PUBLIC TUBEWELL IRRIGATION IN UTTAR PRADESH, INDIA

A case study of the Indo-Dutch Tubewell Project

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SUMMARY

The development of groundwater resources for irrigation, was an essential component in the spread of the Green Revolution. It would provide an adequate and reliable, extra source of irrigation water. From the 1970s onwards, deep tubewells were constructed on a massive scale in different countries in Asia. These *public tubewells* were financed out of national funds and through contributions from international lending agencies. In India and Bangladesh public tubewells were constructed to expand the irrigated area. In Pakistan, deep tubewells were primarily constructed as vertical drainage facilities to lower groundwater tables and secondly to provide supplemental irrigation water.

In 1988 the Indo-Dutch Tubewell Project (IDTP) started in Uttar Pradesh, India, with the objective: *...to increase the agricultural production and improve the living conditions of farm households by providing irrigation water through tubewells of improved design and by the provision of supporting activities* (Formulation Mission, 1987b:1). IDTP aimed at (a) the construction of 750 public tubewells, (b) the modernization of 125 old public tubewells and, (c) the improvement of 200 old public tubewells. The public tubewells were constructed by the Department of Irrigation. Non-technical components of IDTP were: (a) agricultural extension and research, (b) a Women Agricultural Extension Programme, (c) the creation of a Monitoring and Appraisal Cell and, (d) studies on water management practices in public tubewell command areas. The water management studies resulted in the implementation of a Farmers Participation Pilot Project. The total duration of the project would be 3 years, but the project was extended in 1991 with two years. Construction costs for a new public tubewell were NLG 95,000. Budget available was NLG 90 million, of which 95 % was allocated to construction and rehabiliation of public tubewells.

IDTP adopted a public tubewell system design which was developed by a World Bank project between 1980-1983 in Uttar Pradesh. According to the World Bank (1985b), this project was implemented successfully. The public tubewell consisted of a well, submersible electrical pump and brick-built pumphouse. Water was pumped into a tank or so called elevated distribution chamber, from where it flowed in a buried PVC pipe distribution system. Alfalfa outlet valves each serving about 5 ha were constructed on the pipe system. The tubewell had a capacity of 150 m^3h^{-1} which would serve a command area of 100 ha. Power constraints would limit daily operation to about 16 hours. It was expected that in kharif a public tubewell would operate 750 hours and irrigate 34.5 ha. In rabi a public tubewell would operate 2500 hours and irrigate 56.5 ha. Public tubewells were grouped together in a cluster of some 20 to 30 wells. One cluster had one independent electrical feeder line. Public tubewells were implemented in areas: (a) were the watertable was too deep or the farms too small for private tubewell development, (b) which were not served by surface irrigation systems, (c) where the area served by private tubewells did not exceed 20% of the cluster area.

In 1993, at the end of IDTP, 547 new public tubewells were constructed, 128 old tubewells were modernized and 100 old tubewells were improved. This means that approx. 70% of the planned 1075 public tubewells were constructed and rehabilitated. Quality of construction was generally good. But at many tubewell sites the quality of the constructed closed water distribution system was poor, and field channels were absent. Actual operation of the public tubewells was below the targets set during the designing of the system. In rabi 1990-1991, the average running time of 120 public tubewells was 455 hours, and in rabi 1992-1993 average running hours of 749 public tubewells was 955 hrs. The electricity supply for the public tubewell systems was unreliable and inadequate. In six seasons, from rabi 1990-1991 to kharif 1993, the daily electricity supply varied between 8.5 and 14 hours and daily running hours varied between 2.5 and 7.5 hours per day. The target of 16 running hours per day was never reached. The average net irrigated area per public tubewell was 25 ha in rabi 1990-1991 and 36.5 ha in rabi 1992-1993. Which was below the target of 56.5 ha irrigated in rabi.

