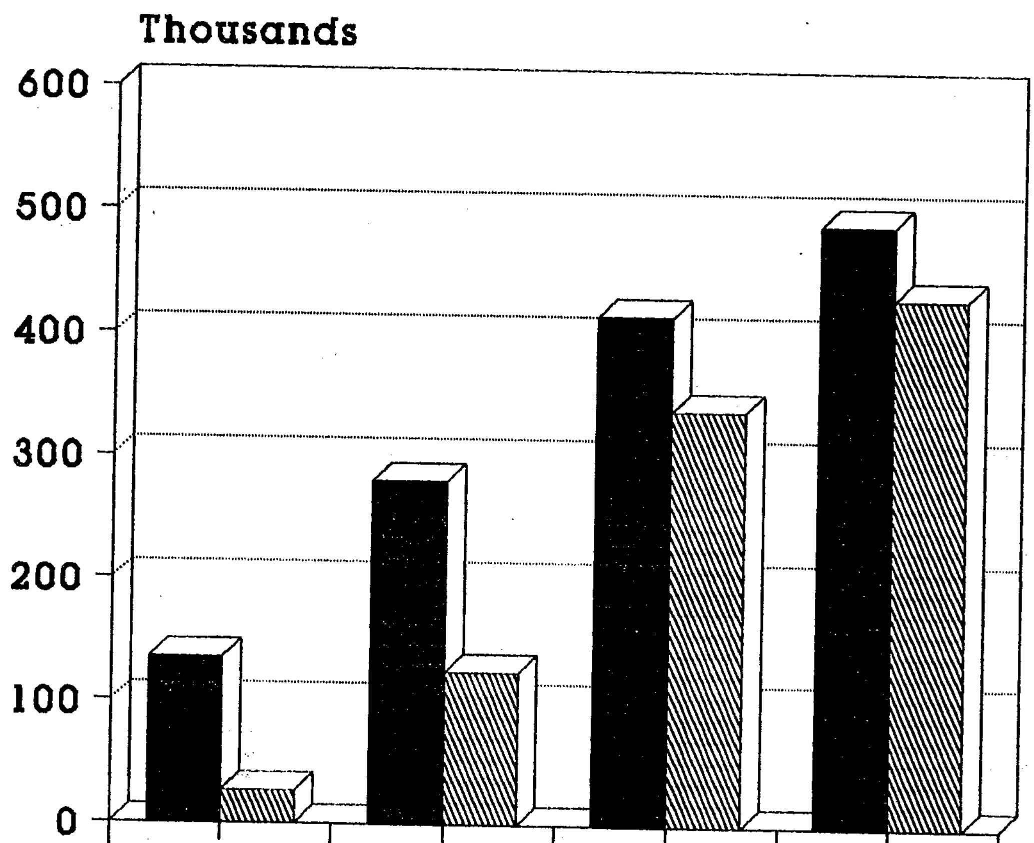
* EDZ comprises all the blocks of Bangalore Urban, Bangalore Rural and Kolar districts, besides two blocks of Tumkur district. As statistical data for parts of the district were not available, the entire Tumkur district is considered as part of EDZ in the present paper.

Wells and Pumpsets
in karnataka state.



	1960-61	1968-69	1979-80	1984-85
Wells	135	280	415	490
Pumpsets	27	124	338	430

Wells Pumpsets

(No. in thousands.)

Figure 2

Dug cum Borewells (DCBs)

The twin effect of large scale pumpset installation and increasing number of new wells has been devastating on the ground water levels, particularly in the LR HR areas, forcing the farmers to deepen the DWs periodically. Conversion of DW into DCB by drilling shallow bores was attempted by many in chasing the declining water levels. However it was soon realised that DCBs had limited use because in many areas water levels receded below the suction lift of the centrifugal pumpsets, rendering the well as well as the pumpset infructuous.

Bore Wells(BWs)

The third phase of development, marked by the introduction of BWs, commenced in the early 1980s. These small diameter (150mm), deep structures (about 50m in depth) could be constructed quickly (it takes about 12 hours to drill a borehole of 50m depth as compared to months of excavation of a DW of much shallower depth) and they dispensed with the problem of frequent deepening required for a DW. Moreover due to thick saturated zone available a BW can be operated continuously. These factors encouraged farmers in the hard rock areas, particularly in the EDZ, to construct more BWs. In a short span of 5 years since 1982, bore wells in the state increased five fold. Increase in BWs is even more sharp in the EDZ (table 1). Proliferation of BWs and their ability to yield more water resulted in further decline of water levels, particularly in areas, wherein concentration of BWs is high (figure 3).

Energisation Programme and BWs

BW proliferation has a strong link with pumpset energisation, because, unlike a DW, a BW cannot be operated without electric connection. The liberal energisation policy of the SEB since 1980 has contributed greatly to the increase of BWs.

Failure of BWs

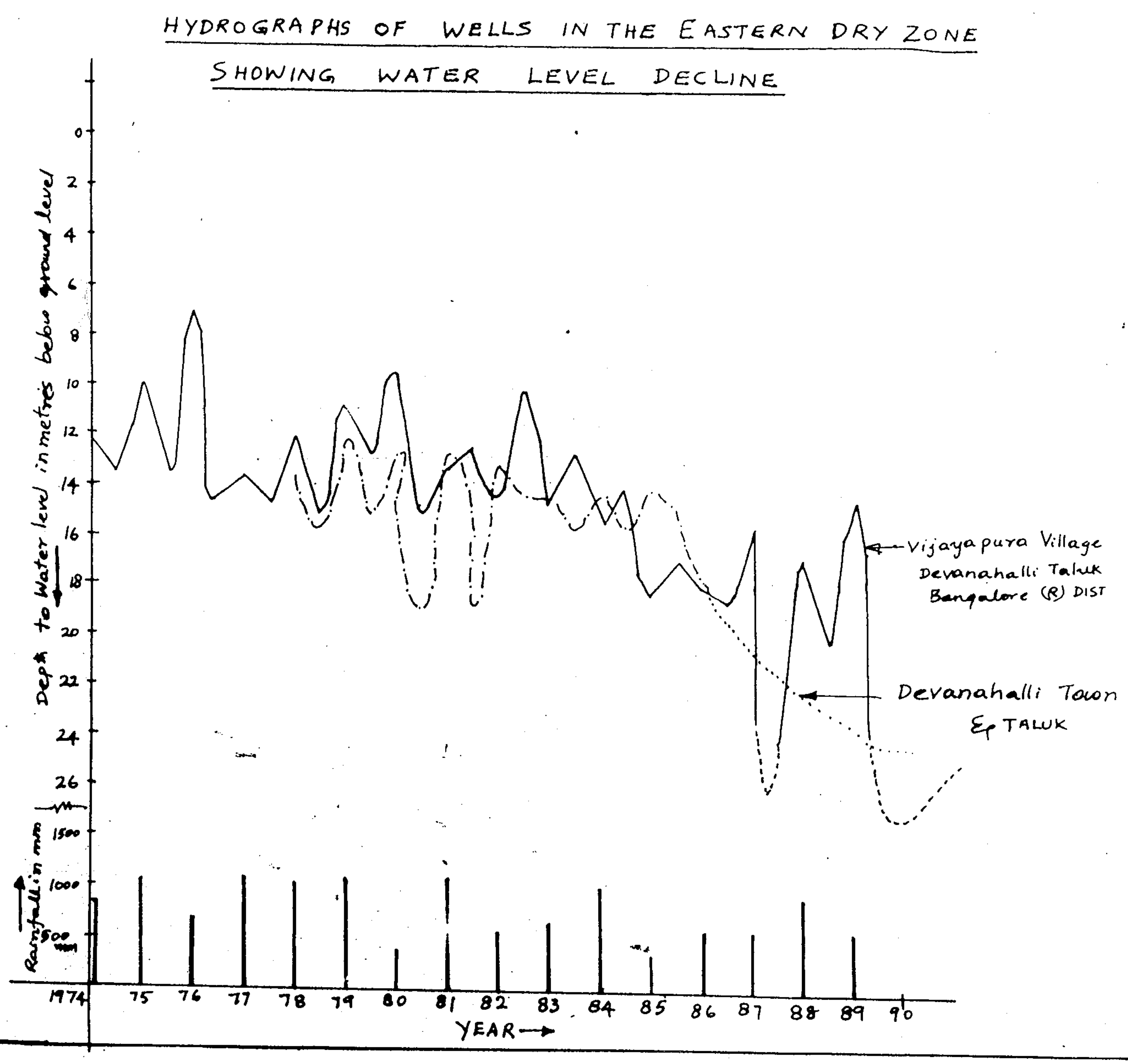
Though BWs have several advantages over DWs they suffer from the serious problem of high failure rate. It is the experience of the State owned Karnataka Agro-Industries Corporation (KAIC) (the nodal agency in the State for constructing BWs under Government sponsored programmes) that the average failure rate of BWs is 30%. As against this, failure in the EDZ, characterised by deep and declining water levels, is much higher, recording more than 50% in a few areas. In addition to high failures at construction stage BWs also suffer from declining yields as a result of fall in water levels, thus reducing the economic life of these structures drastically.

Bore Wells in Karnataka State and Eastern Dry Zone

Table 1

Zone	1982-83	1983-84	1984-85	1985-86	1986-87
EDZ	3328	5786	9862	15176	19077
Karnataka	7855	12935	21136	32385	40923
% of borewells in EDZ to Karnatal	42.2%	44.7%	46.7%	46.9%	46.6%

FIGURE 3


HYDROGRAPHS OF WELLS IN THE EASTERN DRY ZONE
SHOWING WATER LEVEL DECLINE
Depth to Water level in metres below ground level
0
2
4
6
8
10
12
14
16
18
20
22
24
26
1500
1000
500
Rainfall in mm
1974
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
YEAR
Vijayapura Village
Devanahalli Taluk
Bangalore (R) DIST
Devanahalli Town
& TALUK

VIABILITY OF WELL IRRIGATION

Power is supplied to agriculture pumpsets in the State at rupees 50 (US$2) per HP per year. As against the above meagre revenue, the SEB incurs capital expenditure of rupees 15000 (US$600) towards energisation of a pumpset and recurring expenditure of rupees 6400 (US$256) per year towards the cost of power supplied. If subsidy on power supply is withdrawn and the cost of BW failure is accounted, the viability of BWs is seriously eroded (Annexure).

Expansion of Well Commands

It may be seen from the above that there is need for optimising the benefits of well irrigation. It can be achieved by expanding the command area of a well by growing high value crops, preferably those which can be irrigated efficiently through water conservation methods, such as drip and sprinkler systems. The average discharge of a BW is 2 lps. which can irrigate about 1.5 ha. The same BW can irrigate at least 20% additional area if sprinkler system (increase in command area is even higher if it is undulatory land and/or occupied by light textured soils) is introduced. By shifting the crop pattern in favour of widely spaced crops, such as mango or coconut and installing drip system, as much as 10 ha. can be covered by a BW. However, the main constraint in expanding well commands in this manner is the predominance of small land holdings. In Bangalore district, in which the present study area is located, 52% of the land holdings are less than 1 ha (Directorate of Economics and Statistics 1990 (DES)). A similar picture is reflected in most other districts of the State. Therefore expansion of well commands is possible only if small groups of farmers learn to share a well and also the sprinkler/drip system installed on it. A rare example of such an idea in practice is evident in Sullikere village in Bangalore (South) *block.

COMMUNITY SPRINKLER SYSTEM (CSS) IN SULLIKERE VILLAGE

The State Government, under a programme of uplifting the economic condition of the rural landless, gave 13 ha. land free of cost to 16 **scheduled caste agricultural labourers of Sullikere village. Ownership of land did not, however, improve their economic condition because of low productivity of the land due to lack of irrigation facility. Income from one crop of ragi grown during the monsoon season under erratic rainfall conditions was grossly inadequate and the beneficiaries were forced to continue to work as labourers during the major part of the year.

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* Block is a developmental unit comprising of a group of villages. A few blocks form a district.

** Socially and economically backward community, with several constitutional rights and privileges.

The hydrogeology of Sullikere village is suitable for ground water development. Several Government sponsored programmes and institutional credit facilities were also available for construction of wells. However the 16 farmers could not afford wells because the land owned by each of them was too small to support the investment of about 50000 rupees (US $ 2000) for a BW, pumpset etc. Another limiting factor was the undulatory lands, which when irrigated under conventional flow irrigation, resulted in poor efficiency.

Co-operative Effort

Looking into the plight of these farmers, Mr. Basavayya, the then *Block Development Officer of Bangalore (South) block, encouraged them to form a CS and **register it with the SG so that they could derive the full benefit of the various developmental programmes of the Government.

Enthused by the B.D.O. all the beneficiaries resolved to form a CS and practice community BW irrigation. Thus Maruthi Harijana Neeravari Sahakara Sangha (MHNSS) (Maruthi Scheduled Caste Irrigation Co-operative Society) was founded in the year 1986 with 50 members (the sixteen beneficiaries included all the major members of their families as MHNSS members). The by-laws of the co-operative were framed in the lines of lift irrigation societies (several formal societies and informal groups are operating successfully in the northern Karnataka districts of Bijapur and Belgaum and the neighbouring Maharashtra state) for lifting river water for irrigation. The CS was registered with the Assistant Registrar, Bangalore (South) in June 1986. The salient points of the by-laws which were adopted by the CS are :

1) Ownership of the lands continues with the individual members.
2) Members have the liberty to choose the cropping pattern.
3) Uniform amount of water will be supplied to the members irrespective of the size of the holding and the cropping pattern adopted.

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* Middle level SG executive charged with the responsibility of carrying out developmental work in a block.

** Co-operative movement is widespread in India, particularly in the western and southern parts of the country. Movement of the people, for the people and managed by the people for ensuring equal distribution of profits to all the members is the basic concept of the co-operative movement. Any homogenous group of members (a minimum of ten) aspiring for a common cause can form a co-operative. The Co-operation Department of the SG registers the co-operatives and functions as their friend, philosopher and guide. In case of a dispute among the members, the SG acts as an arbitrator also.

Soon after registration, the members elected ten promoters, who, in turn elected the President. A salaried secretary was appointed for correspondence and looking after the day to day functioning.

The president has completed primary schooling and is a natural leader who is capable of carrying all the members with him. He is also capable of interacting with Government departments at various levels. He is the elected president since 1986 and informal discussions with the members revealed that they have no plans of replacing him.

The Secretary is an employee of the local branch of a commercial bank. He has studied up to secondary school and is capable of maintaining records and correspondence.

The nine elected promoters are in different age groups and take active interest in the working of the co-operative. One of the promoters is a literate, middle aged woman.

Technical Aspects of CSS, Sullikere

Action for water Development (AFWD), a NGO with infrastructure for BW site selection and drilling surveyed the project area in the year 1986. However drilling of BWs was not undertaken immediately for want of funds. The beneficiaries did not have own resources and were not eligible to receive bank loans because they had defaulted in the repayment of loans received earlier from banks. Finally, considering the socio-economic status of the farmers, the SG granted funds for 3 BWs, 3 SPs and laying of sprinkler system. Soon afterwards the AFWD drilled 3 BWs (in the year 1989-90) which yielded 2.4 lps, 3.8 lps and 5 lps discharge (Figure 4). SPs of 6.5, 6.5 at 10 HP were installed on the three BWs.

Cropping Pattern

The beneficiaries had their own choice of the cropping pattern. The overall cropping pattern was, however, a judicious mixture of perennial and field crops.

Table 2.
Cropping pattern in CSS farm, Sullikere village.

Perennial crops		Kharif (monsoon)	Rabi (winter)
Mulberry	3.2 ha	Ragi 3.2 ha	Vegetables 3.2 ha
Coconut	4.0 ha		
Mango	1.6 ha		
Banana	1.0 ha		

In view of the undulatory nature of the topography it was necessary to install sprinklers without which the conveyance and application efficiency would be low. Each BW has a definite command area depending upon its discharge. The design of the sprinkler system was based on the principle of applying 2.5 centimetre thick irrigation water, once in 8 days, by operating the system for 12 hours per day. The total discharge requirement for the above parameters worked out to 10.5 lps (90% efficiency) against the total available discharge of 11.20 lps. The sprinkler system was provided with aluminum pipes of 75 mm diameter and 1800 m length for the main and lateral pipes. Altogether 21 sprinkler heads were provided with a spacing of 12 m spacing.

Economics of the Scheme

Though Sullikere beneficieries have received Government grant for constructing BWs, installing pumpsets and sprinkler system, the economics has been worked out assuming market rates for the above investments. It is observed that the scheme is thoroughly viable with Internal Rate of Return (IRR) more than 50%, when the subsidised rate for power consumption is considered. However, if subsidy on power consumption is removed, the IRR is 31% (It is further reduced to 23% if 10% reduction in production is assumed).

Management of the scheme:

Each farmer is provided water for 6 hours, once in 8 days. Shifting of the lateral pipes is the responsibility of the farmer who is going to use the sprinkler system. The CS collects only the electricity charges from the beneficiaries once in a year, which is a nominal amount of rupees 125 (US $ 5) per hectare. Whenever there is pump break down, farmers covered under the particular pump collect money to meet the cost of the repairs. No maintenance fund is built up and repairs are carried out through ad hoc collections.

MHNSS - SCOPE FOR IMPROVEMENT IN THE CSS FARM

Though BWs in the study area have good and sustainable yields, the available water falls short of demand in the peak requirement period viz. late rabi and summer seasons. It is necessary to construct atleast one more BW to ensure adequate supply of water during all the seasons.

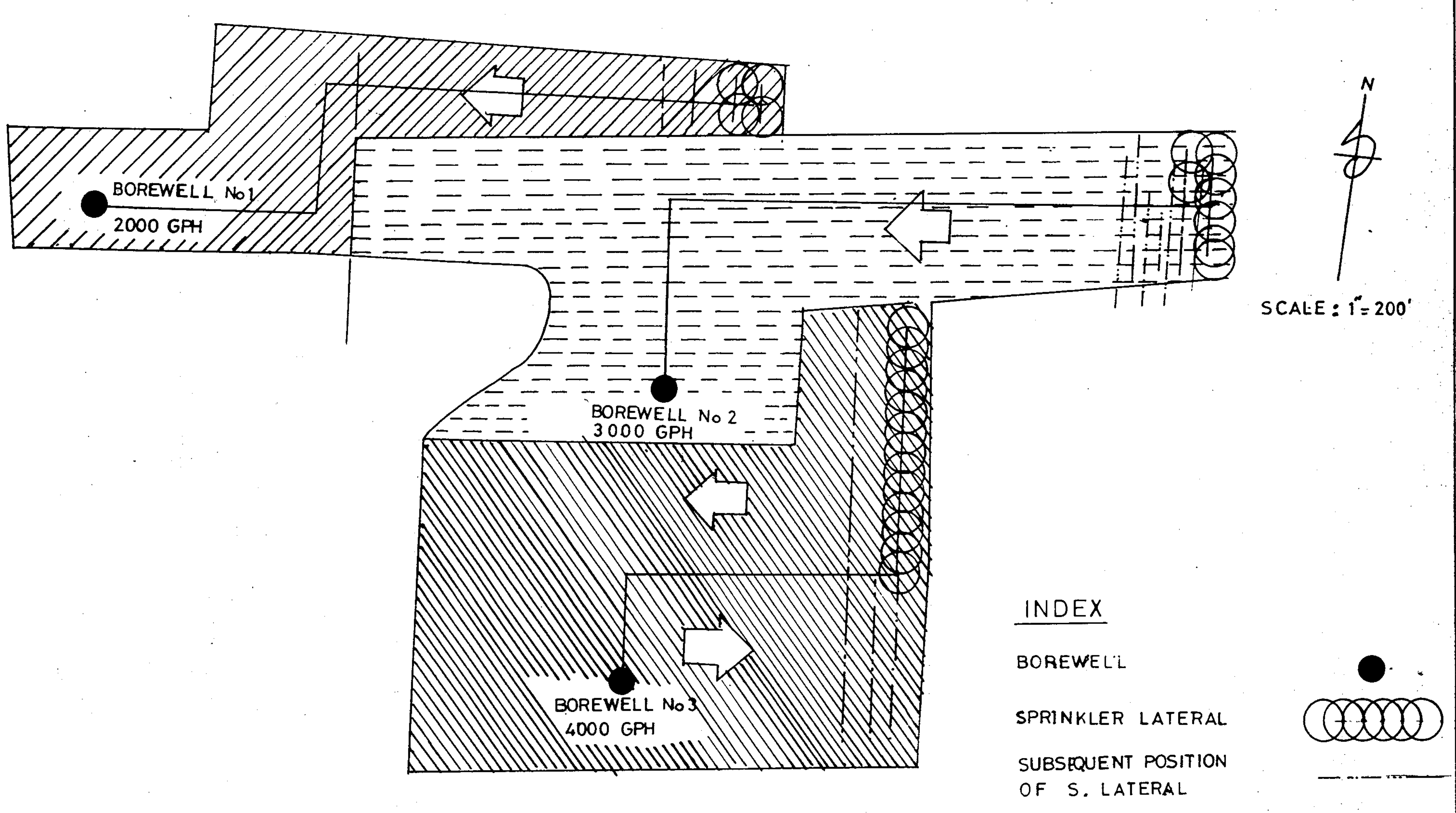
Fencing may be erected to protect the farm from encroachment.

For effective on-farm operations and haulage of agricultural produce to the market, a tractor may be added to the assets of the co-operative.

In view of the highly fluctuating voltage conditions, the SPs are bound to get burnt frequently. Quick repair to the pumpsets is essential, without which the irrigation scheduling will be seriously disrupted. For efficient management of such crisis, co-operative may build up a maintenance fund by collecting every year atleast rupees 250 (US $ 10) per hectare from the farmers.

Figure 4

COMMUNITY SPRINKLER SYSTEM IN SULLIKERE VILLAGE, BANGALORE (S) BLOCK



The beneficiaries should also repay the loans availed from banks which are presently outstanding against them. This will render them eligible for fresh loans and reduce their dependence on Government grants for any expansion or strengthening of their farms.

Efforts must be made to conduct meetings of the promoters regularly, atleast once in a month. It is also observed that elections to the posts of promoters and president were never held after the initial elections. In tune with the democratic norms of the co-operative, elections must be held once in three years, as stipulated by the by-laws.

CONCLUSIONS

The success of CSS at Sullikere could be attributed to the motivation of the BDO in forming the co-operative and the strong leadership of the President. The realisation of the members that unless they share the wells and the sprinklers, they can never have access to irrigation has strengthened the hands of the BDO and the President. Though CSS has come into existence only because of the liberal Government grants, it is a fact that successful operation of this will have a positive demonstrative effect on the marginal farmers in the neighbouring areas. Concerted efforts are necessary from the extension department of the Government in educating marginal farmers about the various alternatives available to them within the given resource constraints. The role of NGOs in this regard would be vital.

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Note: The views expressed in this paper are that of the author and not necessarily of the Organisation where he is working.

Annexure

A. ECONOMICS OF BORE WELL IRRIGATION

(Amount in rupees)

		With Subsidy	Without Subsidy
I	Investment Cost		
	Bore well	15,500.00	15,500.00
	Pumpsets	24,500.00	24,500.00
	Cost of failure	0.00	6,200.00
	Total	40,000.00	46,200.00
II	Maintenance Cost		
	Cost of power consumed/year	250.00	6,400.00
	Maintenance of pumpset/year	800.00	800.00
III	Estimated Net Incremental Income	15,900.00	15,900.00
IV	Estimated Internal Rate of Return	> 50%	22%

B.ECONOMICS OF COMMUNITY SPRINKLER IRRIGATION AT SULLIKERE VILLAGE

(Amount in Rupees)

		With subsidy	Without Subsidy
I	Investment Cost		
	Bore wells (3 Numbers)	54,000.00	54,000.00
	Pumpsets (3 Numbers)	86,000.00	86,000.00
	Sprinkler system	1,87,000.00	1,87,000.00
	Total	3,27,000.00	3,27,000.00
II	Maintenance Cost/year		
	power	1,610.00	60,000.00
	Sprinkler maintenance	3,740.00	3,740.00
	Pumpset maintenance	2,400.00	2,400.00
	Total	7,750.00	66,140.00
	Say	7,800.00	66,100.00
III	Estimated Net Incremental Income	1,44,900.00	1,44,900.00
IV	Estimated Internal Rate of Return	> 50%	31%

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Farmer managed Irrigation Systems and Sustainable Groundwater Management: An endeavour of Proshika target groups* to the Sustainability of Groundwater Management

S.C. Sarker *

INTRODUCTION

Bangladesh is one of the least developed countries in the world. The estimated current population of the country is 108.8 millions and it is expanding at a rate of 2.17 percent per year (statistical year Book - 1991). The sex ratio of the population is 106 males per 100 females. The literacy rate is 24.8 percent for population of 5 years and above. About 85 percent of the total population live in the rural areas and 80 percent are engaged in agricultural professions. Basically, the country's economy is predominantly agrarian, the cultivable land and the water resources are the principal asset of the country.

The total cultivable land in the country is 90,30,00 hectares. There are three main rice crops, cultivated in the country, which are Aush, Aman and Boro. The Boro rice is cultivated in the draught season, that is in between the period of Aush and Aman. These three rice crops cover an area of 22,2189 hectares and the crops other than rice is 516644 hectares. The groundwater Irrigation was done by 22510 Deep tube-wells, 81511 Shallow tube-wells and 12,3,051 Hand Tube-wells in 1990-91, covered approximately a total area of 10,20,000 hectares.

This paper attempts to present a synthesis of the experiences of both Proshika and of the groups of rural poor involved in groundwater Irrigation management. It outlines the total mechanisms of the implementation processes including management system through which the groups are sustaining over the last decade.

Proshika and it's experiences

Proshika Manobik Unnayan Kendra is a National Non-Government Organization in Bangladesh. Since 1976, it has been involved in organizing both rural poor for development through development education, training and support services including credit. From 1989 a similar process has been initiated in the Urban areas to provide development services to the Urban poor. From its inception it has incorporated a sustainable development approach which is economically viable, ecologically sound, socially just and culturally appropriate.

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Over the period of time, Proshika's development activities have extended to 3415 villages of 429 Unions under 70 Upazillas in 26 Districts. Presently, the total number of groups are 23,252 of which 11,615 are male and 11,637 are female. It is notable that each group consists of 15-20 members.

Proshika's work priorities are defined by themes that refer to some of the topical concerns in rural development. And, the priorities cut across its programmes projects and activities in alternative development endeavor which can be grouped into several major areas. These are as follows: a) Organization of the rural poor b) Development Education c) Employment and Income Generating Activities d) Rural Health Infrastructure e) Social Forestry f) Ecological Agriculture g) Urban Poor Development Programme and lastly h) Disaster Management.

PROSHIKA'S ENDEAVOUR TO THE SUSTAINABILITY OF GROUNDWATER MANAGEMENT BY THE RURAL TARGET GROUPS

Context

Groundwater Irrigation Project Management by the target groups as water selling enterprises, is an alternative development approach, because the members of the groups sell Irrigation water to the fields of landlords under some agreed terms and conditions. But the tradition is, the landowners possess the equipment and use Irrigation water to their agricultural field. In some cases the landowners sell water outside of their fields so that any losses from their fields can be enhanced from that additional income. The ultimate aim of the involved groups in groundwater Irrigation management is to balance the social power among the rich and poor.

So, Proshika Irrigation Programme forms a cycle of beneficiaries, starting with the landless who earn an income through selling of Irrigation water to the land owners who intern are making profit by raising productivity of crops which again benefit the larger economy of the country.

CASES STUDIES IN SUPPORT OF THE ENDEAVOURS

The following two cases studies will help the participants to have ideas about the total implementation processes starting from initiating proposal for a project upto its closing. These includes group selection, farmer's motivations, credit support, training, technical assistance, share fixation and collection, Marketing etc. The first one is a story of success and the second one is a story of mismanagement.

The first one. Bastail is a village of Mirzapur Upazilla under Tangail District, Bastail Bhumihin Samity (Landless) was formed 3 years back. The group consists of 30 members and they hold meeting twice in a month. During last three years they had been utilizing their own savings, satisfactorily.

There was an old Deep tubewell installed in 1974 within the periphery of the group's residences. They observed since beginning that the Krishak (Landowners) group could not operate the tubewell satisfactorily and only the manager was functioning individually, holding the full responsibility on his shoulder. He was facing credit, technical assistance & water charge collection problems. After three years of operation the project ceased to operate. In 1985-86, Bangladesh Agricultural Development Corporation issued a circular to sell all the old Deep tubewells to the formal and Non - formal groups and also to any individual.

Depending on the above circular the landed farmers requested the group to take the responsibility of the said Deep tubewell project. The group then expressed their desire to Proshika to support them to undertake that abandoned Deep tubewell which was existing just nearby their locality. The respective animator who organized the group and the Irrigation Technical Worker (Irrigation Engineer) discussed clearly with the group members in a formal meeting regarding social, financial and technical advantages and disadvantages, obligations of the group members and the farmers towards the project, Proshika credit norms etc. The group gave hope and ensured their sincerity and confidence. They also conducted group feasibility survey through in depth discussions regarding uniformity of group by class and by profession, group formation age, amount of own savings and the performance of their own savings management etc. and found the group feasible to operate such irrigation project. The Irrigation Technical Worker then conducted a technical feasibility survey along with the group leaders and the farmers. and found the command area most feasible with an average size of more than 45 hectares.

Then, the Proshika, group, the ex-farmer's group and the Bangladesh Agricultural Development Corporation hold a formal meeting where all the four parties agreed to transfer the said Deep tubewell to the group on cash sale basis. In another day, only group members and the farmer sat together for share fixation and agreed to fix up crop share of 33 percent and accordingly both of them furnished a bond to sale and use irrigation water for five years with renewal of agreement every year. The group then purchased that Deep tubewell for Tk. 52,800* in cash. When all these preparatory works were were done seven members management committee was formed by the group and they were send to receive training on Irrigation Project Management in the local Area Development Centre (field office). At the same time an Engine and Pump operator and a Water Distributor were employed by the management committee and they were send for receiving training on engine and pump operation and water distribution to Proshika Central Training Centre, Koitta, Manikgonj. As a first year, the command area was 18 hectares and the operational loan was given Tk. 50,000 as the cost of fuel and oil, spare parts, wages etc. After completion of first year operation successfully, the group earned Tk.87,192. They sold the paddy in amount equivalent to the loan they received from Proshika. The remaining paddy was evenly distributed among the group members.

During the ongoing operation the pump was broken down three times and were repaired by the mechanics from Bangladesh Agricultural Development Corporation along with the Irrigation Technical Worker. For better implementation of the project, the group followed the systems which were in brief;

* Taka 38.70 = 1 US $

the management committee hold weekly meeting for having approval for the preceding and forth coming expenditures. The management committee presented all the expenditures incurred during last four weeks and raised other relevant crucial management issues in the general group meeting for approval and minimisations respectively. The above systems were followed regularly for controlling operational expenditures, conflict minimisations among the groups and the farmers with Irrigation water distribution etc. During Share collections, the group was subdivided into 4 or 5 sub groups with management committee members as the team leaders. The individual sub-group was responsible for successful collection of shares and giving accounts to the group as a whole on regular basis. This system confined them in serious obligation of successful share collections. Another important system helped the group to maintain group solidarity which was democratic leadership distribution among the group members. They, during the season sit twice along with the Proshika personnel for midterm and final evaluation of their project. During the ongoing operational period the Irrigation Technical Worker and other related Proshika field personnel provided close monitoring.

In this way, the group operated their irrigation project of 30 hectares and earned Tk.1,19,200 in 1986-87, 25 hectares and earned Tk. 1,21,100 in 1987-88, 31 hectares and earned Tk. 1,24,033 in 1988-89, The project got electric connection in 1989 and the group decreased share rate from 33 percent to 25 percent, which brought a positive impression towards the group by the farmers. As a result, the command area increased to 33 hectares and earned Tk. 1,00,105 in 1989-90, and 55 hectares and earned Tk.2,06,032 in 1990-91. This year, the group has planned to irrigate 55 hectares of land with agreed crop share rate of 25 percent.

The second one. Baoni is a village of Sreepur upazilla under Gazipur District, Jonodorodi Samity organized in 1982 comprising 26 members in the group. The group was found feasible in terms of regular meeting, management of own savings, and participation in the social issues. In the same way like the first successful one, the group got the project and started operation with command area of 16 hectares in the year 1985-86.

When the group's feasibility was conducted, all the group members were found in same status in terms of class and professions except one member with a difference. His name was Abdul Malek, Proshika advised the group to terminate Mr. Abdul Malek from the group because he possessed 6 hectares of land under the scheme which made the group heterogeneous in category. Accordingly the group requested Malek to withdraw his membership from the group. But Abdul Malek had been rendering services voluntarily staying away from the group during the season and in this way he made the group members obligated to him. Besides, he diplomatically created conflicts among the group members and the farmers which intern was minimised by him often. As a result, the group felt the need of Abdul Malek and found vital for their project. Accordingly the group convinced Proshika field personnel for his inclusion. He utilized the advantages of the absence of the group members. Because many group members usually had to go elsewhere for finding jobs and thus remained absent in the group meeting often. Soon he took control of the project.

Abdul Malek diplomatically created frustration among the maximum group members by showing the project a failure one. As a result many group members were alienated from the project. The main interest of Mr. Abdul Malek was to cultivate his 2.5 hectares of land free of share and he did that very carefully. But In fact, the project did not incur losses as per general group member's and farmer's opinion. These misappropriations and blackmailing of Abdul Malek disheartened the group members to a great extent. Ultimately the project had stopped after running 4 years with severe losses. The group thus took decision to sell the Deep tubewell elsewhere and pay the outstanding loan of Proshika.

SOME MAJOR FINDINGS FROM THE ABOVE TWO CASES STUDIES

First, the selected group must be free from any mixing (class and profession) and the leadership follows a democratic process, so that each group member can get the opportunity to exercise his responsibility. Second, they should pass a reasonable organizational time for strengthening their unity and there should have enough evidences of own savings utilization successfully. Third, project expenditures must be reviewed periodically and any problem is to be solved immediately after occurrence. Fourth, there should be no confusions regarding the ownerships of the project. Fifth, maximum participation must be ensured and the involved group members are not kept busy unnecessarily all the times for official purposes. Sixth, the project benefit must be distributed evenly among the group members and impartial attentions are to be given for both the interest of the groups and the farmers. And finally, accountability and obligations towards the project are to be rejuvenated through appropriate training process.

1) Landless irrigation fosters economic, social and managerial sustainability. Irrigation water is as important a resource as land for agricultural productions. The mainstream government strategy for agricultural development is to support those who have land to acquire ownership of irrigation resource as well. This has led to further social and economic polarisation and made the landlords as 'waterlords' too, while making the conditions of the rural poor more vulnerable. This topping up of resource endowment of the rural elite as not led to better and efficient management of irrigation system. In fact, there are countless examples of failed irrigation projects due to low command area, faulty and biased water management, corruption etc. So, to address the issue of equity and better management Proshika undertook a pioneering irrigations strategy where the rural poor are assisted to acquire control and manage irrigation resources and thereby contribute to increased productivity while claiming a fair share. This has led to more social and economic power of the rural poor while also improving the management of the water resource.

Proshika has supported 744 groups with credit, training and extension services so that they can sell irrigation water to landowners. Around 80 percent projects are successful from economic, social and managerial point of view. Out of these 78 projects have become completely self reliant needing no further credit and training support from Proshika. However, some technical assistance is provided and communication is still kept by the field workers for their further development. The following table-1 also shows 13 shallow tubewells which were expanded from the income of the group members.

Table-1: List of projects which have become completely sustainable.

Districts Name	Area Dev. Centres (Field offices)	Technologies		Time required in years for reaching sustainable stage		Expansion by group without Proshika credit	
	Name of Upazilla	STW *	DTW *	STW	DTW	STW	DTW
Dhaka	Dhamrai	2	-	2	-	-	-
Madaripur	Madaripur	3	-	3	-	-	-
Do	Kalkini	1	-	2	-	1	-
Keshoregonj	Bhairab	2	-	2	-	-	-
Do	Kuliarchar	1	-	3	-	-	-
Manikgonj	Ghior	20	-	3	-	1	-
Do	Horirampur	2	-	3	-	-	-
Do	Singair	2	-	2	-	1	-
Do	Doulatpur	5	-	3	-	1	-
Tangail	Mirzapur	2	1	4	5	-	-
Do	Basail	2	-	2	-	-	-
Do	Sakhipur	2	-	3	-	-	-
Bogra	Sibgonj	5	-	4	-	2	-
Do	Gabtali	9	-	3	-	7	-
Sirajgonj	Serajgonj	8	-	3	-	-	-
Do	Roygonj	5	-	2	-	-	-
Faridpur	Bhanga	4	-	4	-	-	-
Gopalgonj	Muksudpur	1	-	2	-	-	-
B. Baria	B. Baria	1	-	1	-	-	-
		77	1	3	5	13	-

2) Female groups involved in Ground water management. Participation in the post harvest technologies by the female labourers are commonly found in Bangladesh. But Participation in the crop production sectors are rarely found in Bangladesh. But Proshika has the experiences in that sector. It initiated irrigation programme by the landless female groups in 1987 at Madaripur. After that 5 projects were implemented in the Districts of Manikgonj (Upazilla: Saturia and Ghior), Tangail (Upazilla: Mirzapur and Nagarpur) and Gazipur (Upazilla: Kaliakoir), by female groups. Out of 5 projects one had stopped for the following reasons.

* STW = Shallow Tubewell
* DTW = Deep Tubewell

- Traditional social problems, security and managerial problems.

- Misappropriations by the hired male group members in accounting and Marketing etc.

But still four irrigation schemes have been running by overcoming the above constraints. Proshika has learned a lot from the failures of the above schemes. This ongoing irrigation seasons 14 irrigation schemes are running with more participation by the female group members. They are participating in Engine and pump driving, water distribution and channel construction. Since Deep tubewell management is rather complicated than the shallow tubewell management, two Deep tubewell schemes are running jointly by the male and female groups. The management committees have formed in such a way that the female groups can exercise more control over the project.

But in terms of sustainability of the projects, Proshika is observing that the female groups are doing better, because the female group members are found comparatively sincere, careful and economic than the male group members.

3) Group members training on Engine and Pump Mechanics. Mechanic for engine and pump servicing and overhauling is very vital for the successful completion of an irrigation project. It also requires a dependable and sincere support of a mechanic. Proshika experienced that a group based mechanic is very much effective. Because he renders his duties to his own group's project as an obligation. Since Proshika trained mechanic every year, a single group may have mechanic more than one which helps the irrigation group to get support immediately after any mechanical trouble.

Based on the above experience, Proshika started training on engine and pump mechanics since 1981. Over the last decade Proshika trained 270 group members as mechanic. Among them 221 mechanics have been working since last few years very efficiently and have been earning a significant income every year. The remaining 49 mechanics have been abstaining from working due to the following reasons: 1) Could not get enough scope to exercise skillness resulted discontinuation of works. 2) Could not sell technical skills on competitive basis resulted less income which intern diverted them to work elsewhere other than mechanics.

There is a policy for participants selection which is, an interested group member who wants to be a mechanic, must be nominated by the group and before that he must have experience on irrigation water distribution and thereafter on engine and pump driving. Formal educational qualifications are not essentially required for the participants. But the nominated group member must have zeal and enthusiastic attitude. After completion of training, group usually provides loan to their member mechanic to purchase important tools and if needed Proshika also provides credit support to him through group. Prior to start the season, all mechanics sit together to allocate the working area and to fix up the seasonal charges, so that the irrigation groups do not face any mechanical trouble. There is also a standing policy that the mechanic will not claim any charges for his own project. Besides, the new mechanic will not get any scope to engage himself on major overhauling. He will have to work at least one season under any efficient mechanic. The policies which have discussed above, are setforth just to fix up the accountability and obligations of a mechanic to his primary group.

The mechanic's works are solely monitored by the irrigation technical workers. This mechanics training are often conducted by that Proshika trained member mechanics whose names are mainly ; Kalu Miah from Gabtoli, Bogra District, Abu Bakar from Roygonj under Sirajgonj District and Yasin Ali from Sakhipur under Tangail District. Proshika hired them when needed as resource persons. Proshika has been experiencing this positive endeavor very much since long ago.

CONCLUSION

Proshika's endeavor towards the sustainability of groups through ground water management is a continuous process. It requires a dynamic appropriate policy on project implementation process and Proshika does it with amendments every year by the participation of the group members and the Proshika field level workers. Proshika pays close attention both social, financial and technical aspect, so that the projects achieve a high rate of success. Probably this irrigation water selling concept by the rural poor may be a way out to solve the complex problem of equity and productivity.

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Paper No: 73

WATER UTILIZATION UNDER DIFFERENT DEEP TUBEWELL MANAGEMENT IN RAJSHAHI AREA OF BANGLADESH [1]

M.N.Hassan and M.N.Islam [2]

ABSTRACT

A study was conducted in the Deep tubewell (DTW) irrigation projects of Rajshahi.The DTWS were operated under four different management system,viz. Barind Integrated area Development Project (BIADP) of Bangladesh Agriculture Development corporation (BADC), Rental (BADC), Rental-Rajshahi Krishi Unyan Bank(RAKUB) and Private (owned by farmers).

In BIADP project, informal groups are provided with deep tubewells and the groups are to pay irrigation charge based on estimated cmmand area. Management responsibility lies with the farmers groups or their leaders but BADC retains enough control on the wells to ensure that irrigation charge is paid by the group.

The farmer groups pay BADC an annual rent of taka 5000/- in rental programme. The groups are responsible for operation and maintenance costs. Bangladesh Agricultural Deelopment Corporation retains some responsibilities for repair, but has little control on management aspects

Government has been selling DTW to individual farmers' group, since 1973. The groups are responsible for all aspects of operation and management.

Rental programme of BADC is supported by the RAKUB for seasonal crop production credit requirements . Credit is provided for operation and maintenance (O&M) and other relevent services.

Rajshahi is a dry area of the country where temperature ranges from 5-46°C and total rainfall during the month of May to September is around 1200 mm. Negligble amount of rainfall occurs during the months of October to April. The soil textures is clay to loam with seepage and pereolation rates of 2.3 to 3.5 mm/day. The dominant cropping pattern of the area are Boro- Fallow-Aman, Wheat-Aus-Aman, and Potato-Aus-Aman. Water distribution were followed by block rotation as well as head, middle and tail rotation system in each DTW. The designed discharge of each DTW was 56.6 l/sec. But actual discharge varied from 26 to 51 l/sec. Discharge of all the wells were below the designed dischage. Full irrigation was applied for Boro season and supplenial irrigation was applied during Aman season.

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1. This paper is prepared for presentation at the South Asian Regional Workshop on "Ground Water Farmer - Managed Irrigation System and Sustainable Ground Water Management" held 18-21 May,1992 at Dhaka, Bangladesh.

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INTRODUCTION

Deep tubewell (DTW) irrigation is an important means for rice cultivation during dry period in Bangladesh. There were about 25 thousnad DTWs in the field irrigating 6.1 lakh hectares of land which constituted 19.6 percent of total irrigated area. By the end of the Fourth Five year plan (FFYP) there may be another 17.5 thousnad DTWs which may irrigate an additional area of 4.3 lakh hectares (Planning Commission 1990).

The Bangladesh Water Development Board (BWDB) started irrigation programme in 1964-65. The Bangladesh Agricultural Development Corporation (BADC) joined the program in 1967-68. Both BWDB and BADC are autonomous public agencies. Deeptubewells of BWDB are managed by the agency itself. But the BADC DTWs are operated under several ownership and management systems. Some are managed by BADC itself ---- as in the Barind Area Integrated Development Project (BIADP) and others are rented and privately owned by formal or informal farmer groups. The management systems of the study sides included the following:

1) The BADC's Barind Integrated Area Development Project (BIADP)

In this programme informal farmer groups are provided with wells and required to pay irrigation charge based on estimated command area. BADC provides repairs and maintenance services to a value of up to one third of the charge. The farmer groups collect a fee from the irrigators to meet the costs of the BIADP charge, any further repairs, fuel and oil and the salaries or honoraria of the tubewell managers, operators and drainmen.Management responsibilities lie with the farmer groups or their leaders but BADC retains enough control on the wells to ensure that irrigation charge is paid by the groups.

2) The BADC rental programme

BADC has a number of deep tubewells under its rental program. These wells were installed between 1967 and 1978 and were rented to farmer groups (both formal and informal). In the 1980s, BADC tried to sell the wells to the groups but this effort was, mostly unsuccessful. As a result, the rental program continues. The farmer groups pay BADC an annual rent of Taka 5000.00. The groups are responsible for operation and maintenance costs. BADC retains some repair responsibilities but has little control on well management. The tubewell managers collect fees to cover operation and management (O&M) as well as the rental charge, but very seldome the rent is paid to BADC.

3) BADC rental programme supported by RKUB

Under this programme the DTW rental group receives O&M credit and other back-up services from the bank. The bank helps in the management of funds and the collection of irrigation charges from the various irrigators. The RAKUB program, worked wel upto 1990, but was unable to operate in 1991.

4) Private ownership and management

The government has been selling(at subsidized rates) DTWs to farmer groups since 1979. The groups are responsible for all aspects of operation and management. Most of these farmer groups exist in name only with the wells being owned and run by one or a few individuals. Capital loans were taken to purchase the wells, but the level of loan repament was very low,------- despite the fact that the fees collected from the farmers were sufficient to pay the loan installments as well as O&M costs.

OBJECTIVE

1) To identify major charactcistics of the systems.

2) To examanine the status of water utilization performance of the alternative systems under study.

3) To suggest improvement alternatives to improve system performance.

RESEARCH SITES

The BRRI and IIMI research group selected a number of tubewells in the Rajshahi region under the BIADP. These tubewells were Amtali-1, and 2, Sarengpur-1, and 2, Fazilpur-2, Ramnagar-2 and Sarmangla-1. Six tubewells rented by BADC to farmer's group were selected for the study. These tubewells were Mahabathpur-2, Buckshimal, Darshanpara, Shakua, Haridagachi and Dural-3. In three of these six wells the farmer groups were provided with production costs (including irrigation costs) by RAKUB. These tubewells are shakua, Haridagachi and Dural-3. In the same area three aditional wells owned by farmer group were also selected. These tubewells are Palasha, Moheskondi and Bakshail.

METHODOLOGY AND MESUREMENTS

Relevant data/information for the study were collected from both primary and secondary sources including: farmers, farmer leaders, agency officials, official records, studies and research reports and farmer-groups records. Methods included : participant observation, discussions with officials, farmers and farmer-leaders, maintenance of weekly records of DTW performance.

The research project initiated with the measurements and monitoring of discharge and duration, rainfall, Seepage and percolation at field level, evaporation, water adequacy and water distribution equity. In addition to the above water management parameters, crop production aspects were researched through field trials and monitoring farmer's management practices, yield and input use.

Rainfall

In Barind and Mohanpur, Rainfall was measured by True-check rain gauges, in the research site.

Irrigation water flow meassurement

Irrigation water flow was measured at deep tubewell discharge box to quantify the water aailable in each of the DTW areas. Measurement was made by the use cut throat flume, V- notches and pitot tubes.

Measurement of conveyance loss

Conveyance loss at tertiary, secondary and main canals of the Deep tubewell were measured by the inflow - outflow method.

Evapotranspiration

Evaporation (EV) was measured from U.S.weather Bureau class A pan. In this study potential ET rate for rice was considered equal to the class A pan eaporation rate for the same day. Review of literature suggests that for rice the ET=EV over the growing season more or less close to unity when water is not a limiting factor (Bhuiyan, 1982; Kampen, 1970 and Sevendsen, 1983). Daily measured evaporation data were used to compute weekly and seasonal evapotranspiratlion values.

Seepage and percolation

Seepage and percolation was measured by using the water subsidence techinque (Giroan and Wikham,1976). In this method the water loss from a paddy field takes place as evapotranspiration (ET), surface drainage (DR), and seepage & percolation (S&P). If no water is added to nor drained from the field, then the total water used would be due to ET plus S&P and would be reflected by a corresponding subsidence or loss of head of water on the paddy field surface. Assuming that daily evapotranspiratlion is computed from evaporation pan data and subtracted from this head loss fall in depth of water, the remainder of the daily fall in water level is equal to the S&P rate provided there is no surface water flow into or out from the paddy.

Water use

Water used in the project area was either from irrigation source or from rainfall. Water use status was evaluated interms of; Water used for land soaking & land preparation upto transplanting, seasonal water use and Non-beneficial water supplies preior to seedbed preparation.

Yield assesment

Yield were assessed on the basis of crop cuts taken in each season in the 30 selected plot of each deep tubewell area. Crop cut samples were taken in each season to estimate yeilds. For crop-cut samples a five square meter sample area was harvested from each plot taking one meter square harvests from five different locations of the plot. The harvest was threshed and grain yield measured. Moisture content of the grain was determined by a mositure meter. Yield was adjusted to 14 percent moisture content and expressed in kg/ha.

RESULT AND DISCUSSION

Characteristics of the system managements

For attaining the objectives of irrigation, all systems of management have to perform certai irrigation management tasks which have been categorized and listed by various authors in different ways. Uphoff (1986) identifies twelve irrigation management activities which he has grouped into three broad categories. The three broad headings are : (1) Organization and management activities, (2) physical system activities, and (3) water use activities. Sevendsen and small (1990) categories the activities of an irrigation system into six of what they call Primary irrigation processess : Planning design construction, operation of facilities, maintenance and application of water to the land.

In this section of the paper, the main focus was on the identification of salient characteristics of the four DTWs management systems under study, with reference to some of the management tasks identified by different authors as noted above.As bacaground,certain general attributes of the tubewell systems include :

<u>Pump and well attributes.</u> There was wide variation in the ages of the DTWs of the different management systems. The oldest DTWs belong to the Rental and Rental-RAKUB system , their average age is 15 years. The most recently installed DTWs are private ownership. All of the sample DTWs of this system were commissioned in 1989. The BIADP, DTWs are relatively new, their average age being 4.7 years. All the sample DTWs utilize turbine pumps, and they are operated with diesel.

Command areas. A majority of the DTWs were installed in suitable locations for achieving maximum command area. The topography with reference to the heads of DTWs of Rental and Rental-RAKUB DTWs command areas are sloped, that of Private DTWs are medim sloped and of BIADP DTWs are medium sloped and teraced. The canal networks of Rental, Rental-RAKUB and BIADP DTWs are simple in the sense that they have a few number of branch channels. In contrast, in the private DTWs, the canal network. consists of a large number of main and subsidiary canals & channels.

Water allocation. In Bangladesh if a farmer has land under the command area of an irrigation system, he is entitled to get water from the system provided he pays irrigation fees and abides by the rules and norms decided by the system management in the common interest of irrigators.

In case of DTW irrigation a farmers perceived entitlement to water strongest if the DTW is rented and managed by a group of farmers of which he is member and the entitlement is weakest if the DTW is owned and managed by a few farmers not including himself. In a system when a DTW is owned by a public agency and managed partially by a farmer group and partially by the public agency, and where water is used in return for the payment of a specified irrigation fee, a farmers entitement to water is also strong but not as strong as in the case of a rental DTW managed by his own group.

Farmer organization for managing the systems. All sample DTWs except those under private management have farmer irrigation organization. These organizations are informal in the sense that they are not registered groups or cooperatives.

All of the DTWs, however, have irrigation management committee consisting of nine to eleven members. In all cases when there are irrigation groups, the managing committee (MCs) of the irrigation groups are also the irrigation management committees (IMC). One observation of the research team is that the irrigation groups in all management systems under study are defunct for all practical purposes. They seem to exist mainly on paper. The IMCS/MCS; too, are not very active.Irrigation tasks are managed primarily by the manager of a group in collaboration with one or two other persons.

Water distribution. Mostly DTWs followed a rotational practice of water distribution. Under the rotational practice, the management divided the entire command area into blocks.No of blocks in the Rental System ranged from 3 to 6, in the Rental -RAKUB from 3 to 4, in Private tubewells from 2 to 4 and in the BIADP system from 2 to 5. The blocks were divided in two ways : (a) in terms of head, middle and tail and (b) in terms of rotational sector.

Operation, repair & maintenance of DTWs. In each of the systems the DTWs were operated by a driver who is under the direct control and supervision of the manager. In the private system, repair and maintenance of DTWs is the responsibility of the tubewell owners. BADC, which is the supplier of DTWs, is under agreement to supply the services of mechanics up to five years from the date of sale of a given DTWs. In the Rental, Rental- RAKUB and BIADP systems, repair and maintenance responsibilities lie with the BADC which owns the DTWs. In Rental and Rental- RAKUB, the farmer groups are required to pay Tk. 1000 per year for free supply of some spares. The groups included in the study did not pay this amout but decided to purchase their spares from local markets. In the BIADP system, the cost of spare parts in excess of one third of the fee paid by farmers to the BIADP authority, was borne by farmer groups.

Water availability and utilization

The desgned discharge of each tubewell was 56.6 lit/sec but actual discharge were less than the designed. Among Barind tubewells the maximum discharge of 51 lit/sec was recoreded at Amtoli-1 which was 8% less than the designed and the minimum of 28.3 lit/sec at Sarengpur-2 which was 50% less than the designed discharge. In Mohanpur area the maximum discharge of 50.2 lit/sec was recorded at Buckshimul which was 11% less than the designed and the minimum of 26.6 lit/sec at Mahabbatpur-2 which was 53% less than the designed discharge (Table 1).

In terms of area irrigated during kharif-1 season, in 1990 it was found that the private DTWs performed best followed by the Rental DTWs. On average for each cusec discharge, a private tubewell irrigated 15 hectars and a Rental tubewell had irrigated 13.23 hectares (Table 1). The performance of Rental with RAKUB DTW was 12.81 hectares while the BIADP DTWs covered only 10.3 ha (Table 1). The performance in 1991 followed the same trend as in 1990. Area per cusec discharge under private, rental and BIADP were 13.2, 10.3 and 8.1 ha respectively. However, none of the systems was able to acheive the practicable command area.

Water productivity. On average water productivity for private and rental with RAKUB were 7.63 and 5.73 kg/ha mm respectively. The performance of Rental tubewell was 5.40 kg/ha mm while the BIADP tubewells had 5.10 kg/ha mm (Table 2). The performance in 1991 did not follow similar trend as in 1990. Productivity of water in 1991 under private,rental and BIADP were 6.63, 6.6 and 4.2 kg/ha mm respectively (Table 3)

Field level water use efficiency. Water use efficiency was 92% for Barind tubewells and it was 76% for Mohanpur area (Table 4 & 5). The soil type of Barind was silty clay & it was loamy in Mohanpur. Low efficiency was observed in Mohanpur which may be attributed to light soil type.

Crop yield. Under irrigated conditions,farmers grew only rice during the Kharif-1 season. Crop-cut yield records in 1990 shows that yeild was highest in BIADP DTWs (5.3 t/ha) followed by Private DTWs (4.75 t/ha). The lowest yield was recorded in Rental DTWs (3.76 t/ha). In 1991 private DTWs farms got the highest yield (5.6 t/ha) followed by Rental and BIADP farms(Table 2).

Distribution of water among farmers. It has been mentioned earlier that in 1990 almost all of the sample farmers received water reasonably on time and in sufficient quantity so in this respect there seems to have been no problem of distributional equity in that year. 1991; however, in the Rental DTWs, farmers of all categories stated that they did not receive water in time and in sufficient quantity.

Suggested strategies for improvement of system performance

1) Dicharge capacity of DTW is limited and there is no scope to increase it. Presently the DTW are operated for 8-10 hours a days. Irrigated area per DTW can be easily increased by increasing daily operating hours to 16-20 hours. Increases operating hours will supply greater volume of water for additional area under each DTW.

2) Presently, rotational system of water distribution is not practically followed : consequently huge volume of water is misused resulting in poor area coverage. There is no set rule for water distribution in any agency though it is a key factor for improving area coverage. Rotational water distribution should be followed for blocks as well as for crops' water requirement.

3) Diversified cropping plan should be adopted for maximizing use of land and water resources. Cropping schedule should be adjusted so that Aman cultivation can take advantages of maximum rainfall period.

4) The Bangladesh Rural Development Board and Co-operative societies should come foreward for the management of systems.

5) For smooth distribution of water canal net work should be properly designed.

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Table 1. Designed Discharge, Actual discharge, Command Area, Irrigated Area of the Selected Tubewells of Barind Project, Godagari and Mohanpur, Rajshahi, Boro, 1990 and 1991.

Location	Design discharge (li/sec)	Command area (ha)	Actual discharge (li/sec)		Irrigated area (ha)	
			1990	1991	1990	1991
			BIADP Rental DTW			
Sharangpur-1	56.6	24.3	26.9	39.9	17.5	18.2
Sharangpur-2	34.0	18.2	28.0	28.3	10.7	8.9
Sharmongla-1	56.6	24.3	37.1	33.1	4.4	2.0
Fazilpur - 2	56.6	24.3	34.0	45.6	14.8	9.7
Amtoli-1*	56.6	24.3	49.3	51.0	-	-
Amtoli -2**	51.0	21.9	28.0	33.0	6.8	-
Ramnagar - 2	56.6	24.3	34.2	37.1	14.2	14.0
			IFAD DTW Mohanpur			
Shakua **	56.6	24.3	52.1	-	13.5	-
Haridagachi**	56.6	24.3	40.0	-	18.4	-
Durail - 3	56.6	24.3	45.3	47.5	30.4	20.0
			Rental DTW Mohanpur			
Mohabathpur-2	56.6	24.3	53.2	48.1	23.6	20.9
Bakshimul	56.6	24.3	48.1	50.2	28.3	15.0
Darshanpara**	56.6	24.3	36.8	-	12.8	-
			Private DTW Mohanpur			
Palsa	56.6	24.3	49.3	45.5	27.1	22.3
Moheskondi	56.6	24.3	51.0	41.60	27.7	24.3
Bakshail	56.6	24.3	47.3	44.5	23.7	14.7

* There was no Boro rice crop in 1990 and 1991

** There was no Boro rice crop in 1991.

Table 2. Water Availability and Productivity of the selected Tubewells of Barind Project, Godagari and Mohanpur, Rajshahi, Boro season, 1990.