The public tubewells were often out of order because of mechanical break-downs and defects caused by voltage fluctuations. Leakages in the water distribution system and defect field outlets were often found. The Operation and Maintenance Division of DoI was not able to perform the necessary repair work in time, because budgets were too low and no planning for O&M was made. Because of this, public tubewells were not in operation for long periods of time. The combination of insufficient electricity supply, inadequate construction, inefficient O&M, and frequent defects of the tubewells resulted in an unreliable and inadequate water supply for farmers in the public tubewell command areas

Project monitoring was mainly focused on the progress of construction. A bench mark survey was conducted at project start, but was not followed by a survey at the end of the project. Because of this, a social or agricultural impact study of IDTP was not conducted for an evaluation of the project. However several documents (MAC 1992, EM 1992, NDC 1994&1996) state that the project was not able to reach the target group: the small and marginal farmers in eastern Uttar Pradesh. There are strong indications to endorse this viewpoint. In a ground water market study conducted by Pant (1991) in World Bank public tubewell command areas, which are similar to the public tubewells constructed by IDTP, it was concluded that water distribution practices in the public tubewell commands was inequitable and out of the reach of the poor, low castes and tail-enders. Even if public tubewell operation was optimal and water supply could be assured, scarcity of cheap public tubewell water would persist. In the struggle for scarce water, rich farmers would capture a major part of cheap public tubewell water. Small and marginal farmers would remain dependent on expensive private tubewell water and would not get assured access to public tubewell water. In 1991 the Farmers Participation Pilot Project (FPPP) started and guided the democratic election of 34 Tubewell Management Committees. The FPPP provided training to chairmen and secretaries of these committees. The organization of Farmers Cooperatives by democratic elections was a good step forward in providing equal access to public tubewell water to smaller farmers.

Achievements of the Research and Extension component were far below expectations. The Department of Agriculture, responsible for extension, laid down 1600 demonstration plots reaching only 25 % of its target. The local agricultural university, responsible for research, did not produce reliable research results. The introduction of a component especially aiming at providing agricultural extension for women was new in Uttar Pradesh. Though limited in scale, WAEP proved to be successful, 50 Female Extension Workers were trained and posted in tubewell command areas. Besides extension, income-generating activities were also incorporated in the programme. The achievements of WAEP and FPPP were appreciated by the Mid-Term Evaluation Mission (1990) and the Evaluation Mission (1992). Unfortunately both components could not be incorporated in on-going government programmes nor extended separately at the end of IDTP.

DoI was responsible for the total package of construction, monitoring, O&M and management of the public tubewells. Which included the organization of farmers in the public tubewell commands as well. However DoI was mainly focused on the construction of the public tubewells, the *hardware* of IDTP. Activities such as O&M, management of the public tubewells and organization of farmers, the *software* of the project, showed severe shortcomings. MAC emphasized the need for an integration of socio-economic activities in the project. For example, by stressing the importance of farmers participation in the construction and management of public tubewells.

The public tubewell systems implemented by IDTP did not bring the benefits as expected. In the same period, the area irrigated by shallow private tubewells expanded rapidly in Uttar Pradesh. Because of this, the evaluation report (1992) and World Bank (1991) suggested that private tubewell technology instead of public tubewell technology was a more viable option for groundwater development in India in the future.

Assumptions are normally made during the formulation of a project. Project planners should assess whether these assumptions can actually be maintained during project implementation. Such a verification may not be possible, for example because comparable data is absent. In this situation, donors and project planners should formulate pilot projects in which new techniques or approaches can be field tested on a small scale. Project monitoring should aim at an assessment of the project objectives. Besides a presentation of project progress, more attention should be paid to the analysis of the social, economic and/or agricultural impacts of a project and to the formulation of adjustments when necessary. Agricultural development projects cannot rely on technological intervention, the *hardware*, alone. *Software* components such as management, training, extension, research and institutional development should be integrated in such a project. Both *hardware* and *software* components should consistently be planned and implemented.

LIST OF ABBREVIATIONS

BMS	Bench Mark Survey
BRAC	Bangladesh Rural Advancement Committee
CARE	International Non-Governmental Organization
CCA	Cultivable Command Area
DGIS	Directorate General International Cooperation or Netherlands Development Cooperation, Ministery of Foreign Affairs, The Netherlands
DoA	Department of Agriculture
DoI	Department of Irrigation
DTW	Deep tubewell
EEC	European Economic Community
ERR	Economical Rate of Return
ESTW	Electrical Shallow Tubewell
FEW	Female Extension Worker
FPPP	Farmers Participation Pilot Project
FRR	Financial Rate of Return
GoI	Government of India
GoN	Government of The Netherlands
GoUP	Governement of Uttar Pradesh
HYV	High Yielding Variety
IDA	International Development Association
IDTP	Indo-Dutch Tubewell Project
IDITP	Indo-Dutch Interim Tubewell Project
kharif	wet season (June to September)
kV	Kilovolt = 1000 volt
KVK	Krishi Vigyan Kendra, local NGO
MAC	Monitoring and Appraisal Cell
Mha	Million hectares
MTEM	Mid-term Evaluation Mission
NCA	Net Cultivated Area
NDC	Netherlands Development Cooperation
NDUAT	Narendra Dev University of Agriculture and Technology
NGO	Non-Governmental Organization
NIA	Net Irrigated Area
NLG	Netherlands Guilder
O&M	Operation and Maintenance
PTW	Public Tubewell
QPR	Quarterly Progress Report
rabi	dry season (October to March)
Rs	Indian Rupee
Scarp	Salinity Control and Reclamation Project
TA	Technical Assistance
TDS	Total Dissolved Solids