Location	Actual Discharge (li/sec)	Total operating hour	Water depth (mm)	Rainfall (mm)	Total water (mm)	Yield (kg/ha)	Water productivity (kg/ha-mm)
BIADP Rental DTW							
Sharengpur-1	26.9	977	540	171	711	5000	7.0
Sharangpur-2	28.0	1108	1045	171	1216	5420	4.4
Sharmongla-1	37.1	300	890	171	1061	5230	4.9
Fazilpur-2	34.0	1207	984	171	1155	5320	4.6
Amtoli-2	28.0	632	938	171	1109	5600	5.0
Ramnagar-2	34.2	1133	989	171	1160	5425	4.7
IFAD DTW,Mohanpur							
Shakua	56.6	548	613	171	784	3610	4.6
Haridagachi	56.6	790	617	171	788	3606	4.6
Durail-3	56.6	750	402	171	573	4590	8.0
Rental DTW Mohanpur							
Mohabathpur-2	56.4	677	550	171	721	4453	6.1
Bukshimul	56.6	877	537	171	708	3000	4.2
Darshanpara	56.6	471	480	171	651	3833	5.9
Private DTW,Mohanpur							
Palsa	56.6	690	451	171	622	5566	8.9
Moheshkondi	56.6	599	397	171	568	5233	9.2
Bakshail	56.6	590	546	171	717	3446	4.8

Table 3 : Water Availability and Productivity of the selected Tubewells of Barind Project, Godagari and Mohanpur, Rajshahi, Boro season, 1991.

Location	Actual Discharge (li/sec)	Total operating hour	Water depth (mm)	Rainfall (mm)	Total water (mm)	Yield (kg/ha)	Water productivity (kg/ha-mm)
			BIADP Rental DTW				
Sharangpur-1	39.9	1046	788	39	827	4492	5.4
Sharangpur-2	28.3	748	809	39	848	4250	5.0
Sharmongla-1	33.1	196	1423	39	1162	3925	3.4
Fazilpur-2	45.6	881	1427	39	1466	4777	3.3
Amtoli-1*	-	-	-	-	-	-	-
Amtoli-2*	-	-	-	-	-	-	-
Ramnagar-2	37.1	1273	1148	39	1187	4641	3.9
			IFAD DTW, Mohanpur				
Shakua *	-	-	-	-	-	-	-
Haridagachi*	-	-	-	-	-	-	-
Durail-3	47.5	740	634	59	693	5010	7.2
			Rental DTW, Mohanpur				
Mohabathpur-2	26.6	735	571	59	630	4527	7.2
Bukshimul	56.2	650	748	59	843	4585	5.4
Darshanpara*	-	-	-	-	-	-	-
			Private DTW, Mohanpur				
Palsa	31.13	706	579	59	638	5911	9.3
Moheshkundi	41.60	695	663	59	722	5704	7.9
Bakshail	30.33	512	639	59	698	5097	7.3

*There was no Boro crop.

Table 4. Field level Water use efficiency for rice growing period in Sarengpur-1 Deep Tubewell (Barind) and Moheskundi deep tubewell (Private), Boro season, 1991.

DTW	Irrigated area	Water applied (mm)			Water required (mm)			Water use efficiency
	(ha)	IR	RF	Total	EV	S&P	Total	(%)
Sharangpur-1 (Barind)	18.2	830	39	869	579	225	800	92
Moheskundi (Mohanpur, Private)	24.3	650	59	709	274	262	536	76

Table 5. Seepage and percolation (S&P) rates measured in Barind and Mohanpur areas, Rajshahi, Boro season, 1991.

Month	No. of effective readings	Barind Area * Average S&P (mm/day)	No. of effective reading	Mohanpur Area* Average S&P (mm/day)
March	115	2.40	125	3.60
April	130	2.30	140	3.55
May	150	2.20	170	3.45
Average		2.30		3.53

*Weighted by number of samples

farmer managed irrigation system / groundwater extraction

Paper No 77

SUSTAINABLE FARMER-MANAGED GROUNDWATER IRRIGATION SYSTEMS

M.A.Kalam[1] Aung K. Hla[2]

ABSTRACT

A quiet revolution has taken place in Bangladesh with the introduction of a variety of technologies for abstracting groundwater. These facilities which are primarily Farmer Managed Irrigation Systems (FMIS) have brought irrigation within the reach of millions. The full usefulness of groundwater however, has yet to be exploited. A concerted attack on the challenges of managing the groundwater irrigation systems still remains to be attempted. The problem is compounded by the decreasing per capita grain production and per capita cropped area. The low level of productivity virtually at subsistence level renders FMIS vulnerable to externalities. Prevailing organizational, promotional and support services imposes high risks and heavy managerial responsibility upon FMIS operators far beyond their capability and capital resources.

To move away from traditional agriculture and attract increased investments and the use of resources, four factors must be satisfied; they are :

i) improved and sustainable performance at system level;
ii) improved profitability and production at farm level;
iii) Greater efficiency in the use of resources; and
iv) Overall net benefit.

At the moment too little is attempted to address solutions to the above. There is need to inspire action on the inherent potential of the groundwater irrigation development and transform it into a domestic effort. Strengthening water management institutions by providing support services are also essential to render FMIS sustainable.

Successful development depends on encouraging an interacting system of public and private institutions where investments in areas such as physical infrastructure, research and extension are sustained. Increased attention and efforts must be made to make FMIS investments and productivity viable. To sustain their continued use will depend on resource endowments, institutions, technological changes and policies.

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SUSTAINABLE FARMER MANAGED GROUNDWATER IRRIGATION SYSTEMS

1. INTRODUCTION

Bangladesh,located in the outlet for three of the largest rivers in the world presents the challenge of a densely settled, rapidly growing and improvished population facing alternating seasons of water surplus and deficiency. It is subjected to the raw power of nature distinctively characterized by their destructive, constructive and necessary elements seen nowhere else. It has a population of 110 millions placing about 12 people per hectare of arable land as compared to 1.3 in the USA. The water regime of Bangladesh has made it one of the most rice intensive agricultural systems in the world. Both nature and farmers have adapted themselves to its unique water regime in many ways. In relation to the basic problem of growing enough food for the increasing population, overcoming the lack of winter rain is far more important than managing periodic natural disasters like floods and cyclones. Growth in grain production is directly related to the availability of irrigation, the indispensable 'platform' supporting all other green revolution inputs.

1.1 RESOURCES

A. Land resource

There are 9.03 million hectare (Mha) cultivatble land in Bangladesh of which about 7.56 Mha are considered irrigable. In 1989 irrigation was extended to 3.1 Mha of which about 1.81 Mha came from groundwater irrigation systems. It has been proposed in the Fourth Five Year Plan that by the year 1995 a total of 4.8 Mha is expected to come under irrigation of which about 3.02 Mha is expected to be be extended from ground water (Table-1).

B. Water Resource

Many in Bangladesh are now aware of the wastefulness of thinking in terms of surface water only rather than the entire water resource, much of which is under ground. Master Plan Organisation (MPO) has estimated that available recharge is in the region of about 21,088 million cubic metres (Mm^3) of which about only 8806 Mm^3 was withdrawn in 1990 for agricutural purposes. The future developement potential from groundwater resource will require the active commitment of the political and engineering establishments in moving away from the historical orthodoxy that the only real water is the water that can be seen on the surface. The slow recognition of the abundance and full usefulness of groundwater, and of the particular challenges of its management, must be counted as one of the constraints on full water development.

2. PURPOSE OF THE PAPER:

This paper intends to support discussion on conditions and problems of sustainability associated with Farmer-Managed Irrigation Systems.

3. GROUNDWATER IRRIGATION SYSTEMS:

Groundwater is extracted from the aquifers through waterwells (locally called tubewells) to meet the irrigation demand as well as to supply for domestic and industrial purpose. These tubewells comes in various types and sizes and could be identified under three categories as follows:

a. Manual Irrigation Pump (MIP)
   i) Hand Tubewell(HTW) ii) Treadle Pump(TP)
   iii) Rower Pump (RP)

b. Suction Mode Tubewell (SMTW)
   i) Shallow Tubewell (STW)

c. Force mode tubewell (FMTW):
   i) Deep Tubewell (DTW)

The development of Groundwater Irrigation Systems curiously enough was first undertaken when 'large-scale' capital intensive projects were favoured. As a result DTWs preceeded STWs and HTWs were introduced before the Treadle pump. The type of technology chosen have in large measures affected the organization and management of the irrigation systems. With the multiplicity of technology choice and put through a learning process by encouraging 'Hands On' FMIS systems have enabled us to achieve a technological breakthrough. Gradually with the greater diffussion of technology the country has been able to transform its traditional agriculture and also mechanise the riverine transportation system.

Large-scale DTWs were first introduced in the late 1960's modelled after the Comilla Co-operative Movement that stressed farmers' group management on technology, finance and organisation. It was determined that a DTW with 56 litres per second (2 cubicfeet per second) pumping capacity would be appropriate. According to a 1991 survey there are about 32626 DTWs on the ground.

STWs entered service more unobstrusively in the mid 1970's but has come to reserve its place as a first in the choice of technology. STW suited the enterpreneural urge of the farming community because it was considerate on costs and relatively more manageable than a DTW. A 1991 survey estimated that there are about 2,05,262 STWs on the ground.

To make irrigation available to small and marginal farmers HTW were first introduced in the early 1970's. Subsequently, Treadle and rower pumps which were far superior than HTW and also cheaper were introduced. By 1990 Orr, Islam and Barnes estimated that over 9,00,000 manual irigation pumps were in operation. The rapid pace and size of growth demonstrated the unsatisfied demand for small irrigation equipment which have proven to be more controllable and affordable and stressed farmers entrepreneurship.

4. SUSTAINABILITY OF GROUNDWATER FMIS:

Historically groundwater irrigation systems contrary to misconception was the result of vibrant public-private partnership. While authorisation of resources had been the domain of the public sector, the management at the farms level had always been absolutely with the enterprising farmers. This is a unique example of privatisation of long before it became a fashion. The partnership had encouraged various forms of supply, ownership and management of the irrigation systems at farm level, they are :

1. Public supply and ownership, private management;
2. Public supply private ownership and private management;
3. Public supply NGO ownership-private management.
4. Private supply private ownership and private management.

Despite massive thrust in creating facilities for groundwater irrigation systems, per capita grain production(Fig.1) and per capita cropped area (Fig.2) are decreasing. The low level of productivity virtually at subsistence level is not so much because farmers lack dynamism and motivation. It is because the prevailing organizational, promotional and supporting service for practising modern agriculture imposes high risk and heavy managerial responsibility upon FMIS operators far beyond their capability and capital resources. The low level of research and technical support and inadequate marketing facilities have made them reluctant to intensify and diversify crops. The smallness and fragmented nature of their holdings,a legacy of semi-feudal agrarain system have also discouraged farmers from utilizing modern farm machinery(ISPAN,1989). Against this backdrop some of issues that concerns sustainability of the FMIS needs examining:

4.1 Management Organization :

The ownership and management trend through the years have inexorably put the FMIS to take on responsibilities for which they are not quite prepared. Inspite of a variety of management styles, there is no clear winner because all of them are subjected to externalities quite beyond their control. Reduced credit, high energy costs, equipment pricing, groundwater regulations and cost of produces all have a dampening effect rather than a productive effect.

4.2 Resource Management:

MPO's action research findings have clearly delineated exclusive mutual zones for suction mode and force mode zones, but with the inability of any control over siting of facilities for STWs three differing scenarios are becoming more probable :

i. STWs enroaching on existing DTW command area;
ii. Entire zones of STW areas lowering water tables to the point that everybody pays excessive energy costs of pumping;

iii. DTWs sunk in STW areas lowering water tables to a point that only DTWs are viable and force the suction mode out of operation.
iv. Excessive/unregulated pumping affecting social/ecological environment.

A reasonable legal framework that can be enforceable is clearly necessary to delineate STW-DTW zones and also maintain a sharp edge over aquifer management initiatives continuously.

4.3 WATER MARKET

According to water market study (BAU, 1986) it was found that the market however imperfect was competitive and reasonably efficient. There was ample opportunities to seek to support the water market through institutions. It recommends taking positive actions to promote access by the poor to credit and water markets to allow them to complete on fair terms with the already well endowed.

4.4 EQUIPMENT MARKETING :

The private trading of irrigation equipment though limited to STWs is largely the effect of duty free import of small engines intended for agricultural use. This tariff facility has in practice encouraged foreign dumping of low-cost small diesel engines(in some cases) while suppressing local assembly and which are used extensively for marine and industrial purpose too. Consequently, traders are not required to direct their services to cater to information, repairs and O&M aspects of irrigation equipment. Although FMIS have little to expect anything tangible from traders there is however a real need for an efficient support service sector.

5. ACTIVITIES TO SUSTAIN FMIS:

Of all the challenges confronting Bangladesh perhaps none is more focal and urgent than creating an environment and a policy framework to encourage sustainable farmer managed groundwater irrigation systems. The four factors required to be addressed are:

i. improved and sustainable performance at systems level.
ii. improved profitability and production at farms level.
iii. greater efficiency in the use of resources.
iv. overall net benefit at national level.

5.1 Farms level:

Farms attitudes are shaped mostly by the desire to ensure food security and increasing prosperity and was mould by the public-private partnership involved in developing groundwater irrigation systems. The most significant element inherent in this partnership was the evolving sense of social roles. While FMIS undertook farms management the public sector assistance in terms of price support, O&M support services and arranging credit was imperative. This partnership can cater to the heightented expectation from the farming community as defined by generating more jobs, profits, systems revitalization and generally improve quality of rural life. Some of the activities required to be initiated are:

a) ensure favourable pricing of equipment and produce;
b) improve drainage/water conveyance system;
c) improve farm land command area to assist mechanization;
d) educate and provide training to introduce modern farm practices;
e) protect the environment; and
f) provide sustained investment.

5.2 SYSTEMS LEVEL

With groundwater estimated to provide greater part of the water to meet irrigation requirements for the next 20 years a massive investment programme by both the private and public sectors is in order according to the National Water Plan (1991). Expected investment is not forth coming, because of many uncertainities: a) Private sector not yet fully ready (b) public sector withdrawing very fast, (c) supply is not yet ensured (d) price is not stabilized. The slowed investment has meanwhile just about managed to cripple the water well drilling industry and the manufacturing industry. A smooth transition of groundwater development capability from the public to the private sector is essential. Apart from the institutional aspect some of the other activities required to restructure and transform groundwater irrigation systems are :

a) Maintenance of the pace of creating groundwater irrigation systems per year (2500 DTW plus 10,000 STWs per year) according to MPO (1991) should also take into account replacement of worn out units @ 2000 DTW and 30,000 STW per year.
b) Resources for action research to evolve technological innovations to determine most cost effective technologies under different aquifer conditions should be ensured.
c) Land and irrigation system improvement to increase and consolidate command areas under irrigation as well as encourage the use of modern agricultural machinery from tillage to post harvest operations.

5.3 NATIONAL LEVEL

Increasing self-reliance is a oft stated public policy. The potential to achieve self-reliance is most profound in groundwater development than compared to any other resource. The domestic manufacturing industry have the capacity to manfuacture/assemble all componets of irrigation eqipment, the drilling industry have the capacity to invest,mobilise and construct water wells and the services sector is also poised to move in. There is however no coherent initiatives to transform groundwater development industry into a domestic private market domain.

Steps to restructure institutions to bring about required changes, can be considered by taking the following measures :

1) Rationalization of tax and tariff to encourage local manufacture / assembly of prime movers (diesel engines and motors) both in the public and private sectors.
2) Strengthening the water management institutions at Farm level (both seller and buyers) to perform viable water management.

6. CONCLUSION :

At the very focal point of groundwater development lies the central issue of improved production and profitability that could render FMIS sustainable. The spark to motivate the farmers to invest more and prosper requires examination of a leading constraint - the historical non-commitment of the decision making elites to the primacy of groundwater. Groundwater development has the potential to be a domestic effort which can take us to the path leading towards self- reliance. Yet this sector is allowed to function marginally proportionate to external aid resources which is understandably kept low. Mobilization of domestic resources is inadequate.

6.1 RECOMMENDATIONS:

1. Based on the findings of the National Water Plan a massive groundwater development programme is in order and the effort should attract more public and private investments.

2. Restructuring of Development agencies to handle the Development role as dictated by public-private partnership.

3. Rationalise trade, tax and tariff system and encourage domestic self-reliance in the groundwater-based industries.

4. Strengthen water management institution by providing support as needed.

5. Take measure to develop skills and knowledge at all levels on water and land resource management.

6. Introduce farm land command area high producitivity movement with popular/practical slogan.

7. Strengthen the feedback Information System to monitor performance of FMIS.

TABLE-1

IRRIGATION : ACHIEVEMENT AND FFYP TARGETS

MODE OF DEVELOPMENT		BENCHMARK (1989)			FFYP TARGET (1995)		
		Mha	%NCA	%IA	Mha	%NCA	%IA
A.	Surface Irrigation						
a)	BWDB Schemes	0.21	2	3	0.50	6	7
b)	Low Lift Pump	0.78	8	10	1.09	12	14
c)	Traditional	0.30	3	4	0.20	2	3
	Sub-Total (A)	1.29	13	17	1.79	20	24
B.	Groundwater Irrigation						
a)	STW	1.25	13	16	2.20	24	29
b)	DTW	0.50	5	7	0.70	7	9
c)	FMTW	-	-	-	0.05	1	1
d)	HTW	0.05	1	1	0.05	1	1
	Sub-Total (B)	1.81	19	24	3.02	33	40
	Total (A+B)	3.10	32	41	4.81	53	64

Source : Fourth Five Year Plan (1990)

Abbreviations"

NCA - Net Cultivable Area (9.03 Mha)
IA - Irrigable Area (7.56 Mha)
STW - Shallow Tubewell (Suction Mode)
DTW - Deep Tubewell (Force Mode)
FMTW - Force Mode Tubewell
HTW - Hand Tubewell

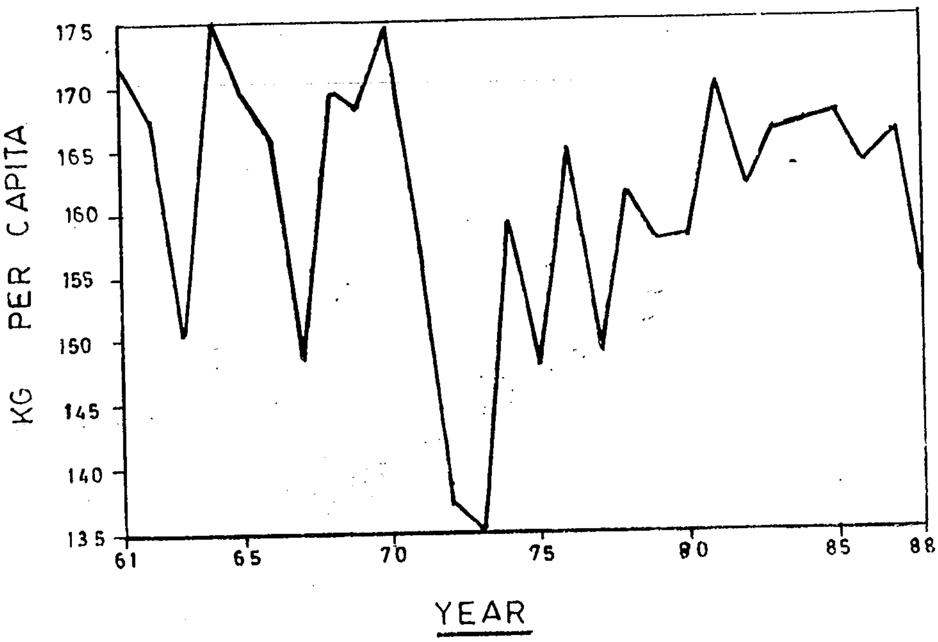

FIGURE 1

Trends In Per Capita Grain Production Bangladesh
Source Statistical Yearbook For Bangladesh 1987

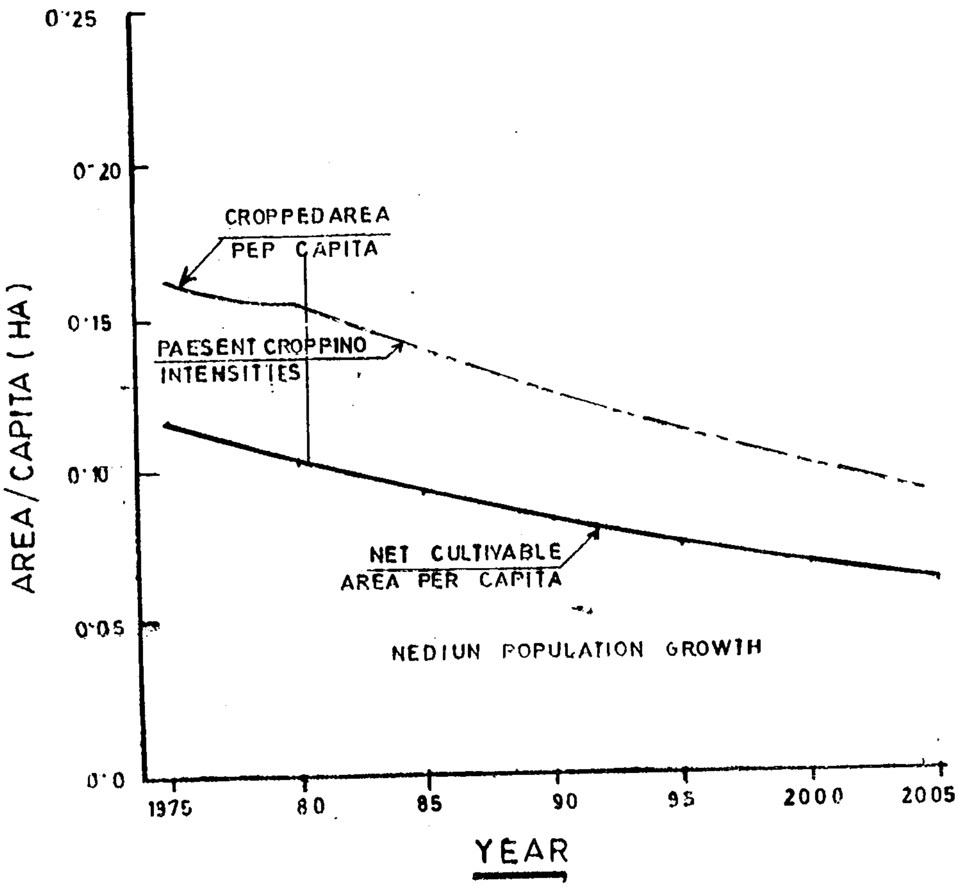

FIGURE 2

Decline In Cropped Area Per Capita In Bangladesh 1975–2005
Source National Water Plan (1985) I Figure 3-2

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groundwater extraction / tubewells / farmer participation

UTILIZATION OF GROUNDWATER RESOURCES IN NORTH-WESTERN SRI LANKA: SOME ISSUES PERTAINING TO SUSTAINABLE DEVELOPMENT

M.D.C.Abhayaratna*

ABSTRACT

There has been an increasing emphasis during the last few years on the development of the groundwater resources in the Intermediate and Dry Zones of Sri Lanka. Construction of shallow dug-wells are subsidized by two implementing agencies of the government through the Agrowells Programme to promote year-round cropping. Nevertheless, the Programme has not preceded by proper hydrological surveys. At the very inception the Programme has suffered a number of setbacks specially with reference to group-wells. On the whole the subsidy covers only a fraction of the cost of constructing a well and poorer farmers are automatically excluded from the Programme as they have no means to meet the balance expenditure. Over-estimation of the potential of the agrowells, exposure of the farmers to the Programme without proper training in the methods of irrigation and pump maintenance, inadequate attention given to agronomic aspects of groundwater utilization, negligence of the institution-building for the post-construction phase and the failure to mobilize active farmer participation are major constraints to the sustainable development of the ground water resources. It is imperative that the strategies followed at present should change towards achieving sustainability for the future.

INTRODUCTION

Expansion of irrigated agriculture in Sri Lanka during the recent past is closely associated with the increase of major irrigation schemes and the rehabilitated village tanks. Despite the significant rise in the irrigated area the total extent covered by all surface gravity irrigation systems do not still exceed 25 percent of the cultivated area of the country. However there are vast stretches of land with favourable soil and terrain characteristics lying outside the command areas of the existing irrigation systems in the Island's Dry and Intermediate Zones[1] where water remains the major constraint for agricultural development. hence, there has been increasing emphasis on the utilization of the groundwater resources with a view to tap the agricultural potential of these lands.

Except in the Jaffna peninsular in the extreme North of the Island where the rich aquifers are associated with miocene limestones, groundwater was never used on a large scale elsewhere in the Dry Zone. Nonetheless, many studies have indicated the potential of groundwater resources for improved cropping and livestock farming in the Dry Zone (Fernando 1973;Madduma Bandara 1977,1979,1984;W.R.B. 1984;Land Commission 1987).

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Realization of the need to utilize such resources particularly for the benefit of those farmers who do not have access to irrigated farmlands, inter alia, led the government of Sri Lanka (GOSL) to assist the construction of shallow dug-wells for agricultural purposes. Assistance took the form of a subsidy to construct a well of stipulated dimensions and was administered through the Agrowells Programme. The two government agencies directly involved in the implementation of the Programme are the Provincial Department of Agriculture (PDA) and the Agricultural Development Authority (ADA).

METHODOLOGY

The present paper makes an inquiry into the Agrowells Programme in the Kurunegala District of North-Western Sri Lanka with a view to highlight (a) the initial problems it has faced (b) implications for sustainability and (c) attaining sustainability for the future groundwater development. Conclusions are drawn with reference to a rapid appraisal of the Kurunegala District Programme in the light of the field evidence from two villages, viz, Nochchiya and Apaladeniya (Fig 1). The villages are purposively selected from two agroecological zones with varying cropping systems. Nevertheless, both villages have agrowells given by the PDA and the ADA.

THE VILLAGE PROFILES

Nochchiya is a tank village situated about 8 km. West of Galgamuwa, a small township in the Dry Zone. Mainstay of the economy of the village is paddy cultivation which is restricted to the rainy season- Maha. Village tank provides supplementary irrigation for the paddy crop during this season. Cropping during Yala, the dry season is uncommon at Nochchiya. However, few farmers have used their domestic wells particularly to grow vegetables on a restricted basis. On the whole, majority of the farm families are below the poverty threshold[2] and have no access to off-farm employment.

The second village - Apaladeniya - which is located in the Intermediate Zone is better endowed both with respect to the amount of rainfall received and the socio-economic standing of the villagers. Here the yaya, paddy tract, is entirely rainfed in Maha and the cultivation during Yala has been irregular. Nevertheless,the majority of the households have substantial incomes from coconut, paddy and betel.

CHARACTERISTICS OF THE AGROWELLS PROGRAMME

Both government agencies implementing the Programme utilized the village level societies and Grama Niladharies[3] to create an awareness about the Programme and to familiarize the application procedure. In both cases the selection of the beneficiaries rested in the hands of a committee comprising

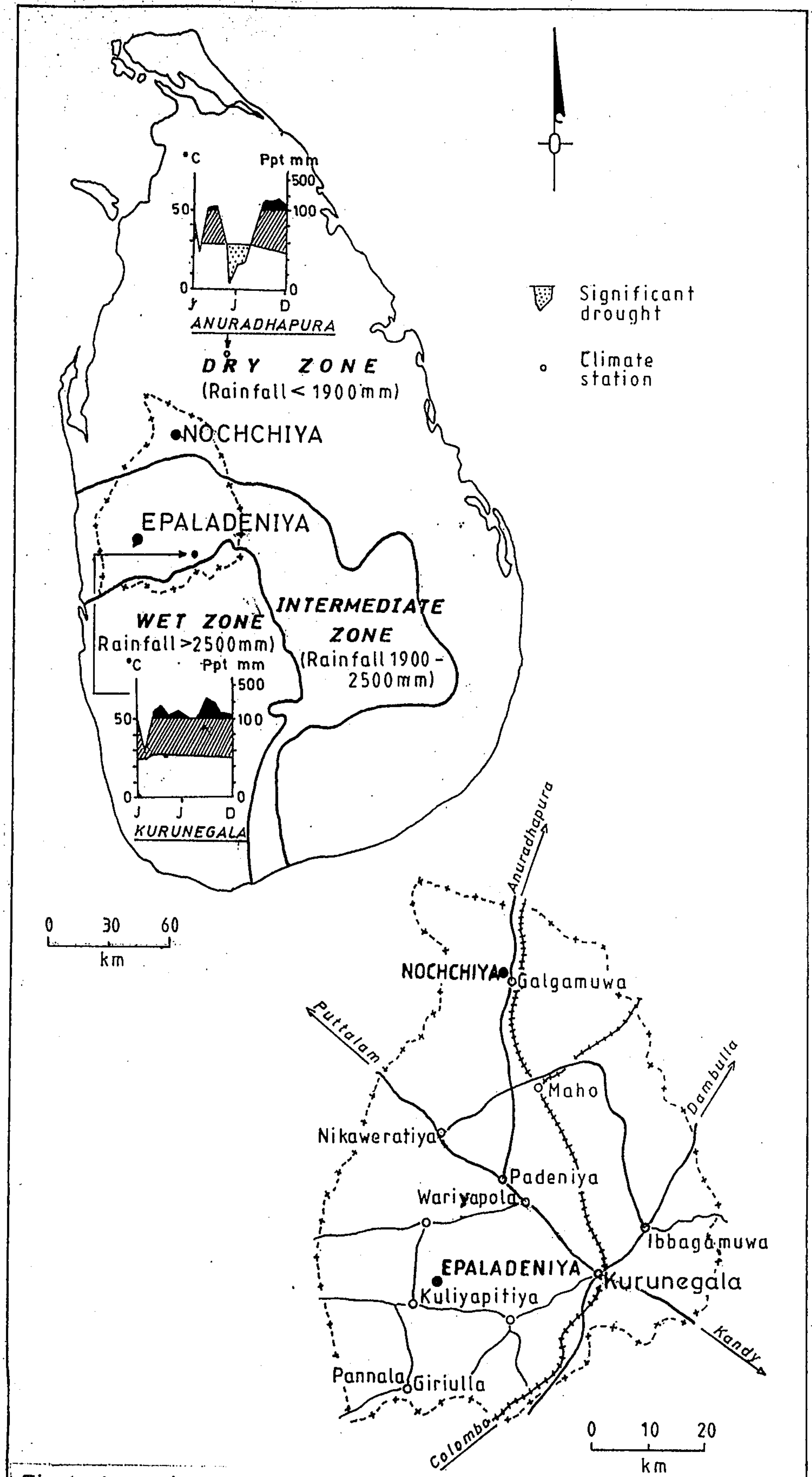

Fig.1: Location of Study Villages

local level officials. However, the Programme administered by the PDA and the ADA slightly differed with reference to the extent of the subsidy and the envisaged tenurial conditions under which the well was operated.

The PDA Programme

The PDA inaugurated its Agrowells Programme in 1989, where a dug-well of 5m. in diameter and 7.5 to 10m. in depth was subsidized to the extent of Rs.20,000 (US $ 476). This amount has been increased to Rs.25,000 (US $ 595) with effect from January 1992. The first instalment is released only after the successful completion of a test well of about 1.2m. in diameter. As the wells are given only to farmer groups under the PDA Programme, group formation had to precede the application. Solidarity of the group was anticipated on a continuing basis for effective water distribution and promotion of cash crop farming through groundwater utilization. Contrary to expectations, group formation has been confined to meet the specific requirement in the application procedure. It is observed that the groups in both villages are not bona fide. Instead of the active farmers who should comprise the group, the names of the family members, relatives and neighbours who are not much interested in utilizing groundwater for agriculture have been included.

At Apaladeniya only the leader of the group in whose land the well is located, is engaged in inter-cropping betel wines in his coconut land. None of the other four members has interests in farming. The leader has got his own water-pump. However, he has not tapped the maximum potential of the well as he is unable to command command the heavy labour requirements of the betel cultivation which supersedes other crops with reference to returns. It is observed that Apaladeniya has a long tradition for betel cultivation which has been irrigated from domestic wells as the need arises. With the introduction of the Agrowells Programme the village received one group-well and 6 individual wells. All recipients of agrowells in the village have more than 0.4 ha. of coconut lands partly inter-cropped with betel and the income level of the villagers are much above those of Nochchiya. At Apaladeniya the introduction of the Agrowells Programme has not led to a completely new cropping pattern, but it has been instrumental in strengthening and expanding the existing inter-cropping system. The choice of other field crops is limited in this villagea as they should essentially be suitable for inter-cropping with coconuts.

However, such restrictions do not exist in many areas where groundwater development has proceeded. Author's experience outside the study locations in the same district confirms that the dynamic farmers have utilized groundwater to grow commercial crops on an organized basis accrued much profits. Spread effects of these ventures among the farming community has been noteworthy.

The situation at Nochchiya stands in contrast to Apaladeniya. The former village exhibits a marked concentration of precipitation received within four months of the year and cropping during Yala is not at all possible without recourse to irrigation. Thus, the provision of agrowells is considered to be a welcome gesture by the farmers at Nochchiya as the utilization of groundwater can not only promote dry season cropping but also save at least a portion of the paddy crop in Maha if the water supply from the tank is reduced to critical levels. However, the location of wells in the yaya itself or in the adjoining lands is necessary for this purpose. Presently this village has one group-well given by the PDA and three individual wells sponsored by the ADA. In addition, the village has been given three more wells by a non-governmental organization which has sponsored rural development programmes in Sri Lanka.

A group of four farmers received the PDA agrowell at Nochchiya. The group comprises the leader, one of his relatives and two neighbours each possessing more than 0.4 ha. of land. The well is located in the land belonging to the leader. One member of the group has already severed his connections with the group owing to personal disagreement with the leader and the other two still cultivate small extents of about 0.1 ha. in their own plots. Once the leader completes his round of irrigation, others obtain the leader's water-pump on hire to irrigate the crops in rotation.

It is observed that no conflicts have arisen pertaining to the distribution of water during the two seasons which were cultivated under the well. Nevertheless, the volume of water that can be stored in the well seems to be inadequate to crop more than 0.3 ha. during the dry months. Two active members of the group other than the leader feel that they will not be economically benefitted by sharing this extent as they have to bear added costs for pump hires. Hence, they wish to withdraw allowing the leader who had been instrumental in getting the well and who possesses the means to lift water, to continue with cultivation. In both villages, for all intents and purposes, one individual - the group leader - exerts his authority in operating the well.

The group-well subsidy also specifies that whenever the land in which the well is constructed belongs to an individual the plot of land with the well has to be separated and vested with the Agrarian Services Committee[4] of the area by a title deed. Similarly, the owner of the land is expected to guarantee that he will not deny the other members of the group free access to the water source. It is observed that this condition has not been fulfilled by the group leaders in both villages. Authorities also find it difficult to enforce the procedure as the owner is in no way compensated for forfeiting a portion of his land on behalf of the group.

In each village the subsidy for the group well has been obtained and the extra costs in completing the well were met by the respective leaders in whose land the wells are located. It is evident that the other members of the group are hesitant to commit financial resources when there is no guarantee about the water rights. Purchase of water-pumps through bank loans has also posed problems to members other than the leader, as they are not assured of continuing incomes from farming through the utilization of groundwater.

No special marketing arrangements or credit facilities have been provided to the beneficiaries. Farmers use the existing marketing channels to sell their produce and to purchase the necessary inputs. The village fair constitute the most common marketing forum. However, at Apaladeniya farmers have formed a Betel Growers' Association with a view to establish linkages with export markets. It should be noted that this development is not a direct outcome of the Agrowells Programme.

The ADA Programme

The ADA launched its programme of assistance to agrowells in the Kurunegala District during 1990. It took the form of a subsidy of Rs.15,000 (US $ 357) disbursed in three instalments. This amount has been increased to Rs.20,000 (US $ 476) from January 1992. As in the case of the subsidy granted by the PDA, here too the first instalment is released only after the successful completion of a test well.

A noteworthy contrast of the ADA activity from that of the PDA is the grant of the subsidy exclusively to individuals. However, the ADA has specified conditions such as the possession of a farmer identity card, membership of the Pension Scheme[5] for the farmers and the ownership of undeveloped land exceeding 0.4 ha. subject to a maximum extent depending on the present use. A beneficiary should also be a resident in close proximity to the location of the well and should not be a defaulter of a loan taken from a bank.

Even if a farmer becomes eligible under the land ownership/operation criterion of a maximum of 0.4 ha. he should be in a position to command financial resources to complete the test well in order to get the first instalment of the subsidy. It is observed that the subsidy can cover only a part (25-50 percent) of the total cost of a dug-well. Entire expenses for a well range from Rs.30,000 - 60,000 (US $ 714 - 1428) depending on the soil conditions, mode of excavation, material used for well-lining and expenses for labour and masonry. Hence, the poorer farmers are automatically excluded from the Programme as the cost of constructing an agrowell is beyond there means. Nor are they in a position to obtain pumps for lifting water.

AGROWELLS PROGRAMME : LESSONS FROM EXPERIENCE

Although the Programmes administered by the PDA and the ADA are at the early stages of development, it is possible to make some observations with a view to rectify the initial errors and to focus attention on the sustainable development of the groundwater resources in the hard rock areas of the Kurunegala District. Detailed surveys to ascertain the extent and the spatial distribution of the groundwater resources have not preceded the promotion of agrowells. However, hydrological surveys were conducted in isolated locations of the Kurunegala District by the Water Resources Board (Wijesinghe, 1990). Present practice followed by the implementing agencies is to ascertain the water availability on the basis of farmers' test wells. One meter depth of water within the first 6 m. and a recharge rate of about 100 - 125 liters during the first hour after emptying are considered to be adequate indicators to suggest water availability for the grant of a subsidy.

Significant aquifer drawdowns leading to water shortages are not evident in the study locations or in the neighbouring areas and the level of recharge is satisfactory with the existing extents of cropping. It is pertinent to note that the farmers still cultivate restricted areas under the wells and year-round cropping is not at all practiced. Hence, it is of vital importance to watch the behaviour of the aquifers very closely with the increasing extraction of groundwater. Thus, the haphazard development without recourse to scientific investigations should not proceed further.

IMPLICATIONS FOR SUSTAINABILITY

Past experience shows that immediate attention should be drawn to a number of factors which are of crucial importance vis-a-vis the sustainability of groundwater utilization.

(a) Many wells have been completed recently and the farmers do not have adequate experience of the water requirements of the crops grown, specially during the dry months. Similarly, they do not seem to have a clear idea of the irrigation intervals. Thus, the existing crops are often over-irrigated or under-watered.

(b) Farmers are still unable to judge for certain the exact extents that can be cropped under one's own agrowell on a year-round basis. It is reliably understood that the officially predicted potential at the inception of the Programme (ie. 0.8 ha.) cannot be realized throughout the year. Cropping in the dry season is restricted even to less than 40 percent of the stipulated extent.

(c) When the genuine farmer groups are formed, involvement of too many cultivators has led to unrealistic economic expectations and disillusionment.

(d) Institution-building to cater to the new demands of commercial crops has not received the attention of the implementing agencies of the Programme. As the subsidy covers only a part of the cost of a well, meeting the credit needs of the farmers to buy water-pumps and the necessary inputs to expand the cultivation of field crops seem to be of crucial significance.

(e) With the increasing demand for agrowells more attention should be paid to the spacing of the wells. The present specification of 100m between two agrowells does not take the existing small diameter wells for domestic cum agricultural purposes into consideration. However, close spacing of wells may lead to reduced yields and restriction of the area under cropping, thus jeopardizing the economic interests of the farmers who ventured groundwater irrigation. Further, it will negate the positive aspects of the Programme.

(f) Effective farmer participation is neither promoted by the authorities nor is it forthcoming. Although a group has been formed owing to the personal initiative of one farmer who becomes the leader in order to obtain the subsidy, farmer groups have not consolidated after the construction of the agrowell. Past experience shows that with the utilization of groundwater for cropping the groups often disintegrated and cultivation restricted to the leader's own plot. Individual owners of the agrowells feel that interaction among the beneficiaries is not a dire necessity as both irrigation and cropping is the concern of one person. However, group activity specially in the fields of input supply and marketing and participation in the Programme through formal or informal meetings and sharing of experiences can be of mutual benefit to the farmers.

TOWARDS FUTURE SUSTAINABILITY

It is imperative that the present strategies should change towards more sustainable use of the groundwater resources. The agencies concerned should think "beyond the well" and try to evolve farming techniques and cropping patterns which can utilize the available groundwater to the utmost benefit of the farmers and to the country at large. Adaptive research will be of much significance to solve area or farm-specific problems such as water quality, soil reaction and adaptability of crops. High-value crops with low water requirements and scope for livestock farming should receive sufficient attention in the research programmes.

"Season mentality" of the Dry Zone farmer should essentially be changed with the development of the groundwater resources. Year-round irrigation should replace the existing Yala and Maha seasons. Periods of harvesting, particularly of vegetables, can easily be adjusted to coincide with the periods of high demand owing to shortage of supply.

Since the ultimate objective of all these changes is to give the maximum benefit to the farming community, strategies should be evolved to seek the active participation of the farmers. Utilizing the existing institutions for awareness creation programmes, encouraging the less active farmers to share the experiences of the successful ones, convincing the farmers about the advantages of group action, increase of farmer-agency interactions, making the beneficiaries partners to the action oriented research programmes and involving farmers in monitoring and evaluation activities are some fruitful strategies to promote farmer participation. Farmer representation in local level committees pertaining to groundwater development will be a significant forward step as the beneficiaries will thus be involved in the decision-making process. Effective farmer training in irrigation methods, water management and pump maintenance as well as the introduction of appropriate agronomic practices should form integral parts of the future groundwater development programmes.

CONCLUSIONS

Experience with the Agrowells Programme shows that it will not reach the poorer farmers with small plots of land. As the full potential of the agrowells are still not realized it is too early to come to definite conclusions. However, in the light of the field evidence it is possible to highlight some basic problems such as the failure of the members of the group-wells to perform up to expectations, over-estimation of the irrigation potential of the agrowells, inadequate attention paid to suitable agronomic practices, lack of preparation on the part of the implementing agencies to cater to the farmer needs during the post-construction period and inability to mobilize effective farmer participation. Hence, it is imperative that the existing strategies for groundwater utilization should change towards more effective policy orientations aiming at sustainable development.

Notes

1. Sri lanka is divided into 3 climatic zones (Wet, Intermediate and Dry) on the basis of rainfall. Although the total precipitation received does not warrant the term 'Dry Zone' it is defined on the basis of the concentration of rainfall and the presence of an effective dry period.
2. Rs.700/= (US $ 17) per month is considered as the poverty threshold in Sri Lanka for official purposes.
3. A village level officer belonging to the lowest hierarchy of the administrative setup.
4. These Committee with farmer representation of the respective areas has been established under the provisions of the Agrarian Services Act of 1979.
5. All farmers in the country are expected to join a pension scheme under the Farmer' Pension and Social Security Act of 1987.

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631.7.6.3 groundwater extraction | financing | farmer managed irrigation systems
Bangladesh

Paper No.89

Mobilization of Financial Resources for Sustainable Groundwater Farmer Managed Irrigation Systems in Bangladesh

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Abstract

In Bangladesh ground water Farmer Managed Irrigation Systems (FMISs) include deep tubewells (DTWs) and shallow tubewells (STWs). This paper examines the present approaches to mobilization of financial resources for DTW and STW FMISs and finds that they are inefficient and inequitable. The paper, while arguing for continuing the present approaches, makes suggestions for minimizing inefficiency and inequity. Among others, the suggestions include strengthing farmer organizations, improving irrigation and water management, and encouraging private sector participation in financing capital and O & M costs of FMISs.

Introduction:

According to a 1991 census of irrigation (Bangladesh CIDA-AST, 1991), ground water irrigation covers 60 percent of the total irrigated area of 6.46 million hectares. Almost all (98.5%) of this ground water irrigation coverage is through the use of deep tubewells (DTWs) and shallow tubewells (STWs). The DTWs and STWs are largely managed by farmers, although much of the stock of DTWs is owned by government agencies and rented to farmers' groups. Those DTWs owned by farmers were typically financed through loans form public financial institutions. STWs are almost entirely farmer owned, some bought by cash and others through loans. In addition to the purchase or rental costs of equipment, farmer managed systems face operation and maintenance expenses that generally range between Taka 3300 and 4800 (US$ 63 and 123) per hectare (depending on irrigation coverage and other factors) during the Boro (winter rice) season.

The mobilization of financial resources for paying rents and capital costs as well as for meeting the operation and maintenance expenses of tubewells is a very important determinant of the sustainability of groundwater farmer managed irrigation systems (FMISs) in Bangladesh. There is growing concern over the issue as the record of loan installment and rental payment by irrigation groups has been problematical and the varied methods of charging farmers to cover costs have raised questions about both equity and efficiency. It is in this context that the present paper proposes to examine some of the issues associated with financial resource mobilization in groundwater FMISs.

Paper Objectives:

The broad objective of the paper is to contribute to the development of an appropriate approach to resource mobilization for sustainable groundwater systems

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[1]Paper to be presented at the South Asian Regional Workshop on Groundwater Farmer-Managed Irrigation Systems and Sustainable Groundwater Management, 18-21 May, 1992, Dhaka, Bangladesh. Mr. Hakim is Research Associate with the International Irrigation Management Institute (IIMI) program in Bangladesh.

managed by farmers. More specific objectives include: a) the identification of existing resource mobilization approaches and methods; b) an examination of their performance records, strengths and weaknesses; and c) the suggestion of possible ways to promote more productive, efficient and equitable methods of financial resource mobilization for sustainable groundwater FMISs.

The paper utilizes primary data collected under the recently completed IIMI-IRRI project on Irrigation Management for Rice Based Farming Systems. This data, collected in the Rajshahi and Thakurgaon regions of Bangladesh, is supplemented by secondary information gathered from other sources. DTW irrigation systems is emphasized with contrasts being drawn between farmer managed and agency managed systems.

Resource Mobilization

Approaches and Issues

In a situation where irrigation systems are initiated and developed first by the government agencies and then turned over to farmers for management, there can be three interrelated approaches to resource mobilization for financing irrigation development programmes. They are (a) cost recovery, (b) benefit from irrigation and (c) ability to pay. The choice of a particular approach or particular combination of approaches depends on a government's objectives in regards to irrigation development and on how that development fits in with broader national development efforts.

In general, the cost recovery approach is seldom fully followed in the sense of recovering the entire capital and O & M costs from farmer groups. In almost all countries subsidies are provided to cover a portion of irrigation costs. While the justifications put forward for this cost approach are fairly clear, its application has posed some problems (Small, Adriano, Martin, Bhatia, Shin and Pradhan 1989). For various reasons such as corruption inefficiency and inappropriate project analyses, the officially reported costs in many projects may be substantially higher than the real costs. The question might then be posed as to why farmers should pay for costs which were not really necessary for the provision of the services received.

Even if the costs are fully necessary for the provision of irrigation, farmers cannot pay them if the incremental benifit due to the irrigation that they receive is less than such cost payment. It is in this context that the benifit approach is considered along with cost approach for resource mobilization.

In some places, members of farmer groups may really receive incremental benifits but they still might not be able to pay the full cost or even of the O&M costs because their general level of income is too low. In such circumstance, a case can be made for either total or partial subsidy. Thus the ability to pay also becomes important in determining resource mobilization strategy.

The other related issues that are generally considered in formulating resource mobilization policy relate to economic efficiency, the generation of public savings and to equity. Finally, political feasibility and administrative capability must be considered in deciding resource mobilization strategy.

In situations where irrigation systems are both developed and managed by farmers, the farmers as a group have no alternative to following a full cost recovery approach for resource mobilization for sustaining their systems. Within the group, there might be differences in individuals' contributions to cost recovery on consideration of differences in benifits received or differences in economic conditions, but as a group the farmers must mobilize resources to cover full costs.

Present Approaches to Resource Mobilization in Bangladesh

In Bangladesh, the objectives of the irrigation development program have been to increase national food production and income as well as the production of subsistence farmers. In line with these objectives, in the early stage of irrigation development the government heavily subsidized irrigation development programs including ground water FMISs. Neither cost recovery approach nor benifit approach was followed in any significant way to finance irrigation development. As the use of irrigation has gained popularity among farmers, the government has begun to gradually reduce its subsidy on irrigation although increased food production has remained the key objective of irrigaiton development. The underlying reasons for reducing the subsidy are to ease budgetary pressures and to increase efficiency. For gravity irrigation systems the government policy is to recover O & M costs from the users while for minor irrigation systems which include ground water FMISs, the policy is to recover both O & M and capital costs. The government has, in fact, adopted a vigorous privatization program to minimize public participation in the development of FMISs.

Ground Water FMISs and Resource Mobilization:

As has been mentioned before, ground water FMISs include DTW and STW irrigation. The Bangladesh Agricultural Development Corporation (BADC) was the pioneering government agency to initiate and develop DTW and STW FMISs in the country. While BADC still plays a major role in the DTW FMIS sector in several ways, its role in the STW FMIS sector has substantially diminished recently. Private traders and commercial banks have taken over much of the role of BADC in STW FMIS development and expansion. In DTW FMISs also, BADC's activities are diminishing gradually.

DTW FMISs

At present there are different categories of DTW FMISs functioning in the country under BADC initiative. For each category, there is a distinct method of resource mobilization. The present paper covers Rental, BIADP and Private FMISs because the relevant information are available on these from a recent IIMI-IRRI study.

Rental DTW FMISs: Rental DTW FMISs are heavily subsidized by the government. In the mid seventies the subsidy constituted 70 percent of total costs, in the early eighties it was 68 percent and at present it is about 62 percent (Table 1). Over the years all of the indirect O & M costs and around 95 percent of the capital costs have have been subsidized. The farmers' groups however have been substantially financing direct O & M costs from their own sources. In fact, at present they are financing all of the O & M costs. Every year before the start of irrigation season farmers' groups make estimates of their O & M costs for the season and decide an area-based (per hectare) fee to be collected from the irrigators. The fee is collected in two to four installments. The first installment is collected before starting irrigation and the last after the harvesting of crops. The collection efficiency of this fee is generally very high and the total fee collected exceeds O & M costs by an amount sufficient to pay BADC rent. This is evidenced from the six rental DTW groups studied in an IIMI/IRRI research project (Table 2 and 3). The rates of subsidy on total costs, as mentioned earlier, has been calculated assuming payment of rent by farmers' groups to BADC. In practice, in many cases, farmers' groups have not been paying rent for years. The IIMI-IRRI study groups, for example, did not pay their rents for a number of years.

Sometimes it becomes difficult for farmers groups to mobilize financial resources in advance to meet O & M costs and this leads to poor irrigation performance. In order to help the farmers in this respect, the Rajshahi Krishi Unnayan Bank (RAKUB) in collaboration with the International Fund for Agricultural Development (IFAD) started a project in the country in the early eighties. Under the project arrangements, rental DTW farmer groups receive credit from RAKUB to finance direct O & M costs and pay BADC rent. In one of the IIMI/IRRI studied upazilas RAKUB started the project in 1984-85 with 16 rental DTW FMISs. The performance of the credit program has not been satisfactory. The recovery rate of the credit has fallen from 100 percent in 1984-85 to 55 percent in 1988-89 (Table 4) and some groups do not now receive any credit because their loan repayment record is very poor. BADC, however, was able to get its rent from the group through the Bank as part of the total credit was ear-marked for paying rent. Because of the fall in recovery rate, RAKUB might close the project soon. IFAD support for the project has already been withdrawn.

In pursuance of the policy of privatization of the minor irrigation sector the rental system was officially discontinued in 1980. BADC however, could not dispose of all the DTWs supplied under the program. At least until recently, there have been approximately 12,000 rental DTWs in continued operation.

<u>BIADP DTW FMISs</u>: BADC has a special Barind Integrated Area Development Project (BIADP) in the Rajshahi area. Under the project arrangement, farmers' groups get DTWs from the project for management and operation for irrigation. About 85 percent of the capital cost is financed by the project and the entire direct O & M costs are borne by the farmers' groups. For the collection of the 15 percent of the capital costs and indirect O & M costs, the project has introduced a new method. It charges from the farmer an annual fee which is based on estimated rather than actual irrigated area under different crops in a year. For each crop there is specific fee rate (Table 5). There is provision for rebates if the fee is paid before certain specified dates. Farmers' groups are not allowed to use a DTW unless they have paid in full the fee charged by the project. Thus the farmers' groups have to mobilize financial resources to pay

the project its annual fee as well as to meet direct O & M costs. To collect the financial resources, they follow the same method as the rental DTW groups. Before the beginning of the irrigation season, farmer groups make an estimate of the total expenses and decide on an area-based fee (per hectare) to be collected from the irrigators. There is some flexibility in the irrigation fee decided upon by farmers' groups. If the fee initially decided upon falls short of total costs, the shortage can be recovered from the farmers. As with rental DTW farmers groups, the collection efficiency of the fee is very high and total collection exceeds total expenses considerably. Six groups studied by the IIMI-IRRI project achieved 100 percent efficiency in fee collection in 1991 (Table 2), and the amount collected exceeded total costs by an amount of Tk.19,892 per well (Table 3).

Private DTW FMISs: Under the privatization programme of the government, BADC has started selling DTWs to government sponsored farmers' cooperatives, NGO supported farmers groups, informal farmers' groups and private individuals at a highly subsidized price. A DTW without subsidy at current market prices would cost about Tk.6,00,000. BADC is selling it to farmers at Tk.1,75,000, thus subsidizing 61 percent of the cost. Considering farmers' inability to mobilize even this subsidized cost, the government has asked the nationalized banks, specially the agricultural development banks, to provide medium term credit to farmers to enable them to buy DTWs from BADC. The loan carries a 16 percent interest per year and is payable in 9 years in 17 installments. The major buyers of the DTWs are BRDB (Bangladesh Rural Development Board) promoted farmers cooperatives. As of the 1990-91 financial year, these coopeatives have bought 12,407 DTWs which is about 40 percent of the DTWs fielded in the country (BRDB 1991). Once the DTWs are bought and commissioned, the responsibility of operation and maintenance of the wells lies with the farmers' group. Before the start of an irrigation season farmers' groups make an estimate of total expenses for the year/season which include O & M costs and loan installments to be paid to the bank and charge each farmer an area-based irrigation fee. The fee is collected in several installments in either cash or kind. Some groups collect fees in both cash and kind. The collection efficiency is also very high in this system and total collection exceeds the total estimated costs. Unfortunately, however, the farmers' groups have not been repaying their loans --- leading to a very poor recovery rate of credit in this sector. The BRDB sponsored groups have repaid only 19 percent and 17 percent of the total amounts due respectively in 1989-90 and 1990-91 (BRDB 1990-1991)[2]. The BKB (Bangladesh Krishi Unnayan Bank) recovery rate has declined over the years and it was less than 10 percent in 1990-91 (Table 6). The RAKUB recovery rate was better being 45 percent (Table 7).

The IIMI/IRRI project studied three private DTWs in the Rajshahi area. The groups' performance corroborates what has been noted above. These groups charged the farmers an area-based irrigation fee to meet their costs. One group collected fees in cash, one in kind (paddy) and the third group in either cash or kind. The collection efficiency of fees was 97 percent in 1991 and the total fee collected exceeded the O & M costs by an amount of Tk.56,714 per well which

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2 BRDB recovery rate has been calculated on the total loans for DTWs, STWs and LLPs (Low lift pump)

was more than the amount needed to pay back loan installments averaging about Tk.40,000.00 (including interest). Of the three groups, however, only one has paid its loan installments in full and the two other groups have paid less than one percent of their loans.

STWs FMISs:

STW FMISs were also initiated by BADC. Unlike DTWs however, STWs were sold to farmers' groups from the very beginning of BADC's program. Initially, STWs were sold on a hire-purchase basis. Under this system, the buyers paid 10 percent of the price as down payment and the rest in five equal annual installments. No interest was charged on the balance amount. Some maintenance expenses were borne by BADC. All other O & M costs were borne by farmers. Under this program the subsidy received by farmers amounted to 31 percent of total costs (Khan 1980). The terms and conditions of the hire-purchased systems were changed subsequently which reduced the subsidy from 31 percent to 19 percent (Khan 1980). As the hire-purchase system did not work well primarily because of BADC's inability to collect loan repayments from farmers' groups, the system was discarded. STWs are now sold to farmers by BADC as well as by private traders at full cost in both cash and credit. There are now about 288,000 STWs fielded in the country for irrigation purposes.

Since STWs are sold at full cost and farmers bear all O & M costs, theoretically there is no subsidy involved in this sector. There is, however, a large implicit subsidy because the recovery rate of STW loans has been found to be very low. The BKB recovery rate has fallen sharply over the years and it was only 5.6 percent in 1990-1991 (Table 6). The RAKUB recovery rate was also low being 6.4 percent in 1991 (Table 7).

Agency-Managed DTWs:

Agency-managed ground water irrigation systems are much less efficient in resource mobilization than are those run by farmer groups. In addition to financing the entire capital cost of such systems the government also subsidizes O & M costs substantially. The IIMI/IRRI research project studied the NBTP (North Bangladesh Tubewell Project) which is the largest ground water agency-managed project in Bangladesh. It was found that the government subsidized 100 percent of capital cost and, if the irrigation fee charged were assyned to be collected in full, the government subsidy to O & M costs would be 93.5 percent. Fees however, have not at all been collected in full. Average fee collection efficiency from the year 1984-85 through 1988-89 was only 24 percent only (Table 2).

Strengths and Weaknesses of Resource Mobilization Approaches and Methods

The discussions in the preceding sections reveal a number of strengths and weaknesses of the various financial resource mobilization approaches examined in regards to the sustainability of ground water FMISs. The heavy subsidies and liberal credit support have resulted in a rather impressive expansion of ground water FMISs, especially STW systems. The farmers' groups, on their part, have followed a policy of cost recovery aiming at mobilizing financial resources to pay for the costs for which they were responsible. Their method of mobilization has been effective and efficient. Their collection efficiency of fees has been very high --- close or equal to 100 percent --- and they have been mobilizing enough resources to meet all O & M costs as well as pay rents and loan installments (whether or not they actually paid the latter two).

The resource mobilization approaches, however, suffer from some serious weakness which may well constrain the sustainability of the FMISs. First, a culture of dependancy has been developed. To subsidize irrigation development government had to mobilize resourses. Since mobilizing resources from domestic sources was a relatively harder task for various reasons, the government opted for the easier source, that of foreign aid. Now when foreign donors are pressing the government to mobilize domestic resources, the government is unable to respond very positively. The farmers, on their part, have become dependent on the government and tend to resist any proposal for reduction of subsidies. Many of those working in the elaborate network of irrigation bureaucracy that has been created over the years to implement the subsidized program, for fear of losing their own positions and status, tend also to sympathize with the farmers. Now the sustainability of a foreign aid dependent subsidized program may face serious problems if the foreign aid is disrupted for some reason. This is true especially in the context of the present day tight foreign aid environment. Even if subsidies are provided from national resources they probably cannot be continued indefinitely. It has been noted that loans provided by the banking systems to buy DTWs and STWs and meet O & M costs have remained largely unrepaid. If the banking systems fail to realize money from the farmers groups (or farmers groups do not repay their loans) money will not be available to continue the credit programs. As a result, sustainability of FMISs will suffer. According to the Bangladesh-CIDA-AST minor irrigation census, 30 percent of the DTWs and 6 percent of the STWs in the country were out of operation in 1991. A major reason for this non-operation has been BADC's or farmer groups' problems in financing the repair of major mechanical breakdowns.