TMC	Tubewell Management Committee
UP	Uttar Pradesh
UPI	First Uttar Pradesh Public Tubewell Project of the World Bank
UPDESCO	Uttar Pradesh Development Systems Corporation Ltd.
UPSEB	Uttar Pradesh State Electricity Board
WB	World Bank
WAEP	Women Agricultural Extension Programme
zaid	summer season (April to June)

FOREWORD

This report is the result of a study ILRI conducted during 1997. The aim of ILRI in initiating this study is to learn from experiences of the past and use these lessons for improvement of future projects. Since the 1970s deep tubewells have been installed on a massive scale in various Asian countries for instance in Pakistan, India and Bangladesh. The primary objective was to expand the irrigated area and most tubewell schemes were financed from national funds and from funds supplied by international lending agencies. In the course of time private tubewells became more popular in areas with favourable groundwater conditions. However the private tubewell projects proved to be ineffective in reaching the poor marginal farmers. The Government of India realized this and to assist these farmers a deep public tubewell scheme was started in Uttar Pradesh in the early 1970s. After initial World Bank funded projects the Indo-Dutch Tubewell Project was funded by the Netherlands Government. This particular project is the subject of this study.

The study was conducted by J.H.Alberts who was guided by various ILRI staff, in particular M.Jurriëns, Th.M.Boers, R.van Aart and A.Schrevel. We appreciate the efforts of the author and other staff involved in conducting and finalizing this report. This study is published as a *Special Report* and is given limited distribution to concerned parties. We hope this report will help in understanding the problem and the project as it was executed and will also serve in discussions on how to improve approaches in assisting poor and marginal farmers of Uttar Pradesh in their development. ILRI is particularly interested in finding adequate ways to assist these farmers in obtaining access to water for irrigating their fields as part of a long term interest in land and water development projects.

Wageningen, 12 March 1998

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1 INTRODUCTION

1.1 Public tubewell projects on the Indian subcontinent

Since the 1970s deep tubewells have been implemented on a massive scale in different countries in Asia. In Pakistan, India and Bangladesh numerous deep tubewell projects were executed. The development of groundwater resources for irrigation, was an essential component in the spread of the Green Revolution, since it would provide an adequate and reliable, extra source of irrigation water. Deep tubewells were financed out of national funds and by contributions from international lending agencies. The construction of deep tubewells was generally conducted by public agencies. In Gujarat, India, cases are found where deep tubewells were financed and constructed from private sources (Moench, 1993:8).

Deep tubewell projects in India and Bangladesh primarily focused on the expansion of irrigated agriculture. In Pakistan, deep tubewells have been installed primarily to lower groundwater tables and secondly to provide supplemental irrigation water. In other countries deep tubewells were installed on a smaller scale for instance in Nepal, Indonesia and the Philippines.

India

Tubewell irrigation in India has expanded enormously in the last four decades, from nearly non-existent in 1950 to a net irrigated area of more than 11 million ha in 1985. The total net irrigated area in India was 41.8 million ha in 1985 (World Bank 1991:2). This area is irrigated by several millions of shallow tubewells and by approx. 60 thousand deep tubewells, which are mainly located in the northern states of India (Bhu-Jal 1991 in Palmer-Jones 1995:21). Drilling of private shallow tubewells is the only way in which groundwater can be developed in most of the hard rock areas of India, as in Madhya Pradesh. In these areas small local aquifers exist in fissured rock. In areas having alluvial aquifers, as in the north-eastern Gangetic plain and in Gujarat, other water lifting devices can be used as well.