A second area of weakness of the present resource mobilization system, which follows substantially from the first, is that it is not very productive. Subsidies, both explicit and implicit, have contributed to the inefficiency of FMISs. They are being utilized much below their capacity. Also, because of inefficient management, yield and production of irrigated crops are low leading to low farmer income. Systems with under-utilized capacities and low farmers' income are less productive in resource mobilization for sustainability than are more productive systems.

Third, present resource mobilization methods tend to be inequitable. It has been seen that the total fee collected by the farmers' group management is in excess of the direct O & M costs that they incur. The excess fee is ostensibly collected to pay rent or repay bank loans. But both rent and loan installments have remained largely unpaid. Where does the money go? Field observations show that the excess money is not shared by all members. It is pocketed by a handful of group leaders. Further, it has been noted that the defacto ownership of the subsidized irrigation equipment is, in many cases, enjoyed not by all members of the group but by a few persons who dominate the management.

As to the methods applied by the farmers groups to collect irrigation fees, the cash method is less efficient and less productive than collection in kind. Collection in kind can take place in two ways: collecting a fixed amount of crops per unit of land (per acre) irrespective of yield and collection of a certain proportion of the total yield. The former method can be productive but tends to be inequitable while the latter method is both productive and equitable. The BIADP system of collecting fee from the farmers by the project is efficient but not particularly productive. Under this system, farmers have to pay BIADP's annual fee all at a time before irrigation is started. Thus BIADP is assured of full collection of its fee. But those groups which fail to mobilize resources in time do not get tubewell water to irrigate their land. Thus a number of DTWs remain idle during the irrigation season. Further, farmers have to pay fees for all seasons during a year even if they grow a crop in only one season. Thus the system is inequitable --- but from BIADPs resource mobilization point of view the system can be seen as a success. Part of the confusion here may be in the name. Perhaps the charge should be called an annual equipment rent rather than an irrigation fee.

The weaknesses of the approaches to financial resource mobilization are explained by a number of factors in addition to those of subsidies and collection methods. Among them are the following: a) many farmer organizations suffer from problems such as factionalism and large farmer domination which result in inadequate participation of a cross-section of farmers in the management of their organizations; b) broad categories of farmers are not always aware of the financing mechanisms or of their responsibilies in the payment of rent or credit as they are not clear about the ownership of irrigation equipment; c) irrigation and water management methods are generally inefficient --- leading to inadequate farmer water control and wastage of water; d) the contact and communication between farmers and irrigation agency and bank officials is inadequate; e) management of credit by nationalized banks is generally inefficient, partly due to the lack of competition from a private banking system in the country; and f) the successive governments in the country have frequently exempted farmers from credit repayment --- a practice which decreases incentives for groups to repay their loans.

Suggestions and Conclusion

In Bangladesh return to investment in irrigation, including investment in ground water FMISs, is high (World Bank 1978, Hakim et at 1991). However, since the level of living of farmers is generally very low and the country has yet to achieve self-sufficiency in food grains, a policy of full cost recovery cannot yet be supported. It is also not politically feasible. A portion of the cost of ground water FMISs, especially the capital cost of DTW FMISs, may well need to be subsidized if such technologies are to be applied at all. Such subsidies however, could be reduced gradually. Further, in order that farmers can continue to buy DTWs at subsidized prices and STWs at full costs, farmer groups will need to have access to credit. Credit may also be given to FMISs to cover O & M costs.

There are serious consequences on the sustainability of FMISs of the inefficiency and inequity in the existing system of financing. Such inefficiency and inequity can be reduced substantially --- leading to improvements in the management of FMISs and management of credit. Specific suggestions in this respect include a) strengthing farmer organizations to ensure participation of a cross-section of farmers in the management of their organizations, b) creating awareness among common farmers about the mechanism of financing of their systems and ownership of their systems, c) introducing improved irrigation and water management methods through research and action research and disseminating the results through training, d) increasing contact and communication between farmers and irrigation agency and bank officials, e) encouraging participation of private banks to finance FMISs, and f) discouraging indiscriminate exemptions of credit repayment by the government.

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Table 1: Estimated Rates of Subsidy on Rental DTW FMISs

Year of Estimates	Subsidy on Capital Cost (%)	Subsidy on Direct O & M Costs (%)	Subsidy on Indirect O & M Costs (%)	Subsidy on Total Costs (%)
1978[a]	95.2	7.2	100	70
1980[b]	96.2	13.6	100	65.7
1991[c]	94.4	nil	100	62.0

a = Estimates by World Bank (1978)

b = Estimates by Hamidur Rahman Khan (1980)

c = Estimates by Present paper

Table 2: Irrigation Fee Collection Efficiency of Different Categories of IIMI-IRRI Studied DTW FMISs and Agency Managed DTW Project

FMISs	Period	Collection Efficiency (%)
Rental	1991	91
BIADP	1991	100
Private	1991	97
Agency Managed (NBTP)	1984-85 to 1988-89	24

Collection Efficiency = Total Fee Collected divided by Total Fee Collectible

FMISs = Farmers Managed Irrigation Systems

DTW = Deep Tubewell

STW = Shallow Tubewell

NBTP = North Bangladesh Tubewell Project

Table 3: Irrigation Fee and O & M Costs in Different Categories of IIMI-IRRI Studied DTW FMISs 1991

Category of DTW FMISs	Irrigation Fee in Taka/Hectare	Income from Irrigation Fee in Taka/DTW	O & M Costs in Taka/Hectare	O & M Costs in Taka/DTW	Surplus of Income from Irrigation Fee Over O & M Cost in Taka/DTW
Rental	4026	62564	3320	51592	10972
BIADP	7264	60944	4893	41052	19892
Private	6621	119244	3472	62530	56714

FMISs = Farmer Managed Irrigation Systems

DTW = Deep Tubewell

STW = Shallow Tubewell

BIADP = Barind Integrated Area Development Project

Table 4: Recovery of RAKBU Loan to Rental DTW FMISs of Mohanpur Upazila for Meeting O & M Costs (in Hundred Thousand Taka)

Year	Amount of Loan Disbursed	Amount Recovered with Interest	Recovery Rate (%)
1984-85	14.92	15.02	100.7
1985-86	10.81	10.04	93.6
1986-87	11.42	9.40	82.5
1987-88	9.50	5.39	56.8
1988-89	10.23	5.60	55.9

Source: RAKUB Mohanpur Branch Office, Mohanpur, Rajshahi

RAKUB = Rajshahi Krishi Unnayan Bank
FMISs = Farmer Managed Irrigation SYstems
DTW = Deep Tubewell

Table 5: Irrigation Charge Imposed by BIADP on Farmer Groups

	Discharge of Deep Tubewell (In Cusec)		
	1.20-1.50	1.51-1.75	1.76-200
Minimum Irrigated Acreage on Which Charge is Imposed (hectares)	18.22	21.86	24.29
Assessed Irrigation Charge[a] (taka)	10126	12150	13500
Charge Payable with 20% Rebate (if paid by 31 January)	8100	9720	10800
Charge Payable with 10% Rebate (if paid by 15th February)	9121	10935	12150

BIADP = Barind Integrated Area Development Project
DTW = Deep Tubewell

[a] = At the rate of Taka 555.75 per hectare per year, Taka 259.35 for Boro, Taka 74.11 for Aman and Taka222.30 for Aus. The fees collected by farmer groups from farmers include charge to be paid to BIADP and also direct O & M Costs of irrigation.

Source: Bangladesh Agricultural Development Corporation (BADC) Deed of Agreement (undated)

Table 6: Recovery of BKB Loan for DTW and STW Purchase (In hundred Thousand Taka)

Year	DTW				STW			
	Amount Disbursed	Amount[a] Due for Recovery	Amount Recovered	Recovery Rate (%)	Amount Disbursed	Amount Due for Recovery	Amount Recovered	Recovery Rate (%)
1985-86	160.21	81.48	69.39	85.2	2037.30	3310.02	2439.93	73.7
1986-87	65.4	176.03	138.32	78.6	482.75	2783.12	1552.10	55.8
1987-88	30.26	218.93	99.67	45.5	786.97	3378.57	1876.24	55.5
1988-89	27.63	683.95	82.15	12.0	1278.61	12807.69	1210.76	9.6
1989-90	109.06	946.94	151.24	16.0	445.21	16071.92	1476.72	9.2
1990-91	343.34	1059.74	103.62	9.8	179.19	22938.15	1186.80	5.6

[a] = Amount due for Recovery = Overdue + Recovery

BKB = Bangladesh Krishi Unnayan Bank

DTW = Deep Tubewell, STW = Shallow Tubewell

Source = Bangladesh Krishi Unnayan Bank, Dhaka

Table 7: Recovery of RAKUB Loan for DTW and STW Purchase

Category of Well	Amount Disbursed (1-7-1990 to 31-12-1991)	Amount Due for Recovery (1-7-1990 to 31-12-1991)[a]	Amount Recovered As on 31.12.91	Recovery Rate (%)
DTW	180.38	164.98	74.38	45.0
STW	44.64	23500.22	1512.80	6.4

a = Amount due for Recovery = Overdue plus Recovery

RAKUB = Rajshahi Krishi Unnayan Bank

DTW = Deep Tubewell, STW = Shallow Tubewell

Source: RAKUB Head Office, Rajshahi

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Pakistan

Tubewells | farmer participation

Paper No.95

TECHNICAL APPRAISAL OF FARMERS TUBEWELL SCREENS IN PAKISTAN

BY

SHAFAAT AHMAD QURESHI*, DR. IRSHAD AHMAD** & SH. MOHAMMAD SADIQ***

SYNOPSIS

Pakistan has a total gross area of 90 million hectares of which nearly ¼ i.e. 25 million hectares is under cultivation; and another 11 million classified as culturable waste. On more than 15.76 million hectaters irrigated Agriculture is practiced. A significent feature of Pakistan's Irrigated Agriculture is its Indus Irrigation System which is the biggest single gravity flow irrigation net work on the surface of globe (with more than 40,000 miles of irrigation channels capable of handling more than 100 million acre feet of water) However, surface supplies are short of the water requirements of crops, so to meet the growing demand ground water is being utilized through more than 300 thousand public and private tubewells installed mainly in the Province of Punjab. Various types of screens such as coir string, nylon string, cement, P.V.C.,mild steel, brass and fibre glass have been used.

As large number of farmer's tubewells (though of small capacity) performed well towards supplemental water supply through efficient exploitation of sweet ground water, besides meeting drainage requirement in those areas,government is now implementing a transition programme to close down its deep large capacity tubewells by encourging the farmers to install their own shallow tubewells.Since technical and economic appraisal of different screens was done during the last 22 years, under different research projects on tubewells, in the Irrigation Research Institute,Lahore, in this paper, an effort has been made to elucidate the salient aspects of tubewells screens of farmer tubewell such as behaviour of different screens under different water quality and soil strata, etc.Also important conclusions and recommendations are being made on the basis of research and investigations. It is hoped that these will prove highly beneficial not only for Pakistan but also for other countries of South East Asia.

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INTRODUCTION

Despite its declining relative importance, agriculture continues to be the mainstay of Pakistan economy. It contributes about 30% of its G.D.P., Provides about $\frac{2}{3}$ of its total exports and employs approx: 55% of country's labour force. It has close linkages with other sectors of economy so that it deserves greatest attention. However, with less than 150 mm of average annual rain fall the Indus Basin, where agricultural lands are mostly located lies in arid and sami arid zone. Thus artificial irrigation is must for sustained agriculture. In the past to meet the irrigation requirements the country was almost entirely dependent on its canals where the largest/contigous gravity flow net work in the world was built. However, as there was scarcity of surface water as compared to need of its cultivable area, despite construction of two big Dams to store surplus flood waters, it became essential to supplement the surface water supplies to meet increasing strain on land due to food and fibre requirements of growing population. Thus the tubewells in recent years have gained equal importance. It may be stated that in Punjab alone against a total estimated diverted discharge of 54.50 MAF (6.72 Million Hectare Meters) through canals the tubewells are pumping about 39.85 MAF(4.92 MHM) supply at present. It cannot be, however, over looked that availability and quality of subsoil water in Indus vally alluvium is wholly dependent on fresh surface water recharge by seepage from canals, rain water and rivers etc.

HISTORY OF TUBEWELL INSTALLATION

Since surface supplies have been short and less as compared to consumptive use of crops, progressive farmers started installing their own tubewells to augment the canal supplies or to raise their crops in barani areas. Thus by 1940 there were 439 such tubewells installed in Punjab alone (Agricultural Census, 1960).

Government on the other hand also, from 1945 onwards installed a large number of tubewells under Grow More Food Schemes and later as anti water logging measures (through Rasul Tubewells Project and Salinity Control and Reclamation Projects- (SCARPS). Thus in 'Punjab' about ten thousand tubewells have been installed in public sector. Most of these tubewells are deep and have electric driven, high capacity turbine pumps (2-5 cusecs) or 0.0566-0.142 Cumex).

During early sixtees Government started encouraging farmers to install their own tubewells by granting concessions, loans, subsidies etc. Thus the number of small capacity private tubewells increased to 21,776 by June, 1964 and to 2,71,719 by June, 1991. The year wise and cumulative number is shown in diagram I. The capacity of these tubewells was however, small and the cost of irrigation by tubewell remained much higher than canal water charges levied by the government.

The farmers have installed their tubewells mostly in good quality ground waters areas. However, in brakish ground water area also as generally shallow water quality (due to seepage from canal etc) is good, the farmers have installed tubewells in depths varing from 80 feet to 120 ft (24-36 meters)where depth of strainers range from 60 to 100 ft. The Capacity of these tubewells varies from 0.5 cusecs to 1.25 cusecs(0.0142-0.0425 Cumex) and installed Horse Power from 10-15 H.P. for electric tubewells and 15-20 H.P. for diesel engine operated units.

Although there are many advantages for the farmers in the installation of their own tubewells but in the private sector growth of shallow tubewells is mainly due to their low initial cost using indigenous techniques and equipment; and complete control on operation of the tubewell to arrange needed irrigation water on"ON DEMAND BASIS".

OTHER BENEFITS OF FARMER'S TUBEWELLS

Besides adequate and timely supply of water through out the year, Tubewells have enabled their owners to bring their culturable waste land under plough and the intensities of cultivation have also increased.

Another beneficial effect of practising tubewell irrigation has been the lowering of water table. Large tracts of lands affected by this menace have been reclaimed by tubewells and are yielding good harvests.

As regards the social benefits, the owners of tubewells command great respect among their fellow farmers and are economically better. Fueds over the distribution and turns of canal waters have declined in such areas. The local Industry and technical know-how is increasing in the country, which is a good sign for a developing nation. As the farmers are becoming more and more conscious of their investments they are putting their idle period of motive power to other uses, such as saw mills, grinding mills, etc.

SALE OF TUBEWELL WATER BY FARMER

Many tubewell owners who have surplus water than for their own use sell water to their fellow cultivators. The cost of tubewell water is generally negotiated. If paid in cash it ranges between Rs.25/- to 50/- per hour for electric and diesel tubewells. In the shape of crop produced, the farmers are generally found to sell water at higher rates as compared to cash payment. In any case as it is higher than cost of production this business has been profitable for many of them and thus has affected their socio-economic aand even political structure.

Quite a few farmers have installed tubewells on cooperative basis, but the experience is not as good as in other countries, where water users associations are handling water supply problems for irrigated agriculture.

PRESENT PRECTICES AND
WELL SCREENS INSTALLED

Shallow tubewells facilities are basically designed to be operated using locally manufactured equipments and more so centrifugal pumps.As location of pumps within the suction depth of water level is critical,even in areas where pump cannot be located at land surface a sump (typically brick lined) is constructed near to the water table at the well site where centrifugal pump, delivering through a discharge pipe to a brick built surge tank is placed. The wells are completed at 6 inches diameters with well screens chosen either from their own past experience or on advice by local artisans.

It is to be observed, however, that screen is the most important component of a tubewell because although the economics of pumped water would depend on many factors but useable life of a strainer is one of the major item. Its function is to hold back the formation and allow sand free water to flow into it. For water to flow freely with least obstruction or resistance, a strainer should have proper type of slits or holes. The area and size of these slits should correspond to the characteristics of the formation and type selected should also suit water quality.

WELL SCREEN USED IN PAKISTAN

i) Coir string wound on M.S. cage.
ii) Nylon string wound on M.S.cage.
iii) Brass slit type.
iv) P.V.C. slit type.
v) Cement slit type.
vi) Mild steel slit type.
vii) Fibre glass slit type.

i) Coir String Strainers.

Mild steel casing with screen of coir rope or string wrapped on mild steel cage has been the earliest and most commonly type used. A coir strainer consists of iron bar on M.S. round cage of 5 to 8 inches diameter, generally with single twisted string wound on it. Very few had a punched iron sheet around the strainer as protection for the coir. Generally length of strainer is 40 - 120 ft (25-35 meters). Water flows through the pores of coirs of fibre; and mainly from the interstices between two strings.

Laboratory studies have shown that with an open area of about 12%,this continuous type screen provides greatest open area for slot opening. Also permeability of single wound coir string is 2.52×10^{-2} cm/sec while that of medium sand formation is 4.284×10^{-2} cm/sec.

A coir strainer's life varies from area to area depending on water quality and soil strata. However , in Punjab Province such tubewell components have been found to have a life of more than 7 years in fresh ground water conditions.

ii) Nylon Strainers.

Nylon string is wound on M.S. cage in the same way as coir strainer. However, the diameter of Nylon-6(commercial name), generally used, is 1.7 mm and is formed by winding 210 number yarn x 15 ply x 3 final studs (i.e. 45 yarns in the string). The specific gravity of the thread (which would dissolve in concentrated Hydrochloric Acid) is 1.14 . It has a breaking load of approximately 143 lbs, which is sufficient to bear strains of suction, lateral earth pressure, hammering effects etc.

Preliminary studies have shown that under suction it elongates 38% in dry condition and the elastic recovery of the string is 98-100%.Wet and dry strength ratio is 0.87.

Although the open area of Nylon String wound strainer is less than coir string but as during suction elongation occurs in-flow into the strainer increases. In some installed tubewells, the upper one-third portion of strainer is of nylon string while the lower portion is of coir string. However, in case of increased draw-down as the order of surges at the start and at ~~the close~~ of the pump are very high, so the upper portion is also wound by nylon string. Presently, therefore, full length of nylon wound screens are being used in some areas.

iii) Brass Strainers.

Brass strainers have generally slot sizes of 12/1000 x 2½ inches giving an open area of 4 to 5 per cent. Some of these have been shrouded by gravel of the size of 1/16 to 3/16 inches. The studied tubewells which had yallow brass strainer (composed of 65% copper & 30% Zinc) were found to have installed before 1970; proving that this type of strainer has longer life as none of the brass strainer tubewells has been re-bored to date. However, because of its high price, it is not being used by the farmers.

iv) P.V.C. Strainers.

Poly-Vinyle-Chloride (P.V.C.) slotted screen is a relatively recent innovation. The slit sizes very from 12/1000 to 14/1000 inches and the open area from 4 to 6 %. This screen is being used by farmers with high hopes because the P.V.C. material is inert to many chemicals and it does not corrode and is less liable to incrustation. It is of light weight and is much less costlier than brass and fiber glass.

The average length of surveyed P.V.C. strainers was 80 ft. The areas in which clay lenses damage coir screens, the farmers prefer P.V.C. screens.

v) Cement Strainers

The cement pipe is made locally by spinning method or by hand-moulding. Stretched galvanized iron wire is used as the re-inforcement. Before curing, in the green condition, "10/1000 to 14/1000 x 2" to 3" size slots are made. The strength of the pipe depends upon the sand cement ratio and curing methods etc. During slit making an extra-ordinary care and craftsmanship is needed. The uniform width of a slit is rarely seen. Out of the surveyed tubewells, only one tubewell was shrouded, and it was visually observed that all the other unshrouded tubewells were yielding a little sand. The open area of slots is about $1\frac{1}{2}$ to 2%. The length of cement filter installed generally varies from 80 to 120 ft. (25 - 35 meters) IRI surveys and experience during implementation of Scarp Transition Pilot Project revealed that cement screens are becoming popular, being the cheapest one.

Many cement screen manufacturing concerns were visited and many defects were noted in their manufacture; such as material was not of standard quality, mix-ratio of mortar was lean and re-inforcement material was also of low quality. So research is needed to develop standards for more durable and better cement strainers.

vi) Mild Steel Strainers

These are scarcely used in the private sector, but were used extensively in public sector SCARPS tubewells. The mild steel screens used are 8" or 10" diameter and the slot sizes are 2,5/8" x 1/16". The open area is 30 sq. inches per ft. length of the strainer.

Even during early operation, it was noticed that serious deterioration had set in and the yield of wells started to fall quickly . So the sponsors were faced with serious problems because whereas the useful life of a tubewell was assumed to be about 40 years, a sharp fall in the yield after a short period (due to corrosion and incrustation) was a matter of concern to authorities. In the specific type of Indus Valley formation , mild steel screens were generally found to be unfit and as such they have been discarded for future installation in public and private sector.

vii) Fibre Glass Strainers

It is an epoxy bonded fibre glass material. The argument put forth for the use of costly strainer in the public sector was that it is non-corrosive and resistant to incrustation. However, it is not strong enough to be pulled out and recovered.

These strainers were used in SCARP-II & III areas of Punjab where dia of strainer varied between 10 inches to 8 inches and the slot size was "3/32" x $1\frac{3}{4}$ " and 1/16" x $1\frac{1}{4}$" for respective diameter strainers. There are no tubewells having this type screen in the private sector.

According to Planning & Development Survey through the University of Engineering and Technology, Lahore in 1969, 93% of tubewells were having coir string strainers. IRI survey in 1972 revealed that the coir string screens was used in above 70% cases where as about 20% tubewells were installed with cement screen. Experience during implementation of Scarp Transition Pilot Project (1987-90) and present survey during 1991-92 shows, that in reborings and new installations the farmers are preferring cement strainers over coir strainers etc. as these are very cheap, available every where and can be easily installed by village mechanics. However, in farmer managed Irrigation Systems, tubewells are installed by them without any expert advice, just according to their own experience or counsel by local artisans, only on economic/cost considerations and as per available technology with them.

DETERIORATION OF FARMER TUBEWELL SCREENS

Though the farmers generally install tubewells in shallow good quality water ,yet corrosion and incrustation problems are encountered, as discussed below:-

CORROSION, INCRUSTATION AND
RENOVATION OF TUBEWELLS SCREENS.

It is found that most commenly used coir string deteriorates in areas having clay lenses. Moreover if water is corrosive, it corrodes iron cage and the rust also damages the coir string wound on it. Thus it is recommended to use cages of either inert material like P.V.C. or use anticorrosive paints on M.S. cages. Cement strainers produced locally by a number of manufactures, have different lives ,due to quality of cement used, curing methods and time allowed ; and size of slits, etc. So there is a lot of scope for improvement in these screens. In areas of low water quality farmers prefer to use P.V.C. slit type screens, as these are non corrosive. Mostly farmers do not use shrounding around their tubewells screens, though it is highly desireable especially around slotted screens.

The commonly used renovating acids were tried to judge their real effectiveness in renovation of choked screens. It has been observed that renovating acids are very harmful to coir strainers and cement strainers. So these should not be used in any concentration for the said strainers.

In the absence of efficient and econmical renovation methods particularly coir strainers and cement strainers , farmers are obliged to arrange a new bore and installs a new strainer as soon as the running of a choked tubewell becomes uneconomical.

The research is therefore to be continued to develope some suitable technique to renovate choked wells efficiently and economically. The IRI is presently engaged on development of an ionic bombardment technique, based upon electrolysis of common salt (i.e.Nacl) for the renovation of choked metalic tubewell screens.

CAVITY WELLS (WITHOUT SCREENS)

Cavity wells are now being recommended to be installed specially in abandoned Riverian areas of flood plains, in the Indus Plain., Where alluvial deposition occurs , and with the geological process of centuries, clay lenses are compacted with fresh deposits of the bed load of flowing rivers.
A cavity well is not very deep and just requires sufficiently hard clay strata to form a strong and dependable roof above the cavity. Quite contrary to screens, which are incrustated with passage of time when their discharage is reduced.. In case of cavity wells, with the passage of time, the discharge increases as the dia of cavity increases. Cavity well has longer life than conventional tubewells, provided discharge is optimum and water pumpage is controlled. So it is suggested that not more than 0.5 cusecs water should be pumped from a cavity well.

SALE OF TUBEWELL WATER BY FARMER

Many tubewell owners who have surplus water than for their own use sell water to their fellow cultivators. The cost of tubewell water is generally negotiated. If paid in cash, at ranges between Rs.25/- to 50/- per hour for electric and diesel tubewells. In the shape of crop produce , the farmers are generally found, to sell water at higher rates as compared to cash payment. In any case as it is higher than cost of production this business has been profitable for many of them and thus has affected their socio-economic and even political structure.

Quite a few farmers have installed tubewells on cooperative basis , but the experience is not as good as in other countries, where water users association are handling water supply problems for irrigated agriculture.

CONCLUSIONS AND RECOMMENDATIONS

On the basis of various research studies on farmers tubewells screens, the following main conclusions and recommendations are made:-

CONCLUSIONS.

i) Out of 3,00,000 tubewells in Pakistan there are 2,72,324 farmer tubewells in Punjab, 70,758 are electric driven and 2,01,566 are diesel operated.

ii) The well screens, most commonly used by the farmers are coir-string screens, cement screens and P.V.C. screens.

iii) Farmers use locally made Centrifugal pumping units and all screens are country made in the private sector.

iv) According to the latest surveys, coir string screens and cement sloted screens are very popular in the farming community of Pakistan.

v) Farmer's tubewells are yielding one cubic ft. of water per second on the average and their working hours are 25% of the available hours.

vi) Farmers install tubewells in shallow good quality waters, so corrosion and incrustation problems of screens are generally not very serious.

vii) As there are no efficient and economical methods for renovation of chocked wells, so farmers install cheap strainer, locally made, and when discharge of a tubewell reduces more than 50%, they usually install a new screen.

viii) The farmers, with their long experiences on behaviour of different types of screens, try to select such screens as may suit their water quality and soil strata.

ix) Some farmers install tubewells on cooperative basis and some other farmers sell their water to their neighbouring farmers.

x) As farmers are managing groundwater fairly efficiently, so the Government has made a 'Transition Programme' under which deep tubewells imstalled under Salinty Control and Reclamation Projects (SCARPS), particularly in sweet water zones, are being closed and farmers in these areas are encouraged to install shallow tube wells with cheap, locally made screens.

RECOMMENDATIONS

i) Farmers tubewells should be encouraged by the Government and maximum facilities in supply of electricity and granting loans to the farmers should be given . A farmer realises full cost of his tubewell within a few years.

ii) In string wound screens, atleast 30 ft length of blind pipe must be used just beneath the reflux valve. If the suction is within a string wound screen region, the string may break easily because of negative pressure created within casing/screen, causing failure of the tubewell.

iii) In areas where there is sweet water overlying saline water and water table is not deep, the use of multiple strainers run by a single centrifugal pump may be tried by the farmers for skimming sweet water.

iv) Wherever sloted screen made of brass, cement, P.V.C. Fiber glass are used, shrounding with well graded material should be used . Proper shrouding wrap with due consideration to the grade of sand of the formation will improve the inflow velocity, thereby increasing the useful life and yield of a tubewell.

v) Manufacturing of screens must be standardised and advice through extension services should be given to farmers and manufacturers.

vi) Renovation method should be developed to clean screens in situ to enhance the life of a tubewell. Acids are very harmful to coir strainers and cement strainers so these should not be tried for their renovation.

vii) Areas should be surveyed and demarcated for cavity wells (without screen tubewells) as these are more economical and cheaper than screen wells.

viii) Equilibrium between sweet and saline water zone and intrusion of saline water into sweet water should be studied and measures should be taken to avoid deterioration of groundwater, as deteriorated water affects not only crop production but also the useable life of a strainer.

ix) The possibility of use of telescopic screens in the private Sector should be studied in detail.

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TYPE OF STRAINEES USED BY FARMERS IN SCARP TRANSITION PILOT PROJECT.

SCARP TUBEWELL NO.	NO. OF PVT T/W INSTALLED IN PLACE OF SCARP TUBE WELL.	TYPE OF STRAINER			DEPTH OF BORE	LENGTH OF STRAINER
		COIR STRING ON IRON CAGE.	CEMENT.	PVC		
216	6	2	-	4	100 - 110	70- 80 ft.
218	18	7	1	10	100 - 110	70- 80 ft.
196	6	2	-	4	110 - 130	70- 80 ft.
198	9	2	-	7	100- 120	65- 85 ft.
199	15	2	-	13	100 - 120	70 - 80 ft
201	21	6	-	15	100 - 150	70 - 90 ft.
202	14	12	-	2	150 - 180	120 - 150 ft.
205	10	5	-	5	100 - 115	70 - 80 ft.
206	8	4	-	4	100 - 115	70 - 80 ft.
210 / 211	13	3	9	1	100 - 120	75 - 80 ft.
174	5	4	-	1	115- 180	80 - 150 ft.
200	6	5	-	1	130 - 180	100 - 150 ft.
203/ 204	14	3	3	8	100 - 115	70 - 80 ft.
172	5	5	-	-	150- 210	120 - 180 ft.
178	8	4	2	2	100 180	70 - 150 ft
164	7	7	-	-	150 - 210	120 - 180 ft.
170	8	7	-	1	110 - 180	80 - 150
171	9	9	-	-	150 - 220	120 - 200
173	5	4	-	1	120 - 150	70 - 120
177	3	3	-	-	120 - 150	90 - 120
183	18	10	-	-	90 - 150	90 - 120
171	1	1	-	-	150	120

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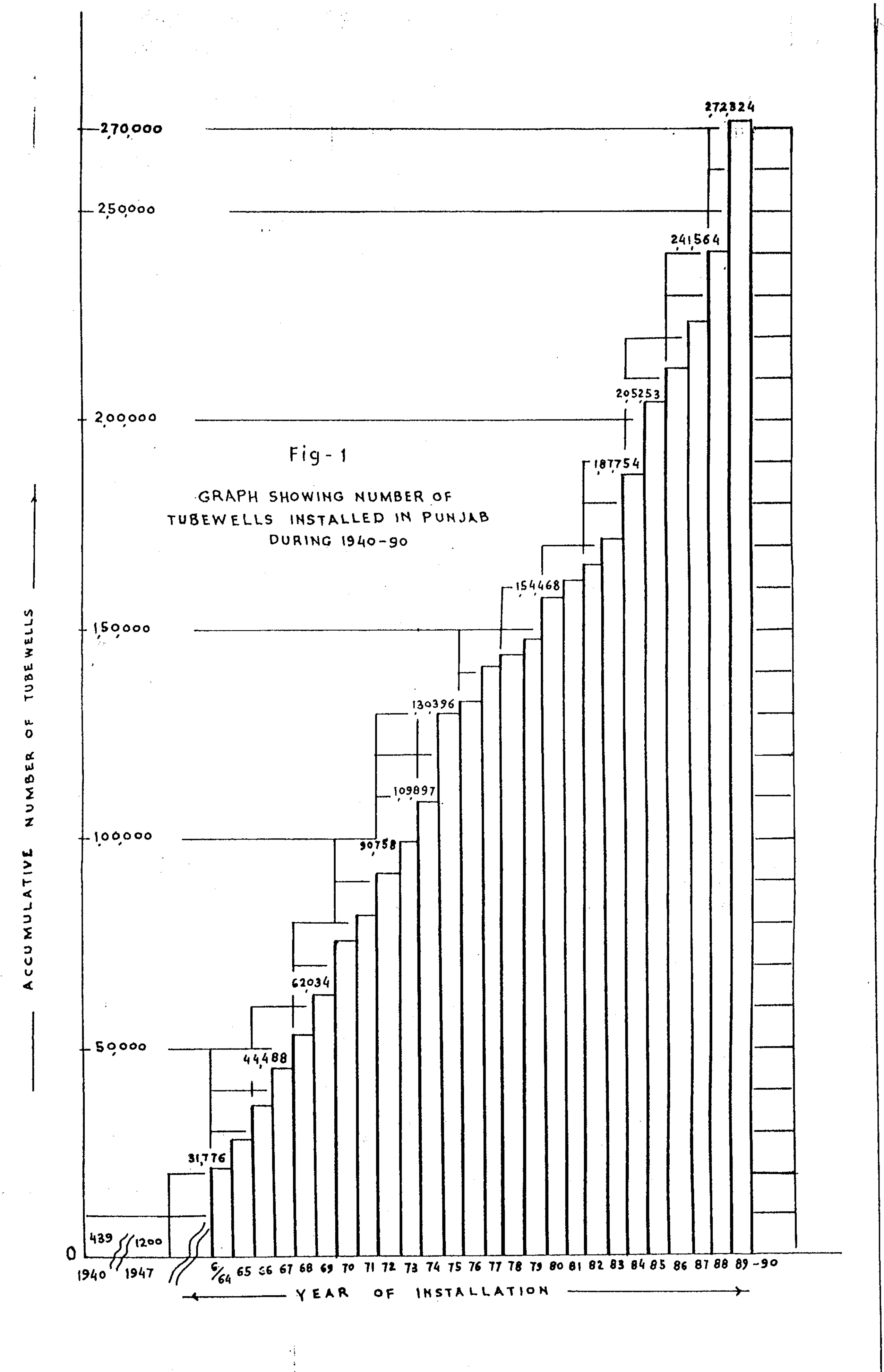

Fig - 1
GRAPH SHOWING NUMBER OF TUBEWELLS INSTALLED IN PUNJAB DURING 1940-90
ACCUMULATIVE NUMBER OF TUBEWELLS
YEAR OF INSTALLATION
270,000
250,000
200,000
150,000
100,000
50,000
0
272824
241564
205253
187754
154468
130396
109897
90758
62034
44488
31,776
439
1200
1940
1947
6/64
65
66
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SUSTAINABILITY OF GROUNDWATER FARMER-MANAGED IRRIGATION SYSTEM (GFMIS) IN INDONESIA

A case study on Gunungkidul and Nganjuk/Kediri areas

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ABSTRACT

In the late of 1970's the Government of Republic of Indonesia launched Groundwater Development Project (GDP) as effort to overcome water shortage in several surface irrigation command areas and to alleviate the poverty problems in the region with limited natural resources. The GDP constructed several numbers of tubewells pumping system in the whole country. During the first two years after construction, The GDP undertakes O&M activities and then the system is turned over to the WUA under supervision of local government.

Sustainability of the systems after turning over was examined in this paper. The sustainability of pumping systems were classified into two levels. Pumping system is considered sustainable at level I whenever its sustainability is attained without any support from the government or external agencies. If the sustainability is attained through government support in replacement or heavy maintenance, the pumping system is categorized as second sustainable. Several samples of GFMIS located in Gunungkidul and Nganjuk/Kediri areas were taken.

Result from study showed that GFMISs in Gunungkidul could be classified as level II of sustainability. In Nganjuk/Kediri, the present status of sustainability of most in deep tubewell pumping systems could be categorized between level I and level II , i.e government subsidies is provided for minor repair only. Meanwhile in intermediate tubewell area, private pumping system started imposing the GDP irrigated area. It seemed that the existence of the GDP system would not be longer because its positions in the competition was weaker than private pumping system.

irrigation in this area is very limited and farmers plant their lands twice during wet season only.

Most of geological formation in Gunungkidul is limestone, groundwater is found in the particular area because distribution of permeability within the limestone is very varied and difficult to detect. So, groundwater pumping irrigation system can not be developed in the whole area. Major aquifer is only found in the Wonosari plateau 36,000 ha and Gunungsewu 70,000 ha (Sir McDonald and Partners, 1984). Totally, 34 deep wells have been installed and irrigate about to 1,100 ha. The main objective of development of GDP in this area was to alleviate poverty problems.

<u>Nganjuk and Kediri area</u>

The side by side Nganjuk and Kediri districts are located in about 120 km South West of Surabaya, the capital of East Java Province. Nganjuk/Kediri area located in flood plain area. Different with Gunungkidul most of geological formation in these areas is volcanic-alluvial aquifer. The important aquifers are developed in the volcanic clastic sediments and their reworked and sorted alluvial. Weathering profile over lavas, or joints and cracks within the lava may also be water bearing (Sir McDonald & Partners, 1979). These wide range of aquifer characteristics emphasizes variation in geology. Groundwater can be withdrawn from various depth by constructing whether shallow, intermediate and deep wells with well's yielding up to 60 l/s. There are 72 wells in Nganjuk and 91 units in Kediri are available to serve 1322 ha and 5296 ha irrigated area, respectively.

Several surface irrigation were also established in Nganjuk/Kediri areas. However, during dry season, surface water is very limited and can not to be spread out in the whole area, as results some parts of the systems suffer shortage of surface irrigation water. Hopefully, by developing the GPIS in these areas, problems of lacking of irrigation water can be overcome.

RESULT AND DISCUSSIONS

Government policies in developing GFMIS

In the development of GFMIS in the country, the GDP constructs tube well irrigation systems in the selected areas. All investment cost including design and consultant costs, are covered by the GDP. Following the completion of construction, the GDP guides and trains farmers in water management and farming systems during the first two years period. In this period the GDP encourages farmers to set up Water User Association (WUA) in the irrigation scheme, even all of O&M activities and cost of the system are still rest to the GDP.

After two years operations, the responsibility on operation and minor maintenance of the system are turned over to the WUA under supervision of the Local Government. In Yogyakarta, heavy repair of the pumping unit and monthly incentive of pump operators (as a temporary employee) are covered by Provincial Irrigation Service (PRIS) as a part of Local Government O&M budget. This policy is implemented because the main objective of development of GFMIS in Gunungkidul is for poverty elevation.

Different with Yogyakarta Province, the East Java Province only provides mechanics and workshop facility which are located in the district capital to do major maintenance only. The WUA has to purchase spare parts and contribute small parts of repair cost (usually as transport fee of mechanics). In recent years the East Java Provincial GDP limits the support of fuel up to 1,000 hours/years in the first two years. By implementing this policy, it will makes the WUA to be stronger and operate pumping system in more efficient way.

Variables to measure sustainability

Based on figure in Appendix A and table in the Appendix B, all variables and parameters which affect sustainability of GFMIS can be expressed in four variables only, i.e.: i) pump operation hours; ii) system efficiency; iii) actual discharge and irrigated area; and iv) fee collection and the WUA's saving.

The number of pump operation hours can be considered as the main indicator of the project technical impact on the GFMIS performance. However, this variable is affected by several limitations as follows : a) policy of provincial GDP in supporting and providing subsidies and facilities; b) cropping pattern and kind of crops grown in the area; c) number of rainfall; d) other factors, such as conjunctive use and competition with individual farmer pump.

Together with pump operation hours, system efficiency and actual pumping discharge reflect the suitability of design, construction, skill and attitude of operator and O&M activities of the system. Meanwhile, the capability of farmers to involve in O&M activities and renewal pumping unit when the technical live finished are measured by fee collection and the WUA's saving.

Performance of GFMIS

<u>Pump operation hours</u>

Following the development of GFMIS, whether cropping intensity and cropping pattern in both study areas have been raised. In Gunungkidul, cropping pattern increases from rice

(R) - upland crop (UC) to be R - UC (beans/maize) - UC (beans/maize) - UC (maize). In the last UC farmers grow maize as green seed for animal feeding with age of crop less than two months.

With this kind of cropping pattern, water requirements will be relatively constant every year. So, pump operation hours only depend on the number of rainfall only. By considering to this phenomenon, the relationship between long term period of number of rainfall with pump operation hours can be expressed as simple regression as follows :

$$Y = A + B X \quad .... \quad (1)$$

with : Y = monthly pump operation hours (hrs.)
X = monthly amount of rainfall (mm).

Relationship between these two variables of 10 GFMIS samples in Gunungkidul during the beginning period of operation, 1979-1983 and the recent years, 1989-1991, is given in Eqns. (1) and (2), respectively, as follows:

Year 1979 - 1983 : $Y = 307 - 0.70\,X$ .... (2)
$r = -0.97$, mean of Y = 168.1 hrs

Year 1989 - 1991 : $Y = 259 - 0.69\,X$ .... (3)
$r = -0.84$, mean of Y = 136.4 hrs

Comparing these two equations, it seems that the sensitivity of farmers to operate pump with respect to the number of monthly rainfall little bit decreased. In the recent years, they tend to operate pump longer when they have the same value of decreasing amount of rainfall. Decreasing mean of monthly pump operation is suspected that farmers try to minimize the pumping hours because upland crops more tolerant to water shortage than rice, and the cost for pumping is quite expensive.

In another hand, in Nganjuk/Kediri pump operation hours does not reflect any technical performance of GFMIS yet due to several reasons as mentioned previously.

<u>System efficiency, the actual irrigated area and actual discharge</u>

According to Ferguson (1987), efficiencies of diesel engine and turbine pump are 44% and 60 %, respectively. So, the system efficiency will be 24%. Result of calculation of pump efficiency, engine efficiency and system efficiency in both study areas is presented in the Table 5.

From this table , system efficiency in both study area are relatively the same. However, special attention should be given to Gunungkidul area, where farmers enable to attain this efficiency and they have to operate the pumping system with actual discharge exceed design discharge. Pusposutardjo and Arif (1992) show that drawdown in Gunungkidul in the recent years increases even the static water level is relatively constant. This phenomenon is suspected to the increase of well losses.

Significant decrease command area in several intermediate wells in Nganjuk/Kediri is attributed to competition with individual/private pumping system.

<u>Fee collection and the WUA's saving.</u>

At present, the O&M fee of pumping unit per hour varies between US $ 1.00 to $ 1.50 for deep well and $ 0.50 for intermediate well. The biggest part of the operation fee goes to fuel and oil cost (80%), and maintenance fee is only 10 % and nothing for saving to renewal pumping unit when the technical lives is attained.

By observing to the component of O & M fee, seemingly farmers do not provide enough fund for maintenance. Annual reports of the GDPs in both study areas show that maximum the WUA's saving is less than $ 150.00. This amount clearly is not enough for major repair of pumping units as well as irrigation structures.

Moreover, monitoring report of GDPs also indicate that income of farmers is relatively low. It is only about to $ 200.00/month/ha. By this amount of farmers income the WUA faces difficulty to increase the O & M fee.

The individual/private pumping system

In Nganjuk/Kediri area, several places have a great potential to provide groundwater even in shallow aquifer depth. So, actually, the groundwater irrigation system has been introduced since the Dutch Colonialism period in sugarcane plantation. In this system the Dutch government used steam engine to lift irrigation water from the open dug wells.

As well as farmers knew that groundwater is available in the shallow aquifer, they also constructed open dug wells in their own lands and used buckets manually to elevate water and irrigate their lands. After the GDP introduced technology of installing tubewells in this area, farmer also able to construct shallow tubewell pumping system up to 30 m depth using manual auger hole.

Development of machine industry in the country has encouraged farmers to purchase small portable pumping unit. Several trade marks with engine horse power up to 8 Hp are available in local market complete with after sale service, spare parts and workshops. Using this kind of engine they can elevate water in 10 lps to 12 lps which can be utilized to irrigate up to 2 ha of land.

The development of these individual/private pumping systems in the former GDP command areas causes strong competition among of them. In several areas farmers seem prefer to shift from the GDP system to the individual/private system. Reasons of farmer to shift their choice from the GDP to private owned pumping are : i) farmers have understood technology of shallow tubewell pumping system whether in term of construction or O & M technologies; ii) easier procedures to request water and payment method and, iii) greater conveyance efficiency and greater possibilities to have irrigation water in the private pumping system.

Impact to the sustainability

From the technical performances it seems that except intermediate well most of GFMISs showed appropriate conditions, eventhough, some of them have been operated since last 10 years. To keep this way, roles of local government such as what the Yogyakarta PRIS has done in supporting the O & M activities are very useful. However in another side this policy makes farmers who manage the pumping irrigation system rather spoil. They always request to the government subsidies when they faced problems in managing pumping unit. Actually, what they needs are more on management and technical assistants rather than government subsidies.

The relatively loose of government intervention in O & M activities in Nganjuk/Kediri have made the management of GPIS (whether WUA or individual/private system) stronger. In the deep tubewell systems, the WUA can manage the pumping unit in the appropriate ways as reflected by system efficiency. Another example was found in the TW 182 Ringinpitu, when the well damaged, farmers were capable to reconstruct new well even construction cost were more than $ 3,000.00. In the intermediate tubewells area where several individual pumps exist, farmers do not too much depend upon the government pumping systems. A good example was found in TW 138 Nglaban, the pumping unit has been out of order since January 1991, however, no effort of WUA to repair the unit, because farmer like to use their own pumping system. This was reflected by increasing number of pumping unit from 20 units to 25 units during one year (from 1991 to March 1992).

More attention should be given by local government because some wells have met the technical lives. Data on farmer income in both study areas showed that farmers are not capable to reinvest the new pumping system. Seemingly, up to present there are no fix plans or programs will be implemented to anticipate this problems. Revolving funds such as being implemented in several places in the country may can be considered to be practiced in both study areas. However, the local governments have to strengthen the WUA management before this program is implemented.

CONCLUDING REMARK

According to classification of sustainability, all of GFMISs in Gunungkidul can be categorized as sustainability level II since they need government subsidies for O&M and major repairments. In Nganjuk/Kediri the coming up of individual pumping system in the intermediate tubewell command areas causes decreasing irrigation service area and makes farmers are not dependent upon government subsidies anymore. However, in another side this phenomenon makes government investment to be useless. So, according to the sustainability classification the private pumping system is under level I sustainability. In case of deep tubewells, a little subsidy is still needed in major repairing, so, class of sustainability in this system may be classified in between level I and level II sustainabiltiy.

Eventhough, technical performances in most system express good condition, however, technical life of several wells in the study areas have finished. It seems that renewal of pumping unit is beyond capability of farmers. With no government assistant this problem can affect the sustainability of GPIS in both study areas.

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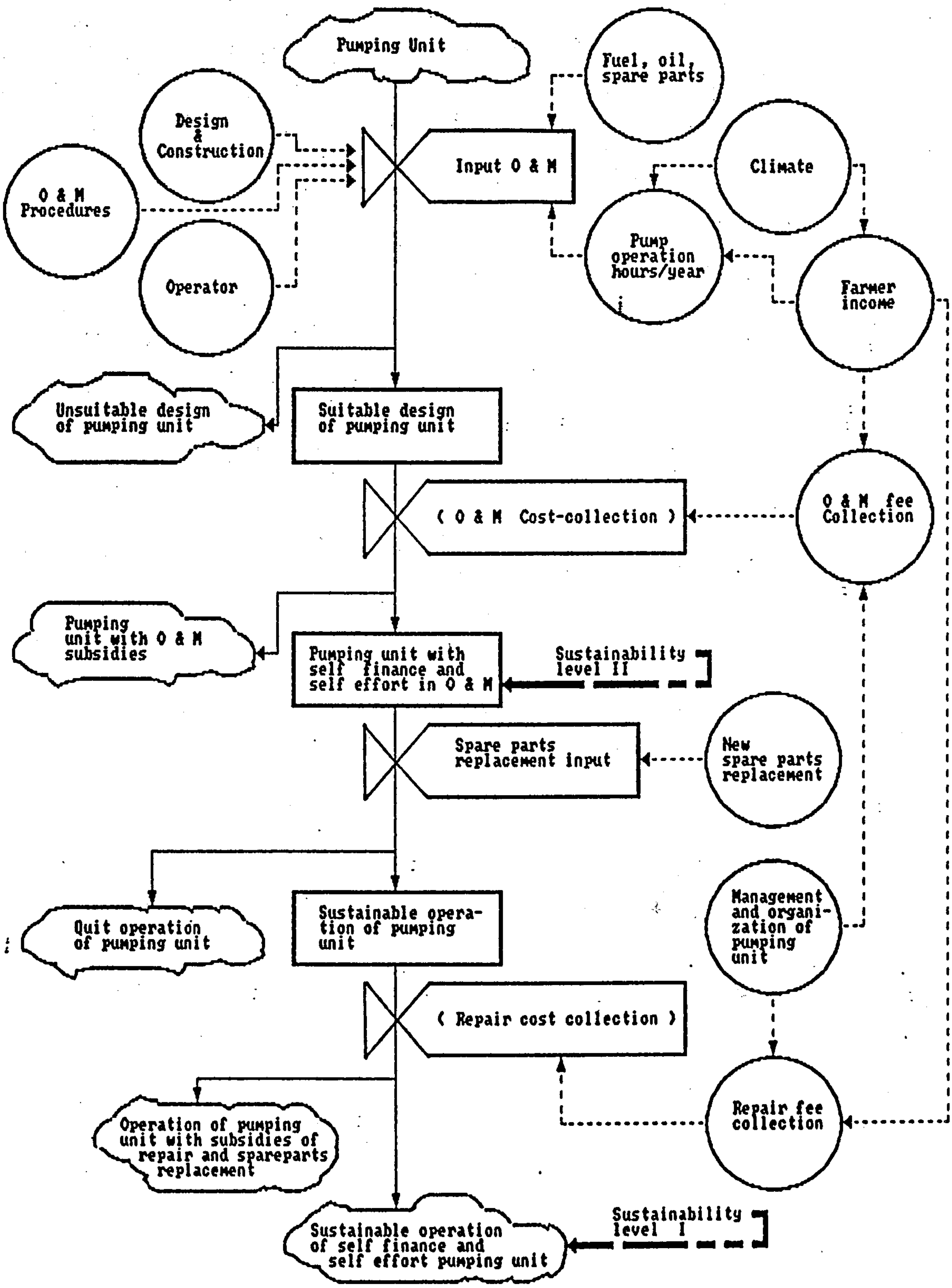

Figure 1. Block model diagram of sustainability of G F M I S (Pusposutardjo & Arif, 1992)

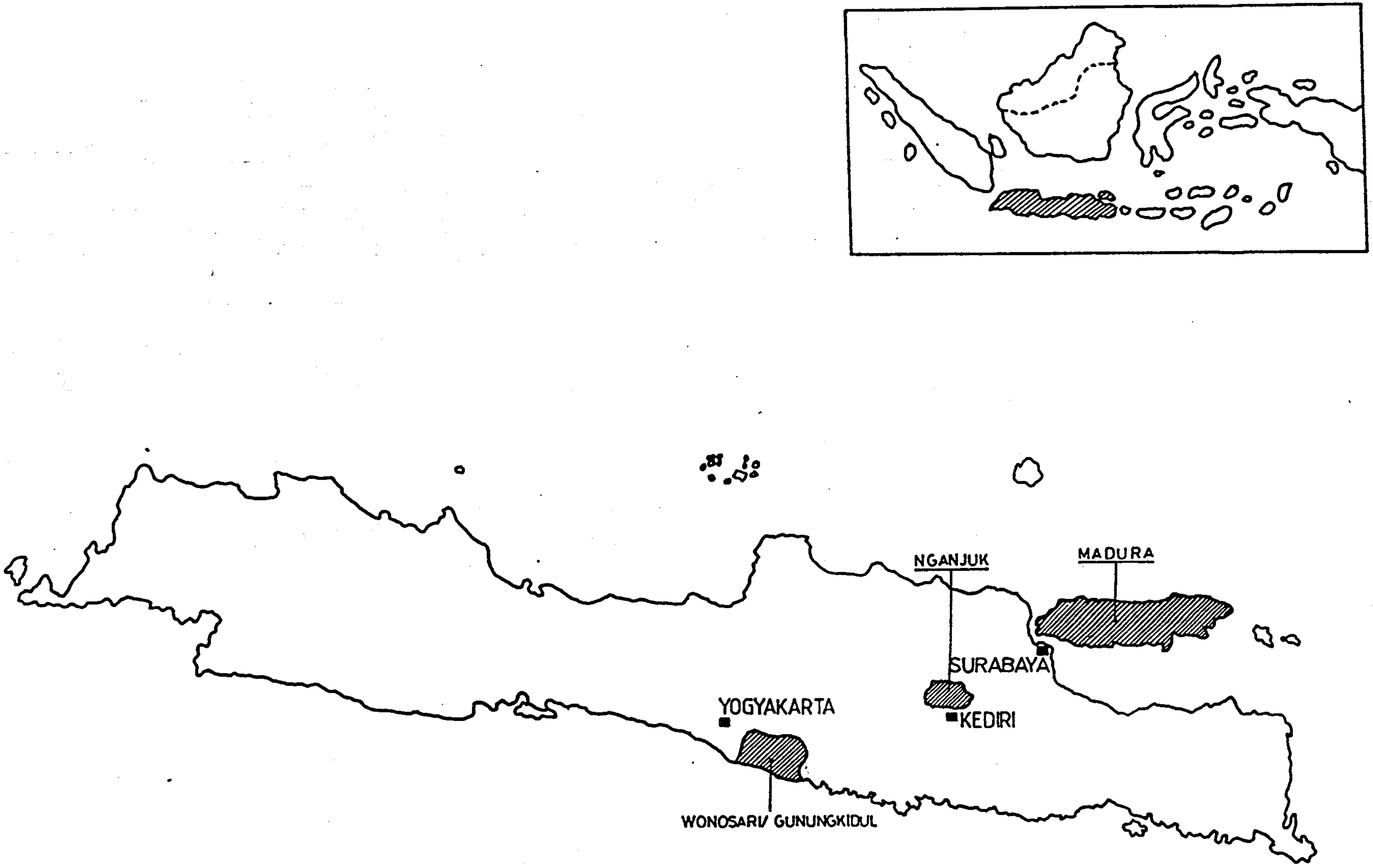

Figure 2 : Location of Study of Area

Table 1. List of variables and parameters used to measure sustainability of GFMIS

No.	Principal variable	Variable descriptor	Parameter
1.	Appropriate design of pumping unit (pump, engine, irrigation water conveyance)	Suitability between : power engine, pumping load (pumping head, discharge, hydraulic head) well costruction, irrigation networks with climate and farming system.	- Hp/rpm - diameter of pump inlet & outlet - number and kind of pipe bends - depth and size of casing - depth of well, specific yield, discharge, SWL - distribution of depth and number of rainfall - water balance - length, size and kind of canal - number and kind of other irrigation structures
2.	Appropriate costruction	Suitability between design and costruction	- number, kind and starting occurrence of damages - occurrence frequency of damages
3.	Appropriate O & M	Suitability between actual O & M with procedure O & M	- availability of manual procedure of O & M - time schedule of O & M - repair method - availability of O & M facilities - availability of savety of operation
4.	Fuel, oil and O&M spare parts	Availability and accessibility	- number, quality, price, purchasing method
5.	Operator and mechanic	Availability	- number, skill, education
6.	Pumping hours	Number and distribution of pumping hours	- average pumping hrs/mo - distribution of pump operation hours.
7.	Replacement spare parts	Availability and accessibility	- kind, number, price and purchasing method.
8.	Replacement facilities	Availability of mechanics and workshops	- qualification, number and accessibility

Table 2. List of GFMIS samples in Gunungkidul and Nganjuk/Kediri

Location	Well #	Village	Subdistrict	Area (ha)	Year operated
GUNUNGKIDUL	W -05	Bogorkidul	Playen	46.6	05/1978
	W -08	Siraman	Wonosari	31.1	07/1978
	W -11	Jaran Mati	Karangmojo	30.5	08/1978
	W -14	Karangwetan	Karangmojo	42.2	03/1979
	W -16	Playen II	Playen	33.3	08/1978
	W -19	Ngipak II	Karangmojo	44.4	04/1979
	W -20	Awar-awar	Wonosari	11.0	03/1979
	W -21	Jatisari	Playen	42.2	05/1979
	W -22	Plumbungan	Karangmojo	41.2	04/1979
	W -28	Bolo	Playen	34.6	06/1980
NGANJUK/KEDIRI	W-152	Jaan	Gondang	43.93	12/1981
	W-153	Kepanjen	Pace	49.99	07/1982
	W-174	Sumberagung	Gondang	44.145	10/1985
	W-010	Sidowareg	Plemahan	49.20	08/1974
	W-025	Ringinpitu	Plemahan	44.353	11/1981
	W-061	Sidowareg	Plemahan	37.95	11/1987
	W-116 *	Putukrejo	Loceret	20.14	06/1979
	W-117 *	Putukrejo	Loceret	21.561	06/1979
	W-138 *	Nglaban	Loceret	24.745	03/1980

Note :
* : Intermediate well

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Table 3 . Total and mean of monthly pump operation (hrs) of 10 well samples in Gunungkidul.