In practice, private groundwater development can only be undertaken (a) where the aquifer is shallow enough to use a simple water point and (b) where farmers have the financial resources to invest in their own irrigation system (Cunningham, 1992:35). Agricultural development in north-eastern India: Bihar, West Bengal, Orissa and Uttar Pradesh was rather slow compared to Punjab and Haryana. In these states, farmers were able to invest substantially in private shallow wells. The agrarian structure in the north-eastern states, which is characterized by a large proportion of small and resource-poor farmers, would hamper agricultural development by private means. Therefore substantial public investments were made to give a strong impuls to agricultural development in this region (Palmer-Jones, 1995:27).

Support by foreign donors to tubewell projects was mainly focused on Uttar Pradesh (UP).

From 1961 to 1964, the World Bank supported a project for the construction of 800 public tubewells. From 1970 onwards, the World Bank provided 5 loans for a private tubewell credit programme in UP. However, results showed that only about 66% of the borrowers for private tubewells were small farmers (below 3 ha), while more than 90 percent of the households in UP were small farmers. This means that larger farmers took a disproportionate share in the loans (World Bank, 1983a:1-2). Between 1980 and 1990 World Bank supported two public tubewell projects in Uttar Pradesh. The first project concentrated on the construction of 500 public tubewells in twelve districts in Uttar Pradesh. A second World Bank project became operational in 1983, aiming at the construction of 2,200 public tubewells and the rehabilitation of 750 old tubewells (World Bank, 1983a). In 1988, the Indo-Duth Tubewell Project, subject of this report, started in Eastern Uttar Pradesh. In the same period a similar World Bank public tubewell project was implemented in West Bengal (World Bank, 1985).

Private tubewell development was promoted by Free Boring Schemes in several states of India. In Uttar Pradesh, drilling of shallow tubewells was subsidized up to 4000 Rs per borehole for farm holdings smaller than 2 ha. Investments by farmers were made in the pump and motor. (Evaluation Mission, 1992:25) Though the irrigated area served by private and public tubewells expanded tremendously in the past decades, an undeveloped irrigation potential of some 10 million ha from groundwater irrigation is left over, which is located in the States of Uttar Pradesh, Bihar, West Bengal, Orissa and Madhya Pradesh (World Bank, 1991:8).

Bangladesh

Since the mid-1960s more than 35,000 deep tubewells were imported and installed in Bangladesh. The first deep tubewell project in Bangladesh, the North Bengal Tubewell Project, started in 1961 and was implemented by the Bangladesh Water Development Board with assistance from West Germany. In the 1970s and 1980s the World Bank took the leading role in groundwater development by supporting several organizations such as the Bangladesh Agricultural Development Corporation in the construction of deep tubewells through two projects: the North-West 3000 project and the IDA DTW2 project (Palmer-Jones 1995:35). Funds of the Asian Development Bank, EEC and Arab countries were used by the Government of Bangladesh as well, for the installation of deep tubewells. Deep tubewell technology was subject of an intense debate in the late 1980s which concentrated on two points: the efficiency of capacity utilization, and the equity impact. Much of the installed deep tubewell capacity was under-utilized, actual command areas were smaller than designed and a large proportion of deep tubewells was not in use at all.

Much effort has been put in improving the management of deep tubewells through technical and institutional innovations. In cooperation with national and international NGOs such as BRAC, CARE and the Grameen Bank, a number of institutional management alternatives were tried as for instance farmer co-operatives, Water Users Groups and Landless Groups. However none of the alternatives proved to be sustainable in the end (Palmer-Jones 1995:36). Regarding the equity impact of the deep tubewells, Aeron-Thomas (1992) concluded that larger farmers were able to secure a disproportionate share of irrigation water in 10 IDA DTW2 command areas.

Since the 1970s the use of private shallow tubewells expanded rapidly over the country, supported by incentives from the Government of Bangladesh and the World Bank. However due to a growing concern over groundwater mining and frequent mechanical problems of tubewells, a virtual ban was imposed on the official sale of shallow tubewells in 1983. As a result shallow tubewell sales dropped and agricultural growth halted. In the late 1980s imports of tubewells were liberalized, and constraints in the installation of shallow tubewells were removed, leading to a rapid agricultural growth in the following years. By 1985/1986 approx. 310 thousand ha was irrigated by 75 thousand shallow tubewell units and approx. 350 thousand ha by some 20 thousand deep tubewells (Morton, 1989:5).