Well #	Location		Month 1	2	3	4	5	6	7	8	9	10	11	12	Total
W-05	Bogor kidul	*)	22	33	97	184	235	409	458	435	461	285	205	123	2947
		**)	9	9	10	55	163	61	314	258	271	163	256	115	1684
W-08	Siramam	*	22	13	77	50	126	334	323	301	205	205	177	75	1908
		**)	24	6	15	24	81	24	245	206	197	101	207	85	1215
W-11	Jaran mati	*)	37	22	31	66	188	314	289	394	208	145	141	63	1698
		**)	4	33	18	18	144	34	294	295	213	184	286	288	1811
W-14	Karang wetan	*)	21	22	66	188	314	289	394	208	194	169	75	169	1778
		**)	3	11	4	144	34	294	295	213	133	27	52	135	680
W-16	Playen 2	*)	33	35	58	66	182	323	324	323	376	236	212	106	2274
		**)	11	16	12	21	110	28	320	243	220	124	176	140	1421
W-19	Ngipak 2	*)	82	30	79	132	217	308	294	285	136	115	108	80	1866
		**)	12	20	17	18	180	43	288	267	305	205	219	194	1758
W-20	Awar-awar	*)	18	19	32	30	87	145	175	136	127	101	58	106	1034
		**)	10	2	33	7	50	12	54	85	76	71	54	15	469
W-21	Jati sari	*)	63	65	129	166	228	387	303	394	450	311	285	171	2949
		**)	5	9	42	73	118	9	325	271	304	218	311	119	1804
W-22	Plumbungan	*)	31	54	99	143	257	329	350	385	253	231	175	123	2430
		**)	5	17	37	28	150	60	296	262	215	167	208	143	1588
W-28	B o l o	*)	17	16	44	101	256	424	327	258	159	126	103	62	1623
		**)	3	13	4	16	21	21	268	230	235	132	162	190	1295
	T o t a l	*)	346	309	712	1050	1961	2860	3063	2964	2569	1724	1539	1078	20577
		**)	76	136	192	264	1083	299	2542	2217	2169	1392	1931	1424	13725
	Mean	*)	34.6	30.9	71.2	105	196.1	286	306.3	296.4	256.9	172.4	153.9	107.8	2057.7
		**)	7.6	13.6	19.2	26.4	108.3	294	254.2	221.7	216.9	139.2	193.1	142.4	1372.5

*) Source : Sir McDonald and Partners, 1984
Monitoring data of 1979 to 1983

**) Source : Monitoring report of PRIS,Yogyakarta, 1989 to 1991

Table 4. Total and mean of monthly pump operation of sample wells in Nganjuk/Kediri (hrs)

Well #	Location	Month												
		1	2	3	4	5	6	7	8	9	10	11	12	Total
TW-152	Jaan, Gondang	51	31	35	64	93	146	153	223	274	252	128	98	1548
TW-153	Kepanjen, Pace	17	28	2	2	10	7	90	210	227	168	110	44	901
TW-174	Sumberagung, Gondang	21	9	3	5	53	28	52	54	134	129	74	40	711
TW-010	Sidowareg	5	2	52	1	44	40	112	160	169	102	86	14	741
TW-025	Ringin jati	32	21	20	11	132	188	291	315	314	260	165	84	1835
TW-061	Sidowareg	37	8	16	33	70	111	168	209	233	195	141	30	1255
	Total	163	99	128	116	402	520	866	1171	1351	1106	704	310	6991
	Mean	27	17	21	19	67	87	144	195	225.2	184	117	52	1165

Source : Pusposutardjo and Arif (1992)

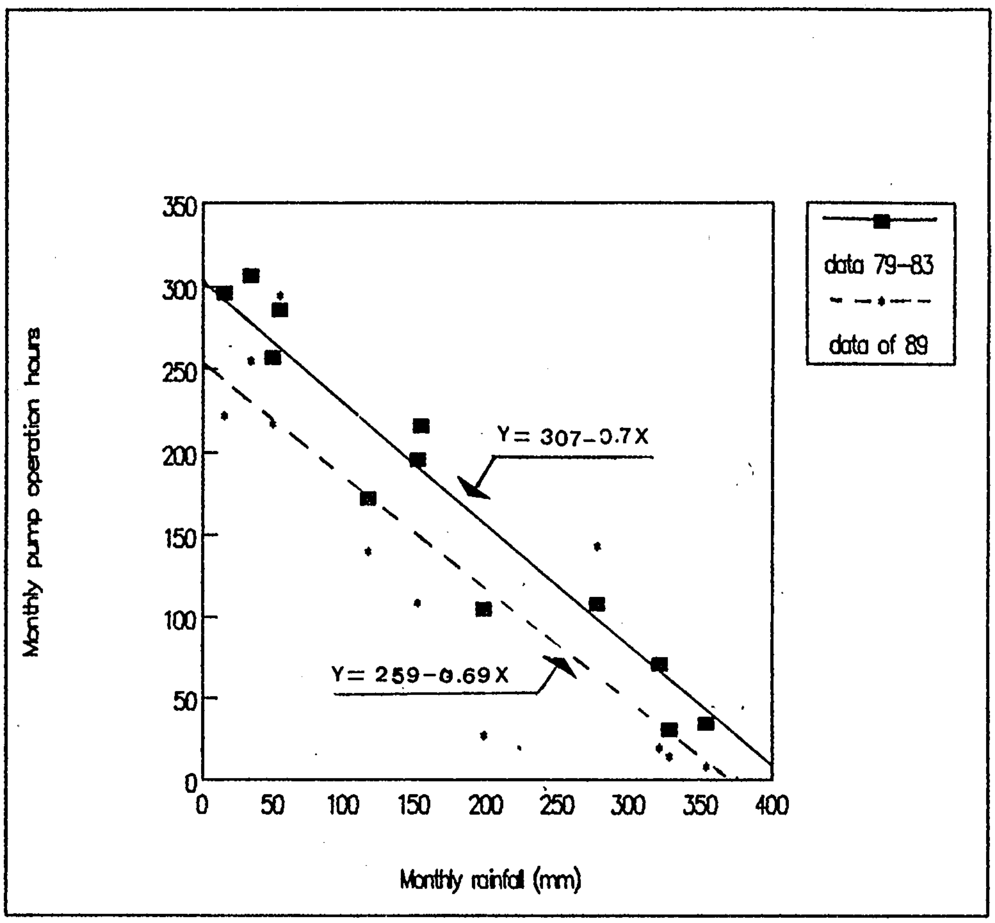

Figure 3. Relationship between monthly rainfall with monthly pump operation in Gunung Kidul.

Table 5. Relationship between pump efficiency, engine efficiency and system efficiency

Location	Qd l/s	Qa l/s	Qa/Qd	Fuel power KW	Water power KW	Pump Eff. %	Eng.Eff. %	Syst. eff. %	Hp
Gunungkidul									
Bogorkidul	31	24.3	0.78	43.21	3.8	28.3	31.07	8.79	18
Siraman	21	26	1.24	-	4	-	-	-	-
Jaranmati	29	25.6	0.88	38.88	4.14	30.83	34.5	10.65	18
Karangwetan	19	27	1.42	54.01	8.09	28.9	51.79	15	37.5
Playen II	25	29.5	1.18	43.21	5.2	38.72	31.07	12.04	18
Ngipak II	25	35.8	1.43	43.21	8.95	31.9	64.7	20.71	37.5
Awar-awar	20	18	0.9	43.21	4.41	32.84	31.08	10.21	18
Jatisari	25	53.4	2.14	-	5.23	-	-	-	-
Plumbungan	25	26.9	1.08	43.21	5.93	44.16	31.26	13.72	18
Bolo	17	23.2	1.36	43.21	4.32	32.17	31.08	10	18
Nganjuk/Kediri									
Kepanjen (W-153)	60	54	0.9	64.81	9.53	34	43.2	14.67	37.5
Jaan (W-152)	60	50	0.83	48.6	8.82	34.7	52.2	18.15	34
Sumberagung (W-174)	45	15.6	0.35	32.4	3.08	17.6	54.1	9.52	23.5
Sidowareg (W-010)	60	54	0.9	64.81	10.05	40.2	39.1	15.72	34
Sidowareg (W-061)	90	33	0.36	64.81	6.14	24.2	39.1	9.47	34
Putukrejo (W-116)	25	20	0.7	2	26.2	31	31	8.1	9
Putukrejo (W-117)	25	18	0.7	2	23.2	23.2	31	7.3	9
Nglaban (W-138)	25	17	0.7	1.5	22.3	22.3	41.4	9	9

Source : Pusposutardjo & Arif (1992)

Paper No.100

CAPABILITIES OF WATER USERS ASSOCIATION IN MANAGING GROUNDWATER PUMP IRRIGATION: A Case Study in East Java, INDONESIA[1]

Agus Pakpahan and Sumaryanto[2]

Abstract

Major problem in sustaining the benefits from groundwater pump irrigation is problem of endogenizing resource fixity, size of investment, and costs of transaction into WUA's effective decisions and operations. The smaller the adaptive and innovative capacity of the WUA in endogenizing those factors, the smaller the sustainability of the groundwater pump irrigation will be. This paper outlines the process of adaptation and innovation of WUA in responding to resource fixity, size, and costs of transaction based upon a case study of groundwater pump irrigation systems in East Java, Indonesia. Based upon organization performance such as pump working hours, areal utilization index, WUA's savings and revenue, the adaptation and innovation capacity of the WUA were evaluated and classified. The process of adaptation and innovation ranges from crop selection and diversification, water price formation and pricing rules, diversification of savings, managing external agents, and structural changes. In general, this research concludes that learning capability of WUAs to recognize the problems, and to find and to execute alternative solutions of them, is one of the most important factors of groundwater pump irrigation sustainability.

CAPABILITIES OF WATER USERS ASSOCIATION IN MANAGING GROUNDWATER PUMP IRRIGATION : A Case Study in East Java, INDONESIA[1]

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INTRODUCTION

This study is limited to groundwater pump irrigation (hereafter pump irrigation) provided by the government of Indonesia through Groundwater Development Project (GWDP) scheme operated by Department of Public Works. Even though there are wide ranges of pump irrigation schemes, the role of government in Indonesia plays a significant role in the development of deep well pump irrigation.

Groundwater pump irrigation development project provided by the Indonesian government was initiated in East Java early 70s. The number of groundwater pump irrigation in Indonesia by 1990 were 853 units: 604 units in East Java and the rest distributed in Central Java, West Java, Yogyakarta, Bali, West Nusa Tenggara, South Sulawesi and Central Sulawesi. Out of 853 units of pump irrigation in East Java, 504 units are deep well, 60 units are intermediate well, and 40 units are shallow well. The total hectarages of pump irrigated land in Java are 23,380 hectares, 422 hectares, and 144 hectares for deep well, intermediate well, and shallow well, respectively (Pakpahan et al., 1992). Even though the pump irrigated land in East Java is only about 2.6 percent of total surface irrigated land in this area, the pump irrigation in East Java serves the largest and oldest areas relative to other regions. Therefore, East Java can be treated as a good social laboratory for studying the dynamics of groundwater organization (Pakpahan et al. 1992).

Pump irrigation is turned over to a Water Users Association (WUA) created by the government, after two years of obtaining services from the project. The WUA should provide operation and maintenance costs. In addition, the WUA is usually also assumed to be responsible for replacement. A logical consequence of this rule of the game, the WUA is called for to be capable to handle the problems associated with operation, maintenance, and replacement. Since the initial endowment of the WUA in managing the new common pool resource such as groundwater pump irrigation is approaching zero, except to some degree for areas previously irrigated by surface irrigation, the growth of learning capability of the WUA in both adaptability and innovative ability is the key factor for

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sustainability of the pump irrigation scheme. This paper is intended to seek some understandings on the successes or failures of WUAs in managing the resources, namely, to answer whether there are prospects for sustainability of pump irrigation given the existing basic structure of WUA.

NATURE OF GROUNDWATER PUMP IRRIGATION

To organize the production means to allocate resources owned by input suppliers using certain rules accepted by all participants given technology in order to achieve certain predetermined outcomes under uncertain world. The capability to organize is conditioned or interdependently determined by the nature of the good under consideration. In other words, the success or failure of organization to achieve certain performance depends on the capabilities of the organization to control the sources of interdependencies which are reflected by the intrinsic nature of the good under consideration (Schmid 1987).

Pump irrigation is characterized by relatively high fixed cost, resource fixity, and considerable costs of transaction. High fixed cost is reflected by high construction costs. For example, the total cost of deep well construction in East Java in 1990/91 was Rp. 64.3 million (US $ 33,840) (Pakpahan et al. 1992). The fixity of resource is indicated by the immobility of the pump and command area. This situation implies that the distribution of surplus is determined by the condition of canals through out the command areas. Finally, managing the pump irrigation, namely, allocation of resources, distribution of outputs, maintenance of irrigation facilities, handling risks and uncertainty, and so on is not without costs. For an organization, the most important cost is costs of transaction, namely costs of managing internal affairs (coordinating all input suppliers) and costs of conducting external affairs. Such costs include exclusion costs, information costs and contractual costs (Schmid 1987).

Resource fixity, size of investment, and transaction costs of pump irrigation have their own implications to the organizational tasks. Such as mentioned above, resource fixity has implication to distribution of surplus or land rent across participant and sharing the cost due to immobility of the asset. Immobility of asset and land rent differential provides opportunities to conduct water price discrimination either across location or across commodities.

Size of investment implies the cost structure faced by the organization. The higher the size of investment, the larger the output required. It means certain size of operation should be achieved if investment wants to be economized. Otherwise, there will be too costly to operate the pump. This implies that entry and exit of customers into pump irrigation system are very important factor. In other words, exit will create loss to the organization, therefore, to be sustainable the organization should be able to manage the problems associated with exit of customers and supports from other participants.

The most important activity in any economic affair is transaction. Within the organization transaction is governed administratively and between organization transaction is conducted through market process. Nature of the good will affect the kind and magnitude of costs of transaction. High exclusion cost which is associated with nature of the good will increase free rider problem. Information problem will increase disputes. The higher the intra-organizational transaction costs, the lower the real output produced by the organization. In addition, the higher the inter-organizational transaction costs, the lower the real value of the output transacted. Therefore, volume of the good being transacted will decline. Differences in decision rules adopted by an organization will create different performance of the pump irrigation as far as they have different ability to control sources of interdependencies such as resource fixity or immobility, economies of size, and transaction costs.

Nature of groundwater is spatially not homogenous. We classified groundwater into deep aquifer and shallow aquifer and volcanic terrains and limestone terrains. Within these categories, we focus our study on pump irrigation in the regencies of Kediri and Nganjuk which represent volcanic terrains, and Madura Island which represents limestone terrains.

WUA PERFORMANCE

The capabilities of the WUAs are defined based upon their achievement (performance) that has important contribution to sustainability of the pump irrigation system. First we consider resource allocation performance and secondly we deal with distribution performance of the organization.

Resource Allocation

Land Utilization Index (LUI) and Pump Operation (PO). Performance of resource allocation in pump irrigation is indicated by LUI and PO. LUI is defined as summation of irrigated land throughout a year divided by designed area and PO is defined as pump working hours per year. Both LUI and PO reflect the capabilities of WUA in dealing with pump size, resource immobility, and transaction costs. The lower the value of LUI and PO given certain size of investment the lower the capabilities of WUA.

Table 1 shows that high performance of existing pump irrigation utilization has been achieved by TW66 in Madura with LUI and PO were 2.35 and 2395 hours, respectively. And, the lowest performance has been found in TW174 in Nganjuk with LUI and PO were 0.68 and 446, respectively. Those figures correspond to values of cropping intensity, namely 295 percent and 167 percent for the earlier and the latter case, respectively.

This finding implies that the organizations which are indicated by low LUI and PO have low capability in managing areas of operation, therefore, they cannot control size of investment and immobility of assets. In general, WUA that runs deep well pump irrigation has better performance than that of performance of organizations run organization under shallow aquifer environment. The latter environment produces sources of difficulties for the organization to deal with exit of the customers due to the entrance of private pumping into the areas or farmers invest their owned pump in their owned land. Even though there is a legal base for protecting the boundaries of the organization, the current performance implies that the existing transaction costs are too high to be enforced relative to the value of commodities being considered.

Table 1. Areal design, LUI and PO according to aquifer and location in East Java, 1991

Aquifer/Location	Code	Areal design (ha)	LUI	PO (hour)
Deep well				
Nganjuk	TW152	43.93	1.29	1751
	TW174	44.12	0.68	446
Kediri	TW10	49.21	1.40	2120
	TW61	37.95	2.00	1389
Madura	TW09	23.50	0.81	950
	TW66	44.20	2.35	2395
	TW97	32.70	2.00	2018
	TW102	32.30	1.80	658
Shallow well				
Nganjuk	TW116	20.54	1.02	513
	TW117	22.82	1.31	1756
	TW138	20.75	1.20	1631
	TW153	32.97	1.19	1007

Source: Pakpahan et al. (1992).

Conflict Resolutions. Management of pump irrigation is management of conflicting interests, including conflicts between current and future generations, as a consequence of water resource scarcity. In general, where market does not exist, conflict resolution over resource is usually solved by administrative processes such as indicated by water distribution schedule across blocks of irrigation. The higher the degree of scarcity, the higher the demand for administrative capacity.

In the pump irrigation, the effective demand for water is reflected by LUI. Low LUI means low effective demand for pump irrigation water (low effective demand for water does not mean low need or low availability of water). It also means that low degree of administrative procedure required. For example, instead of the WUA creating a tight schedule of water distribution, water allocation is made based on first come first serve base. This situation corresponds to the situation in Nganjuk which allocated water based on first come first serve base rather than following block schedule. On the contrary, the situation in Kediri and Madura where LUI quite high, water is allocated according to block schedule.

Pump irrigation in Sidowareg village, Kediri regency, has a unique feature, namely, there are 11 units of groundwater pump irrigation in one village. First pump irrigations, TW10 and TW12, was developed in 1972 and started operation in 1974. At the beginning, there were one WUA for one unit of pump. After experiencing almost ten years, and induced by TW71 breakdown, and they found out that they cannot replace the pump by each own resources, through initiation from the GWDP, a federation like organization has been created. Based on this administrative mechanism, the WUA has more power to manage the resources, particularly in dealing with size of assets, uncertainty, and conflicts.

Pump irrigation technically provides opportunities for the market to work relatively well. It is possible because metering problems and exclusion cost are relatively low. Therefore, price or water fee is very important instrument for rationing and more importantly to induce an efficient water resource use. The base of pricing rules can be classified into operation cost, time, crop, area, or combination of those bases.

In general, water fee is determined based on the average cost that has to be borne by the WUA in producing certain amount of water. That cost includes operational, maintenance, savings, and organizational costs.

The implementation of charging water fee based upon the above cost takes varieties of form. The charging rule provided by GRDP is that the collection of water fee should be based on time rate. In the fields, however, there are some modifications and/or advancements made by the organization.

Most WUAs charge water fee using time based approach. In Madura, however, particularly for areas where tobacco are dominant, WUAs also use crop base, namely, water fee is determined based on crops being watered. An illustration of water fee development across paddy, corn and tobacco in TW66, Madura is as follows.

The cropping pattern in TW66 area in a year planting season is paddy-tobacco-corn for wet season, second planting season, and third planting season, respectively. By September 25, 1990, paddy which is mostly planted in wet season and only watered once or twice a season, was charged US $ 16.67/watering/hectare and corn which is mostly planted at third planting season and usually watered 3-4 times a season was charged US $ 11.11/watering/hectar. Water fee for tobacco was determined differently, namely, the water fee was given for a whole season. In 1990, water fee for tobacco was US $ 44.44/hectare/season. Given the water fees provided, farmers spent for watering paddy, corn, and tobacco about US$ 17.00 - US$ 34.00/hectare/season, US$ 33.00- US$ 44.00/hectare/season, and $US 44.00/heactare/ crop season, respectively. The shares of water input in the total farm budget per hectare for paddy, corn, and tobacco are 5.31 percent, 36.54 percent, and 18.8 percent, respectively.

Practicing area-crop base pricing mechanism is only found in TW66, TW94, and TW 97, all are in Madura. The rest of the samples are applying time base pricing scheme. The earlier scheme is more or less based upon knowledge about crop water requirement which is dependent on the types of crop, type of soil and seasons. Area-crop base pricing mechanism to some degrees solves the problems associated with surplus (rent) and fairness when canal condition is not in good quality, namely, farmers who operate the land on the tail of irrigation pays independently from the distance of the land to the pump. However, the administrative requirements are more complicated than time-base pricing mechanism.

Outcomes performance

Outcome performance is defined as a performance resulting from the resource allocation strategies applied by the organization. Among others, there are two important outcome performances that give important contribution to organization sustainability, namely, net return and savings. The higher the net return, the higher the capabilities of organization to manage the resources and the higher the savings, the higher the capability of the organization to manage maintenance and risks and uncertainties.

Table 2 shows that variations of net return and savings are large. Highest performance in both net return and saving was achieved by TW66 in Madura. This high performance comes from two sources, first, institutional strength such as indicated by leadership, discipline, loyalty, etc. and, secondly relatively high value of crop, namely tobacco. The latter is indicated by non-marginal increase in net return/hectare/year that is more than 60 percent which is much higher than that of in Kediri (46 percent) and Nganjuk (35 percent).

Low performance of the rest WUAs is due to bad irrigation facilities such as indicated by low LUI (Table 1). In this situation average pump operation is low. Therefore, net return is also low. Organizational weakness is also responsible for low return and savings, namely, the organization has low ability to control sources of interdependencies such as mentioned above.

Table 2. Net return and savings of WUAs according to aquifer and location in East Java, 1991

Aquifer/Location	Code	Net Return US $	Savings US $
Deep well			
Nganjuk	TW152	115.44	195.56
	TW174	15.44	94.44
Kediri	TW10	590.89	n.a.
	TW61	265.89	n.a.
Madura	TW09	308.83	287.22
	TW66	1,686.50	4,555.56
	TW97	1,287.50	3,418.33
	TW102	615.67	333.33
Shallow well			
Nganjuk	TW116	4.00	n.a.
	TW117	14.06	n.a.
	TW138	64.61	22.17
	TW153	32.56	107.22

Source: Pakpahan et al. (1992).

Note: 1) Net return is defined as total revenue minus total operational costs, but not includes organizational cost.
2) US $ 1.00 = Rp. 1 800,-

CONCLUSIONS

The variation of capabilities of WUAs in managing groundwater pump irrigation are high. Type of aquifer seems as an important factor that conditions the capabilities of organization. The shallower the aquifer, the higher the cost for the organization because the lower the cost for customers to exit. The latter is possible because investment cost in shallow aquifer is much lower than that of a deeper one. Therefore, WUAs types of organization is only suitable for deep well pump irrigation.

Majority of WUAs work under low performance such as indicated by LUI, PO, net return and savings. However, they operate the irrigation system under their owned sources. In this sense, they have low to medium degree of sustainability. If replacement cost is considered as a part of sustainability of WUAs, serious efforts are called for: 1) to increase area of irrigated land: improve irrigation canals, increase working hours, develop group farming, improve pump-farming management, improve cropping pattern, reduce operational cost; 2) to increase farmers' ability to pay: reduce operational cost, choose high value crops, improve farm technology, economizing group farming, reduce transaction costs, and 3) to increase organizational ability: find a good leader, develop better standard operating procedures, develop better administrative structure, develop skills and knowledge of participants, develop values conducive to organizational objectives. The case of Kediri in strengthening administrative capacity and the case of TW66, TW94, and TW97 such as found in Madura in both improvement of pricing rules, strengthening organizational capability and other related issues, can be taken as lessons by WUAs to cope with resource fixity, size of investment, and transaction costs.

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Paper No. 102

ECONOMIC AND SOCIAL IMPLICATIONS OF GROUNDWATER IRRIGATION: SOME EVIDENCE FROM SOUTH INDIA

S.Janakarajan

ABSTRACT

Groundwater development in India has been quite impressive. Area irrigated by wells as well as number of wells have been on the increase. This means that the total investment that has been committed to this end has also been increasing overtime. This has resulted in a situation in which large numbers of well owners have had to compete to extract water from the limited available aquifers with a concomitant secular lowering of water table. An extensive field survey (in 27 villages) undertaken in the Vaigai basin clearly shows that there has been secular lowering of water table. This directly results in heavy capital and operative costs, which manifests itself in the rise of per unit cost of water pumped. Moreover, the competitive deepening activities of wells drives resource-poor farmers out of the race, who ultimately join the group of water-purchasers. In the water trade again, the resource-poor farmers who have poor bargaining capacity, are subject to unfavourable terms, though it appears at the surface that they benefit by entering into this trade. The water-purchasers are in a more vulnerable condition particularly in a situation where the traditional irrigation systems like tanks and spring channels are on decay and therefore they even lose access to the traditional irrigation sources. The evidence available in South India shows that the spread of well irrigation has been one of the main contributing factors for the disintegration of traditional irrigation communities. More pragmatic and result oriented legislative measures are therefore required for a proper regulation of groundwater utilisation.

ECONOMIC AND SOCIAL IMPLICATIONS OF GROUNDWATER IRRIGATION: SOME EVIDENCE FROM SOUTH INDIA

S. Janakarajan

1. INTRODUCTION

Groundwater has played a critical role in India's agricultural development. Indeed, the spread of bio-chemical technology and achievements in agricultural growth have been attributed, in large measure, to the extensive use of groundwater irrigation. The impact of sub-surface irrigation has been particularly pronounced in a state like Tamil Nadu in South India, where almost all possible surface sources have been tapped for irrigation. Over the last four decades, the proportion of net irrigated area (NIA) accounted for by surface sources in Tamil Nadu has declined, but NIA under wells has shot up tremendously, in particular since the 1960s. This increase is almost exclusively attributable to the simultaneous rise in the number of wells, since NIA per well has remained roughly constant over the last 25 years (Janakarajan 1991).

The fact that the number of wells has been on the increase is consistent with the fact that the total investment that has been committed to this end has also been increasing over time. This has resulted in a situation in which large numbers of well owners have had to compete to extract water from the limited available aquifers, with a concomitant secular lowering of the groundwater table. While use of groundwater on a wider scale may provide scope for more extensive access to this resource, one should also be concerned, with the economic implications and rising social costs of its exploitation.

There is also evidence which suggests that as a direct consequence of the increasing costs of well irrigation, resource-poor farmers have been driven out of the race of groundwater extraction (Dhawan 1990). Moreover, it is feared that the spread of groundwater irrigation in wet lands (i.e., area commanded by surface irrigation systems) has weakened traditional irrigation systems like tanks and spring channels. These developments have been accompanied by the increasing vulnerability of resource-poor farmers, who often in the end have to resort to purchase of water.

Against the background of the broad issues just sketched, this paper intends to discuss the following issues in some detail. First of all, has there been a secular lowering of the water table? If yes, what are the consequences of this phenomenon? This issue is discussed in section 2 with the support of the data collected for the ongoing study on Aspects of groundwater irrigation in the Vaigai basin, Tamil Nadu.[1] Secondly, what are the extent and implications of groundwater markets? This issue is analysed in section 3 with supporting evidence from the ongoing study on groundwater irrigation in the Vaigai basin and with the aid of an intensive case study of a village.[2] Section 4 is devoted to a discussion on the impact of the spread of well irrigation on traditional irrigation systems such as tanks. This section seeks support from the data collected on a large tank irrigation system, viz. Palar Anicut System in Tamil Nadu.[3] The last section provides concluding observations.

2. CONSEQUENCES OF SECULAR LOWERING OF WATER TABLE

In the first round village level survey of the ongoing well irrigation study, altogether 27 villages were selected on the bases of reach and varying degrees of well densities. One of the questions addressed to the sample well owners was what was the original depth at the time wells were first dug and their current depth as on the date of interview. It is quite striking that in all the villages current depth have gone up tremendously, particularly so in dry lands (which have no access to surface irrigation sources). For the purposes of present paper) I shall present only a summary table of all the 27 villages put together (Table 1).

It is clear from the table that of the total of 345 sample wells in wet lands, while 72.4% reported less than 30 feet as their original depth, only 39.7% reported it as their current depth. This implies that about 33% of the total sample wells, whose original depth was less than 30 feet, have moved on to a higher depth range at the time of the survey. Again the original depth of 20% of sample wells fell in the depth range of 30-50 feet, but as per the current depth as many as 42.3% of sample wells lie in this depth range. This again implies that 22.3% of sample wells have moved upto this depth range whose original depth was less than 30 feet. Similarly, percentage of samples wells reporting in the depth range of 50-75 feet was 4.1% as per the original depth; this has gone up to 14.2% as per the original depth. This means that about 10% of sample wells have been deepened upto 75 feet whose original depth was below 50 feet. Such large variations as between original and current depth of wells are striking in the case of dry lands, which is suggestive of the pronounced possibility that the decline in the water table is much steeper in the dry lands than in wet lands.

What does the secular lowering of the water table imply?

The secular lowering of the water table is one of the factors which determines the economics of groundwater irrigation. Its implications are manifold and they manifest themselves in several forms. Though it is not possible to go into the details of all of these, it is worth taking note of certain salient features: First of all, fixed investment in wells and in subsequent improvements such as on well deepening etc. go up. It also means that there is going to be a simultaneous rise in the operative cost such as on energy, maintenance of water lifting devices and so on. At the same time, in a large majority of cases lowering of the water table results in the decline of yield of water per well. The direct result of this is the rise in the per unit cost of water lifted. Secondly, the deepening activities in a well affect an adjacent well: all the adjacent wells which are served by an aquifer also should be deepened in order to preserve their water yielding status. Therefore, what one encounters is a deepening-and counter deepening-

Table 1 : Depth-wise distribution of wells in the Vaigai basin[a]

Depth range (feet)	Wet land[b]				(4)-(2)	Dry land[b]				(9)-(7)
	Original depth		Current depth			Original depth		Current depth		
	No. of wells reporting	Column percentage	No. of wells reporting	Column percentage		No. of wells reporting	Column percentage	No. of wells reporting	Column percentage	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
< 30	250	72.4	137	39.7	-113	334	66.1	159	31.5	-175
30 - 50	69	20.0	146	42.3	77	127	25.1	202	40.0	75
50 - 75	14	4.1	49	14.2	35	31	6.2	82	16.2	51
75 +	12	3.5	13	3.8	1	13	2.6	62	12.3	49
Total	345	100.0	345	100.0		505	100.0	505	100.0	

a) Total number of sample wells selected for the survey were 424 and 660 respectively in wet and dry lands. Of them, original and current depths were available only for 345 and 505 wells respectively in wet and dry lands.

b) Wet land refers to the area irrigated by surface sources. Dry land refers to the area which has no access to surface sources.

Source : Survey, 1991-92

race which ultimately not only raises costs but also imposes a heavy burden on the new comer, who want to dig a new well. Moreover, it is important to note that not all those who engage in deepening activities are successful. For some this activity results in prosperity while for a large majority, it results in heavy losses. Ultimately, those of the unsuccessful farmers and resource-poor farmers who are unable to participate in the race for deepening activities, are driven out of the competition. Therefore, as a last resort these unsuccessful farmers join the group of water purchasers, the issue to which I shall turn in the next section.

3. MARKET FOR WATER

The phenomenon of market for water has been fairly widely documented in the context of both Indian and Bangladesh agriculture (see for instance, Pant 1988; Roth 1986; Boyce 1986; Palmer-Jones and Mandal 1987; Mandal 1981; Shah and Vengamaraju 1986; Shah 1987; and Vaidyanathan and Janakarajan 1989). By and large, the available literature has predominantly focussed on the extent of prevalence of markets in areas where availability of groundwater is relatively abundant and where the rates for water are competitive. However, no systematic efforts have been made to understand the implications of commercial transactions in groundwater for water-sellers and water-purchasers. Before discussing this aspect of the problem, I shall present below evidence on the incidence of water sales in the Vaigai basin. This may enable one to form some impressions of the phenomenon of water sales in a relatively water-scarce area.