Pakistan

The current size of Pakistan's irrigated area is about 16 million hectares, which is mainly situated in the Indus basin. A vast network of barrages, dams and canals has been created in the last century to provide irrigation water to the flat Indus plain (IIMI, 1991). Irrigated agriculture contributes 26 percent to Pakistan's Gross Domestic Production and is thus vital for the national economy (Aklilu and Hussain, 1992:26). However the irrigation system is also a subject of concern since productivity is endangered by environmental problems such as waterlogging and salinity.

The introduction of irrigation without drainage in arid and semi-arid regions, as in Pakistan, automatically leads to a rise of the water table. Due to conveyance losses in canals and percolation losses from irrigated fields, groundwater gets an extra recharge compared to the former natural conditions. Irrigation water, even the best quality, contains salts. Every irrigation season, 0.5-1.0 ton ha^{-1} of salt will accumulate and has to be evacuated. By rainfall or by leaching, salts will percolate to the ground water, which has to be drained. Secondary soil salinity is caused by a high water table. From a shallow water table salts can reach the surface through capillary action. Under-irrigation also causes soil salinity, because the amount of water is inadequate to leach salts below the root zone. Through capillary action salts continue to move towards the surface. An irrigation system without a well functioning drainage system will eventually be faced with waterlogging and salinity problems. To combat these problems, Salinity Control and Reclamation Projects (Scarps) were created since 1958. The Scarps are based on a vertical drainage concept to control waterlogging and salinity.

In 1960 SCARP-I started and demonstrated after completion in 1963, that the water table could be successfully lowered by tubewells uniformly distributed over a large area. Besides, tubewells lift up additional irrigation water. Because of its success, Scarp-I was soon followed by a large number of Scarp projects spread over Pakistan.In 1986 there were about 12,500 public tubewells, with an average capacity of 2 $m^3 s^{-1}$, operating in fresh and saline ground water areas. At the same time, approximately 200.000 private tubewells having an average capacity of 1 $m^3 s^{-1}$ were providing supplementary irrigation water in fresh ground water zones (Aklilu and Hussain, 1992:24).

In recent years the success of the vertical drainage concept is been questioned. The total problem area in Pakistan, having a depth to the watertable less than 1.5 m, is about 2 to 2.4 Mha. However, about 0.4 Mha is situated in completed sub-surface drainage projects, because the tubewell pumpage reduced to only 50% of the designed value (Nespak & Mott MacDonald, 1995: I-6). According to Bäcker & van Steenbergen (1996) about 67% of the Scarp tubewells are out of production or are running at less than 50% of their capacity. Under these conditions the reduction in waterlogging and salinity has only a temporary effect. The subsidies involved in operating the Scarp tubewells became a burden for the state. Scarp tubewells in fresh groundwater zones are now transferred to the private sector or abandoned and replaced by shallow tubewells under the Scarp Transition projects. Deep tubewells in saline groundwater zones remain to be managed by the public authorities.

1.2 Objectives of public tubewell projects in Uttar Pradesh

Around 1935 the Government of Uttar Pradesh observed that in spite of the rich water resources, only limited cropped area was irrigated. To accelerate the use of its groundwater potential the government invested substantially, from 1935 onwards, in the construction of public tubewells, referred to as State tubewells. In this paper these are referred to as public tubewells. The policy of the GoUP was to concentrate these efforts in those areas where they could be complementary to developments in the private tubewell sector (World Bank, 1983a:1). Public tubewells were generally constructed by the Department of Irrigation (DoI) in areas:

(a) which were not provided with surface irrigation system;
(b) where the watertable was too deep for the installation of private tubewells;
(c) where private tubewell development was not likely to occur due to the very limited resources of the relatively small and marginal farmers (MAC,1989:24).

In the seventies World Bank embarked on a new project to support the development of private tubewells through 5 credit programmes. According to the World Bank (1983) this project confirmed that the credits were used largely by medium and large farmers. Consequently, a relatively large group of small farmers continued to be dependent on public sector tubewell programmes. Based on this experience it was concluded by World Bank (1983) that from a social equity point of view, public tubewells were desirable to overcome the under-utilization of both land and groundwater resources. Public tubewells should be constructed in those areas where fragmented and small holdings made the cost of private tubewell development prohibitively high and thus unattractive to small farmers (World Bank 1983a:1). The WB UPI project, which started in 1980, was essentially based on two arguments (World Bank, 1986:11-12):

(a) for social/equity reasons: public tubewells can give assured access to water to those

weaker sections of the community who cannot afford a private shallow tubewell; they can thus forestall the complete capture of an important resource by wealthier farmers;
(b) for technical reasons: deep tubewells complement shallow tubewells in more effectively exploiting the groundwater resource.