Out of 27 villages studied for the first round village level survey in the Vaigai basin, only in 15 was water sale reported. When we take a 'reach-wise' view of the matter, it turns out that the incidence of water sales increases as one progress from the head to the tail reach villages, presumably because in the upper reaches farmers have much better access to surface irrigation sources. For instance, in the head reach, only one out of 9 villages reported water sale; in the middle reach, 6 out 10 villages reported water sale; and in the tail reach all the 8 villages selected have reported water sale. Moreover, the extent of area to which water was sold from sample wells varies a great deal and it turns out to be substantially larger in the tail reach villages than in the upper reach villages.

Table-2 presents summary data on the incidence of water sales in the Vaigai basin separately in wet lands and dry lands. It may be noticed from the table that the incidence of water sale is more in wet lands than in dry lands mainly because a majority of the wells located in dry lands yield very little or no water, whereas the wells located in wet lands yield better water supply, thanks to the recharges available from tanks. Nevertheless, water sale is not very significant in the Vaigai basin; only 40 out of 307 sample wells (i.e., 13%) reported water sale in wet lands and 12 out of 350 sample wells (i.e., 3.4%) in dry lands. This only means that only a few well owners who have sufficiently deepened their wells and who have surplus water sell water. It also implies that a majority of well owners are either just meeting their demand for

Table 2 : Incidence of water sales in the selected villages of the Vaigai Basin, South India, 1991-92[a]

Wet lands[b]					Dry lands[c]				
Total number of wells	Number of sample wells	Number of sample wells reporting watersales	Total number of hours supplied by way of watersale	Extent of area to which water was sold (Acres)	Total number of wells	Number of sample wells	Number of sample wells reporting watersale	Total number of hours supplied by way of watersale	Extent of area to which water was sold (Acres)
610	307	40	18455	326	945	350	12	2118	93

a) This table gives details on watersales for 15 out of 27 villages selected for the survey. The remaining villages have not reported any watersale.

b) 'Wet land' is a revenue classification, which refers to the area commanded by surface irrigation sources.

c) 'Dry land' is a revenue classification, which refers to the area which does not have access to surface irrigation sources.

Source : Survey, 1991-92 (ongoing)

water or face scarcity. Our interviews confirm by and large inadequate supply of water from wells. In fact, many well owners in addition to non-well owners - who face scarcity also purchase water. Water charges are denominated in cash and do not vary much between wet and dry lands. But one finds variations across villages, where the charge has been found to range from Rs.4/- to Rs.12 per hour (US $ 0.15 to 0.44).

The rates very much depend upon the quality of water and the type of energy used. Poor quality water in general is charged low; if a diesel pump is used for lifting water, rates are high irrespective of the quality of water.

What is in fact important is to note the phenomenon of trading in groundwater for irrigation purposes even if its incidence appears to be insignificant. It was reported in our survey that the incidence of trade in water would have been much higher than what was in fact observed had there been sufficient surplus water available for sale. A majority of non-well owners and those whose wells have dried up expressed the desire and need to purchase water, but there were only a few well owners with surplus water to sell. This is one of the main reasons why water-sellers in water scarce areas emerge on top to dictate terms to water purchasers.

What follows next is a case study of a village called Sirunavalpattu in Tamil Nadu, where intensive field survey was conducted during 1982-83. This village study sufficiently demonstrates the fact of not only the high incidence of trading in groundwater, but also its implications for water-sellers and water-purchasers.

Groundwater market is Sirunavalpattu village

As essential feature of the terms and conditions under which water is sold in this village is that the water purchaser will have to part with a fixed proportion of his produce, which is one-third, to the water seller. This payment is referred to as *thanneer varam* or water rent. Table-3 presents survey data (for the year 1982-83) on some quantitative dimensions of the transactions in water. The table indicates that over 72% of the households belonging to the non-well group (who do not have own wells) purchased water. An interesting feature of water trade, as may be seen from table is the transfer of a considerable quantum of output from non-well farmers (who purchase water) to well owners (who sell water). Survey results indicate that a little less than ten percent of the total receipts of produce by the well owners is through sale of water, and about eight percent of the quantity of output marketed by them is accounted for by output received from water purchasers (Janakarajan 1986). By any reckoning, then, the scale of transactions in water is large.

But what kind of implications does it have on water purchasers of this village? First of all, the relative scarcity and unequal access to groundwater not only resulted in the emergence of market for water but that the likelihood that such a market would favour the water-seller was high. How favourable the market to those who have greater control over this ~~previous~~ precious resource may become clear from the terms and

Table 3 : Extent of land for which water was purchased and quantity paid towards water across landholding size classes in Sirnavalpattu (for all the three seasons together)

Size class (acres)	Number of Farmer households	Number of farmer households which purchased water	Extent of land for which water purchased (acres)			Quantity paid towards water (Quintals)		
			Paddy	Ragi	Groundnut	Paddy	Ragi	Groundnut
0.01-0.49	21	14	4.55	1.03	0.64	20.25	1.30	2.80
0.50-0.99	27	14	7.49	2.81	2.47	30.50	2.60	9.20
1.00-1.24	21	15	21.44	0.90	3.98	74.60	1.00	6.40
1.25-2.49	52	39	99.11	5.00	9.64	390.10	5.40	32.80
2.50-4.99	31	29	72.64	3.10	8.93	341.70	1.50	26.40
5.00-7.49	3	2	10.00	0	3.00	40.00	0	7.20
7.50-9.99	1	0	0	0	0	0	0	0
10.00 +	0	0	0	0	0	0	0	0
Total	156	113	215.23	12.84	28.66	897.15	11.80	84.80

Source : Tabulated from field survey data, 1982-83 conditions under which water is transacted. In addition to the payment of water rent, the water purchaser is expected to render certain services which are very often not specified. However, some of the *free* services extracted from the water purchaser are of the following nature : To exercise vigil in the water sellers pump-house so that he is in a state of readiness from the moment that power is supplied, to switch on motor. He must then irrigate the seller's land and his own, in that order. He is further required to deweed the field channels that convey water from the well to the water seller's plots; to assist in lifting the motor and pump from the well in the event of repairs to the pumpsets; and above all, to protect the seller's crop from grazing cattle. In addition to performing these unpaid services, the water purchaser is also required to be on call to perform certain agricultural operations for which prevailing wage rates are paid. To sum up, for most part of an agricultural season, the water purchaser is tied to the seller's farm and pump-house.

A particularly potent source of the control which a water seller can exercise over a water purchaser resides in the fact that the former is in a position to cease supplying water to the latter at a crucial stage of crop-rearing, on alleged grounds of his pumpset being in a state of disrepair, or on the basis of some such similar, transparently flimsy excuse. A cessation of the provision of water after an initial supply lasting for a month or forty five days could expose the water purchaser, who by then would have invested substantially in raising crop, to the danger of heavy losses. Neither is the purchaser free to turn to an alternative supplier of water : a customary practice in force in the village ensures that a water-seller may supply water only to owner's of contiguous plots; and this practice is easily enforced by a self-interested water seller's denial of conveyance, through his own fields, of water from some other potential supplier. Under these conditions, a water-purchaser often has no recourse but to accept an exploitative contract from the seller.

The condition of water-purchasers is particularly vulnerable because they can no longer depend upon traditional surface irrigation systems like tanks. Although the village has two tanks these have remained in disuse for several years, and there is absolutely no collective maintenance work on evidence. Perhaps, wider access to the private source of irrigation, viz., wells has affected the functioning of the traditional irrigation system. What follows next is by way of substantiation of this point.

4. EFFECT OF DEVELOPMENT OF GROUNDWATER IRRIGATION ON TRADITIONAL IRRIGATION INSTITUTIONS

Is it justifiable at all to blame the development of groundwater irrigation as one of the contributing factors for the disintegration of traditional irrigation systems such as tanks? The fact of the matter is that well irrigation has emerged as a predominant source of irrigation in this state (in particular its northern part) in not only dry lands but also in wet lands (i.e., area commanded by tanks). This is mainly due to the additional demand for water resources which is directly associated with the introduction of new technological packages (Bandara 1977). The underlying point is that hitherto irrigation water was treated as a property of a village society, to which every individual user had responsibility for maintenance; but after the emergence of wells in the tank commands and in the command areas of spring channels, irrigation water had become private property, the private property of those who have invested in wells and in water extracting mechanisms. In effect, along with land, water also has become an important productive resource. Therefore, there is every reason to believe that farmers who have access to groundwater have tended to dissociate themselves from the traditional irrigation community; it may be that they have no direct interest in tank irrigation and its maintenance, and so the critical functions of traditional irrigation institutions such as collective effort in maintenance work, system of water regulation and water sharing etc. are either ignored or lacks leadership to carry out these tasks (Vaidyanathan, 1991).

As part of a larger study on water management (Vaidyanathan and Janakarajan, 1989), we studied 15 tanks which are part of a large irrigation system - the Palar Anicut System in South India. One of the major components of the survey was the detailed interviews held with traditional irrigation functionaries. *Neerkattis* or irrigation workers constitute the lowest grade of irrigation functionaries who receive annual kind payments from the users of tank water. The detailed interviews we had with these irrigation workers offered sound evidence to substantiate the point that the spread of well irrigation has been one of the contributing factors to the disintegration of traditional irrigation institutions. It was reported that the irrigation workers hardly receive full payments at present which was stated to be in contrast to the fact that their forefathers were receiving substantially higher payments. They unambiguously point out that the villain of the piece has been the spread of well irrigation in the tank commands (Janakarajan 1991).

Table 4 offers support for this point with some quantitative details. This table gives information on the well density and percentage of area receiving well irrigation in the tank commands. It may be noted that in all the six tanks where the traditional irrigation institution is defunct, well density as well as percentage of area reporting well irrigation is very high. In fact in three of the six tanks, the proportion of area reporting well irrigation is over 80%. The case of Vembi tank is the most interesting of the lot, where the sluices have been kept closed for the last 7 years (prior to the survey), and the tank merely serves the purpose of a percolation pond. This is also the village where irrigation workers have stopped working since 1980.

By contrast, when we look at the tanks where the traditional irrigation institution is effective, the well density as well as percentage of area reporting well irrigation have been insignificant except in the case of two tanks (Velur and Kaliyur). In these two tanks although well density is high, traditional institutional arrangements are effective mainly because of factors such as advantageous location of the tank in a supply channel or availability of multiple sources of supply to a tank. As a result, these two tanks, without much effort, receive an assured supply of water. In this context it is interesting to note that in all the six tanks where the traditional irrigation institutions

Table 4 : Well density and percentage of area receiving well irrigation in the selected tank commands of the Palar Anicut System, 1985-86[a].

Sl. No.	Name of Tanks	Well per acre	Percentage of area receiving well irrigation in the tank commands
Tanks where traditional irrigation institutions are effective[b]			
1.	Peruvalayam	0.04	NA
2.	Agavalam	0.14	NA
3.	Karivedu	0.01	18.7
4.	Pudupakkam	0.02	30.8
5.	Paranthur	0.01	2.8
6.	Velur	0.20	70.8
7.	Kaliyur	0.21	27.5
8.	Kaveripakkam	0.13	NA
9.	Neervalur	Nil	Nil
Tanks where traditional irrigation institutions are defunct[c]			
1.	Thakkolam	0.18	97.2
2.	Perumbulipakkam	0.25	72.2
3.	Poigainallur	0.16	41.3
4.	Tiruppukkuzhi	0.07	67.4
5.	Vembi	0.28	90.0
6.	Sirungathur	0.33	83.8

(a) For sampling and other statistical details see Vaidyanathan of Janakarajan, 1989.

(b) These are the tanks where collective maintenance work is undertaken almost regularly by the users of water. Also these are the tanks, where traditional irrigation functionaries still function actively.

(c) In these tanks absolutely no maintenance work is undertaken and moreover no irrigation functionaries exist.

Source : Survey, 1985-87

are defunct and where the density of wells is high, the supply of water to the tanks through supply channels was stopped long ago, and users do not display any interest in restoring the supply to the tanks. Nevertheless, this is not to deny the fact that there are several physical, technical and institutional factors responsible for the disintegration of traditional irrigation institutions (Vaidyanathan and Janakarajan 1989). But it is also a matter of fact that the spread of well irrigation has been one of the contributing factors to the weakening of traditional irrigation systems.

5. CONCLUDING OBSERVATIONS

This paper has addressed itself to the question of economic and social implications of groundwater irrigation. The fact that there has been a secular lowering of the water table makes the point abundantly clear that both capital and operating costs of lifting have been on the increase. Moreover, there is over crowding of wells which suggests that society at large pays disproportionately more than what may be regarded as socially optimal to pump a given quantum of water. The development of groundwater irrigation should also be viewed in the light of the equity question. It is a matter of fact that the emergence of trading in groundwater provides wider access to this resource, even for those who do not own wells; but does this solve the problem of equity? There is also a great danger of over exploitation of groundwater, which may result in ecological imbalances, particularly so when traditional irrigation systems like tanks and spring channels, which are the principal sources of recharge, are on the decay. Therefore, there is a strong case for government intervention for proper regulation and utilisation of this resource.

The existing legislative measures in India are totally ineffective or not implemented. They are in the nature of denying institutional finance to those who dig new wells in a prohibited area or to those who do not maintain the minimum spacing between wells imposed by a state agency, or denying electricity connections to those who violate government regulations. However such restrictions do not pose any threat to self-financing farmers. Therefore, government regulations should be much more pragmatic and result oriented. This also raises a fundamental question : what went wrong with the existing legislative measures? This warrants a thorough and systematic examination of the socio-economic and political environment in which we are operating.

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Notes

1. This project is funded by the Planning Commission, Govt. of India.

2. This village study was carried out as a part of the author's Ph.D. programme in North Arcot district, Tamil Nadu (South India) during 1982-83.

3. This was part of a larger study on water management funded by the Planning Commission, Govt. of India. This study was carried out by the present author in collaboration with **Prof.A.Vaidyanathan**. The survey was conducted in different phases during 1985-87.

SUSTAINABILITY OF WATER USERS ASSOCIATIONS AS GROUND WATER IRRIGATION MANAGERS A CASE STUDY UNDER ON-FARM WATER MANAGEMENT PUNJAB-PAKISTAN

Muhstaq Ahmad Gill *

ABSTRACT

The paper discusses the Water Users Associations; their organization and operation after the reconstruction/remodelling of small scale community irrigation schemes (Watercourses) with special reference to their sustainability as ground-water irrigation managers. Watercourses carrying canal and ground water (tubewell water) renovated under three different categories viz: managed by: the Water Users Associations, a Government organization and a tubewell owned by a single farmer have been discussed and compared.

INTRODUCTION

Pakistan ranks fifth in the world and third in the developing countries in the size of irrigated area having the largest contiguous canal system. The irrigation system of the Indus Basin comprises of three major reservoirs, 19 barrages, 12 link canals and 43 major canal commands. Total length of irrigation canals is 49,500 km. The tertiary irrigation units (watercourses) numbering 89,000 have a total length of about half million kilometers. The irrigation supplies are augmented by 15,500 large public tubewells and over 300,000 private tubewells.

Poor irrigation efficiency resulting from huge water losses has been identified in the century old community watercourses at farm level resulting lower per acre yield. A diagnostic analysis of the Indus Basin irrigation system particularly at tertiary level inspired the planners to take some immediate steps to consider the improvement of irrigation efficiency at watercourse level by commissioning an On Farm Water Management (OFWM) Project.

Watercourse improvement envisages complete remodelling and reconstruction of community watercourses with partial brick lining and fixing of water control structures. This task is accomplished through farmers active participation. The water users are organized into a Water Users Association (WUA). The main functions of the WUAs are to arrange labour, settle all types of disputes amongst the shareholders, making arrangement for alternate watercourses, supervision of work and post construction maintenance. This unique experience of farmers participation has proved very successful in the Punjab Province.

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The canal irrigation is supplemented with ground water in the Indus Basin. There are about 3,15,500 tubewells in public and private sector, taping the aquifer serving the dual purpose of the irrigation and drainage. Large size deep turbine tubewells have been installed since sixties by the Government under the Salinity Control And Reclamation Projects (SCARP). Their operation, management and maintenance (O,M & M) is being undertaken by the provincial Irrigation Departments. The acute problem of high O&M cost has, however, compelled the Government for their disinvestment through transitioning. The private tubewells are more or less fractional centrifugal pumps installed, operated and managed by individual farmers.

Looking at the success of the implementation of the watercourse improvement programme through WUAs, an effort for managing the ground water exploitation has also been introduced. Ten tubewells operated by WUAs were installed on cost sharing basis in Dera Ghazi Khan on pilot basis. The idea of installation of such tubewells would be their replication in other areas upon success of the scheme. Present study was conducted to compare the results of different management techniques.

LITERATURE REVIEW

Malik (1981) reported an evaluation of the private diesel tubewells provided to the farmers by the government under a subsidy scheme. The study concludes that about fifteen percent of the tubewells have been identified to be installed in open without proper shelter thereby increasing the wear and tear of the machine and decreasing their operational efficiency. The study further indicates that theses privately owned tubewells were mainly used for their own purpose by the owners as only five percent of the farmers sold the tubewell water to the adjacent farmers.

Ashiq, (1981) reported that during the peak demand period the SCARP tubewells remained closed either due to repairs or replacement. The study has further shown that the operators make up the efficiency in their tubewell operation targets during the low demand periods. Moreover, the tubewell operators do not take interest in their assignments. Some of them have been reported to join other private side business and pay occasional visits to their original place of posting while others have never been seen at their job.

Shahid et al.,1990 concluded that, on over all basis, the extent of SCARP tubewell closure in a year due to mechanical faults was estimated as 4.05 months. It was further concluded in the study that although government is responsible for the expenses on operation of SCARP tubewells, the farmers had to pay an amount of Rupees(Rs.)245/- (US$ 9.8), on an average, to keep the SCARP tubewell running in order to fulfill irrigation requirements of the crop growth at the critical stages of the crops. The study further reveals that farmers on 5.5% of the total closed SCARP tubewells and 12.5 percent of running tubewells were ready to take over the SCARP tubewells out of which 56% were ready to take over these tubewells jointly. The reasons identified for not willing to talk over the SCARP Tubewells, are narrated as high electricity bills (68%), lack of cooperation (51%), own private tubewells, (46%), small holdings (40%), high operating and maintenance costs (31%) and apprehension about repair and maintenance (30%). The report further reveals that none of the association has been found willing to buy the SCARP tubewells jointly.

Chaudhry and Yong,1989 have pointed out that the pumping schedules of the SCARP tubewells were never made compatible with estimated canal supplies and crop water requirements. The operators remain frequently absent from tubewells and frequently allow the farmers to operate tubewells themselves. This practice resulted in damaging of electric motors and other protective devices. The pumping capacity of the SCARP tubewells has not only declined but upto 40 percent of the tubewells are not operating due to the maintenance related defects. Maintenance has been reported to be constrained seriously due to lack of availability of funds and when funds are available ,a slow, cumbersome and centralized decision making process caused un-necessary delays in fixing the problems.

METHOD AND PROCEDURE

To conduct the present study, three tubewells each operated by WUA, privately owned and managed by the Government through SCARP were selected in Dera Ghazi Khan. The watercourse No.7665/L managed by a WUA located in Shahbazpur, Tehsil Alipur, District Muzaffargarh having 95 shareholders, was selected for the case study. A nearby SCARP tubewell (No.AP 366) in village Punjaiwala located on Sabaliwala distributary contributing to two watercourses i.e. 7205/R and 6550/L having a total number of 137 shareholders (51 on 6550/L and 86 on 7205/R) and a private tubewell owned by Mr. Rahim Ali having five beneficiaries at the head of watercourse No.824/R Sultanwala, Phulan Tehsil Alipur were also selected for comparison. The shareholders irrigated through one out of every five consecutive turnouts were interviewed. However, the availability and capability of the respondents to answer the contents of the questionnaire was kept in view while selecting the respondents.

DISCUSSION

The shareholders of watercourse No.7665/L, Shahbazpur were motivated to organize a WUA and improve their watercourse with the active participation of the shareholders. This WUA, was provided with a tubewell for its installation at the head of the watercourse and a small agricultural machinery pool with OFWM related implements, including land scraper, ridger, ditcher, border disc, tractor operated rabi and kharif drills and chisel plough for their joint use under the management of the WUA.

The site for installation of the tubewell was selected by the WUA. The owner of selected land donated one kanal(1/8 acre) of land to the WUA to install the tubewell. The shareholders of the watercourse arranged the well drilling at the site and contributed all the expenses in this connection. The concept of cost sharing through provision of labour (skilled and unskilled) by the shareholders and materials by the Department (Government) under watercourse improvement programme was followed in installation of the tubewell, construction of a pump house and a water tank.

The active participation of the shareholders in monetary terms created sense of ownership and responsibility amongst the shareholders. It was experienced only in case of tubewells managed by WUA. All the members of the WUA considered the tubewell as their joint property. The tubewell operated by the WUA benefits 95 shareholders. The WUA tubewell was operated for 1182 hours during the last year.

After installation of the tubewell and handing over the package of farm implements to the WUA, the management committee of the Association was trained in book keeping, administration and management of tubewell and farm implements. The WUA had hired a full time operator who permanently stays at the pump house and receives a monthly salary amounting to Rs.800/(US$ 32).

The WUA fixed the tubewell water charges at the rate of Rs.45/- (US$ 1.8) per hour for tubewell with 1.80 cusec discharge as compared to the tune of Rs.60/- (US$ 2.4) for 1.25 cusec discharge charged by private owners. This rate has been fixed to generate the funds for the salary of a permanent operator, O&M and depreciation. Since sufficient funds are available with the association for operation, repair and maintenance, tubewell is repaired quickly in case of any break down. The tubewell water is provided to the shareholders strictly at the time of their turn for canal water due to rigid warabandi (turn to irrigate) system. However, during canal closure period, the water is supplied on first-come-first served basis.

The shareholder intending to purchase the tubewell water deposits the amount according to his requirement on hourly basis to the cashier of the association at least one day in advance to his turn/requirement. The cashier can keep an amount of Rs.2000/-(US$ 80) with him to cater the emergent expenditure. The amount exceeding Rs.2000/-(US$ 80) is deposited in the Bank. A joint account (A/c No.1029) is being maintained in the names of the secretary and the treasurer of the association in the bank. All members of the executive committee attend the office for one hour daily to enable the shareholders to place their demands for tubewell water or for farm implements. Daily office opening schedule is widely publicized during monthly WUA meetings and is written on the notice board of the office of the WUA for information of all the shareholders.

Sufficient stock of diesel, oil and lubricants (P.O.L) is kept in store for avoiding shut downs of tubewell. In case the tubewell goes out of order, the operator informs the president of the WUA who arranges the repairs/spares immediately. The WUA tubewell was run from March 1991 upto the end of February 1992 for 1182 hours with a total income of Rs. 37,080/- (US$ 1483) against overall expenses of Rs.36,202/- (US$ 1448). Month-wise details of expenditure and income are given in table 1.

TABLE 1. Monthly Details of Operation of WUA and SCARP Tubewells.

Water Users Association Tubewell				SCARP Tubewell Working Monthly Hours			
Month 1991-92	Working Hours	Income (Rs.)	Expenses (POL etc). (Rs.)	1988	1989	1990	1991
Jan:	0	0	700	981	354	236	20
Feb:	15	686	1357	00	290	210	127
March	8	225	180	472	252	10	00
April	121	4035	3291	339	6	30	00
May	128	3853	4967	190	2	20	00
June	140	4202	3812	00	00	00	00
July	98	2969	3128	00	00	00	00
Aug:	226	7079	4913	00	00	00	00
Sept:	8	289	1394	00	00	00	00
Oct:	214	5989	4700	00	00	00	130
Nov:	23	704	1540	360	340	00	00
Dec:	201	7049	6220	131	20	112	255
TOTAL:-	1182	37080 (US$ 1483)	36202 (US$ 1448)	1973	1264	180	532

NET INCOME:- Rs. 878/- (US$ 35)

0 No deman due to rains.
00 The tubewell remained out of order.

The operation, management and maintenance of tubewell and implements through water users association has made this institution viable, active and effective for undertaking other activities. All the shareholders of the association, under the case study responded positively to carry out the activities besides watercourse improvement in order to convert it into a multi-purpose farmer's institution. All of them are satisfied with the working of their WUA. About 95% of the shareholders work together for post improvement maintenance despite eight types of different castes/social groups of the farmers in the village. The meeting of the water users association are held regularly on first Friday of each month and are attended by most of the shareholders.

The private tubewells are not essentially installed near the head of the watercourse, that is why the tubewells have lesser beneficiaries. There is no chance for the upstream shareholders of the watercourse to get water out of tubewell as the same is constrained by the slope of the watercourse. Such private tubewell therefore, remains under utilized.

The tubewell selected for this case study was located in the middle of the watercourse and has only five beneficiaries including the owner. The tubewell remained under operation during the last year only for 190 hours. The owner of the tubewell is handling operation and maintenance the tubewell himself and no independent person has been engaged by the WUA to operate the tubewell. The owner is not available most of the time as he is engaged in his personal assignments and the shareholders cannot reach him to get water to irrigate their fields. This is another reason for the tubewell to remain under utilized. When the private tubewell is out of order, the owner is himself responsible for its repair. He may not have the required funds and time to get it repaired timely. It interrupts the irrigation schedule planned by the nearby beneficiaries. Due to monopoly of the owner, the cooperation amongst the group is poor. It was noticed during this study that 83% of the respondents felt difficulty for getting the water from private tubewells when they required. The water users of the privately owned tubewell spent lesser time for maintenance of their watercourse due to the inactiveness of the WUA as compared to the WUA included in the case study as the latter has installed tubewell at the head of the watercourse.

The third alternative observed under the case study is the SCARP tubewell, installed at the head of the two improved watercourse. It is run by the irrigation department under the SCARP programme. A full time operator has been provided for the tubewell but he takes a little interest in his work. Ashfaq (1981) also reported that many often some of the shareholders of the SCARP tubewells have not seen the operators at all. Moreover, some of the operators are engaged in private business rather than performing their own duties at the tubewell. To get the SCARP tubewell repaired is a time consuming job. A lot of time is wasted in decision making process by the Government offices. Some times it takes even months before the SCARP tubewell is repaired. The tubewell water is provided to the shareholders strictly at the time of their turn according to Warabandi (turn to irrigate). A comparison of installation, operation and maintenance of three different tubewell categories observed under the case study is given in table 2. The table indicates that the tubewell operated by WUA is more successful, economical and effective in terms of their operational annual hours and cost.

Possibility of disinvestment of SCARP was also explored in the case study in order to lessen the burden on the public sector. It was however observed that only 20% of the farmers had shown their willingness to take over the SCARP tubewells under a WUAs with a cost of Rs.10,000/-(US$ 400) on installments @ Rs.2,000/-(US$ 80) per year. When their opinion was sought about engaging the same operator, they disagreed to do so due to high pay of the operators and their inefficient performance. The remaining 80% of the respondents disagreed to take over the tubewell due to high O&M costs, lesser cooperation amongst the farmers, poor efficiency of the tubewell and the heavy electricity charges.

TABLE 2. COMPARISON OF THREE TUBEWELL OPERATIONAL MODES IN THE CASE STUDY

Sr. No.	Details.		Private tubewell	W.U.As tubewell	SCARP, tubewell.
1.	Source of power.		Diesel	Diesel	Electrical.
2.	Measured discharge(cfs)		1.25	1.79	2.80*
3.	Designed discharge.		N.A	N.A	4.00
4.	Annual working hrs.(hr).		190	1182	1108
6.	Utilization factor		0.026	0.16	0.12
7.	Beneficiaries.		5	95	137
8.	Capital cost (based on 1991 prices)	Rs. $	45,950 1838	116,874 4674	1033,785 41351
9.	Life assumed.		10	10	20
10.	Operating cost per acre inch.		54.00	30.00	63.48
11.	Water rate charged from the beneficiaries(Rs./hr)		60	45	N.A
12.	Operating cost per csf per hr		48	25	N.A
13.	Water rate per acre inch a acrecre inch		74.38	79.90	N.A

* @ 70% of the designed discharge.

RESULTS AND CONCLUSIONS

1) The WUA owned and operated tubewell supplies irrigation water at 30% less cost as compared to that of private tubewell.

2) The availability of water to the shareholders is ensured by WUA according to the demand as compared to private tubewell where it depends on the sweet will of the owner and to the SCARP tubewell where it is attributed to luck.

3) Repair and maintenance of the WUA tubewell is quicker due to social and obligatory pressure of the shareholders as compared to the financial and time constraints of private owner and bureacratic approach of the public agencies in case of SCARP tubewell.

4) The WUA tubewell operator, being employee of a private entrepreneur, Non Governmental Organization (NGO), is bound to perform his duties punctually as compared to private tubewell where the owner has to perform his duties himself. In case of SCARP tubewell operator, his salary and services are protected by the government irrespective of his absence from the duty. Accordingly this operator is far less efficient than that of the WUA.

5) Involvement of the WUA in operation of the tubewell enhanced cooperation amongst the shareholders and thus made the WUA more active, effective and viable for taking up other activities like maintenance of watercourse, irrigation scheduling and use of implements resulting better use of available water efficiently and more crop yields. These institutions can accordingly generate their own funds for their sustainability for carrying out proper functions including OM&M of small scale community irrigation, drainage schemes, operation of machinery pools and distribution of non-water agricultural inputs.

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