The main objective of the Indo-Dutch Tubewell Project, which is the subject of this paper was defined as follows (Formulation Mission, 1987b:1):
The purpose of the Indo-Dutch U.P. Tubewell Project is to increase the agricultural production and improve the living conditions of farm households by providing irrigation water through tubewells of improved design and by the provision of supporting activities.
However the project would specifically emphasize the position of two target groups: (a) the small and marginal groups in the farming community; and (b) women in the project area. Additionally, selection criteria for the development of tubewell clusters were formulated:
(a) The clusters would be located in areas where the watertable was too deep or the farms too small for private tubewell development. Preference would be given to those areas where the farmers were backward and the average holding would not exceed 0.65 ha.
(b) The area cultivated under private tubewells should not exceed 20% of the cluster area;

In general, the Government of Uttar Pradesh and foreign donors agreed that the main social/equity objective of the public tubewell projects was *to give especially small and marginal farmers in Uttar Pradesh assured access to groundwater for irrigation, through the construction of public deep tubewells*. The technical objective that deep tubewell development complements private tubewell development for an effective and efficient groundwater exploitation was considered of secondary importance.

1.3 Research questions

The following research questions were formulated: *(a) How was the Indo-Dutch Tubewell Project formulated and executed, (b) what have been the major technical, institutional or socio-economic factors influencing the projects results and (c) what lessons can be drawn for the project?*

1.4 Methodology

The report is the result of a desk study. Main source of information were project documents: mission reports, working papers and progress reports of the Indo-Dutch Tubewell project. Besides the project documents, project correspondence was available. Secondly, literature on similar public tubewell projects in Asia was consulted. Thirdly, experts related to the project were interviewed, and were asked to give comments on earlier versions of this report.

2 SETTING OF THE INDO-DUTCH TUBEWELL PROJECT

2.1 Introduction

Uttar Pradesh is located in north-east India (Figure 2.1). Uttar Pradesh (UP) is the most populous state of the country, with 139 million people (1991 census). UP encompasses an area of 294,413 km^2, which is 9 percent of the total area of the country. During 1991-1992, 60.9 percent of the net cropped area was irrigated, which is substantially higher than the all Indian average of 34.5 percent. (Directorate of Economics and Statistics, 1995) In 1981, 82 % of the total population in UP was living in the rural areas. The average per capita income in 1982-1983 was Rs 1,443. According to the National Sample Survey in 1973-1974, about two-third of the population was living below the poverty line, which was set as $ 90 per capita per annum.

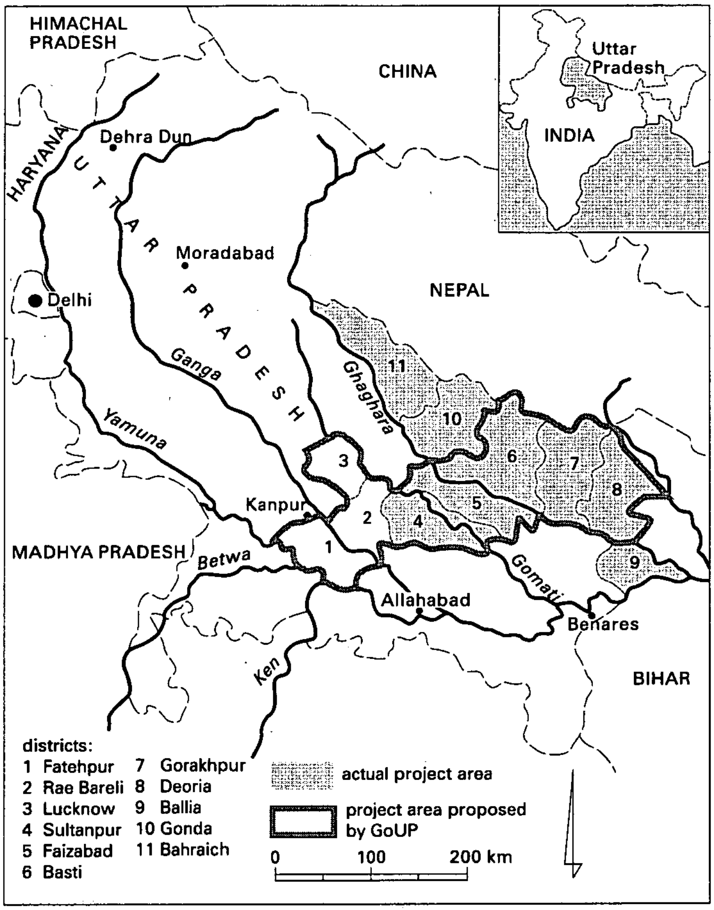


Fig. 2.1 IDTP project area

In 1984 the Government of India proposed to the Government of the Netherlands the construction of public tubewells in eight districts, situated in the Central and Eastern part of UP as shown in Figure 2.1. However, in 1986 the Formulation Mission recommended that it was better to concentrate the project in eastern Uttar Pradesh alone. This recommendation was based on the following arguments: (a) a better coordination would be possible bringing the project under the responsibility of one Chief Engineer, (b) eastern UP was the most backward region, and (c) the project area should preferably form one geographical region. The proposed project area would consist of eight districts: Sultanpur, Faizabad, Basti, Gorakhpur, Deoria, Ballia, Bahraiach and Gonda.

2.2 Characteristics of climate, hydrology & agriculture of Uttar Pradesh

2.2.1 Climatic conditions

Uttar Pradesh has a tropical monsoon climate. Three main seasons can be distinguished:
- hot and dry pre-monsoon season or *zaid* (April to June);
- wet season or *kharif* (July to September);
- dry season or *rabi* (October to March).

As shown in Table 2.1, mean annual rainfall ranges from 800 mm in the West to about 1000 mm in the East. Towards the Himalayan range in the north mean annual rainfall increases to more than 1700 mm. Almost 90 percent of the rainfall occurs in kharif from June to September. Temperature in the Gangetic plain varies from 3 to 6 °C (night) in January till 45 °C (day) in May and June. Evaporation in the plain is between 1400 and 1600 mm annually and is highest from April to June. A rainfall deficit occurs from October till June in every region of Uttar Pradesh, except in the Himalyan region of northern Uttar Pradesh (Banerjee, 1986:10-16).

Table 2.1 Rainfall pattern in Uttar Pradesh (World Bank, 1991)

Area	Average annual rainfall (mm)	Average rainfall June/September (mm)	Share of June/September in Annual Rainfall (%)
North west UP hills	1750	1409	80
West Uttar Pradesh	836	726	87
East Uttar Pradesh	1014	893	88

2.2.2 Groundwater conditions

The greater part of Uttar Pradesh belongs to the Gangetic Plain which mainly consists of alluvial sediments. No bedrock occurs to a depth of 250 m and there is some evidence that locally the alluvial strata extend down to thousands of meters. Based on topographical features the following soils are distinguished (1) recent alluvial soils (2) soils of flat lands (3) upland soils and (4) lowland soils. Texture of these soils vary from coarse sands to fine clays (Biswas *et al*, 1985:410).

Over centuries river inundations have created a heterogeneous pattern of depositions of mainly medium to fine sand with additional clay and silt deposits. The upper 250 meter is composed of clay, silt, fine to medium sand and kankar. Kankar is an Indian term for a calcium carbonate nodule. Such nodules are associated with the occurrence of a hard calcium carbonate layer, or called Kankar layer, at some depth in the soil profile. (Agarwal *et al*, 1979:80) The medium and fine sand layers are local aquifers separated by clay and silt layers. These small aquifers are phreatic and semi-confined. These local aquifers are interconnected and are part of a regional aquifer system, which is a thick highly productive phreatic aquifer (Boehmer, 1988:2).

The water table is subject to seasonal fluctuations. In April-May the water table in the project area is usually at its lowest level between 4 to 8 meters below soil surface. During monsoon the water table generally reaches 2 to 3 meters below soil surface. In large areas of the project after monsoon the water table falls rapidly to 3-4 meters below soil surface. This is followed by a more gradual decline during the rest of the dry season. In the areas with groundwater levels at 4 to 8 meters below soil surface, groundwater extraction by shallow wells is technically possible. In some areas of the districts Faizabad, Sultanpur, Ballia and Bahraich the pre-monsoon water table is as low as 14 to 15 meters below soil surface, and rises during monsoon to about 8 meters below soil surface. The deeper water tables in these areas may be due to a relatively higher elevation of the area as well as a higher groundwater abstraction in combination with a relatively low recharge. In these areas, having a deeper water table, water can only be extracted through submersible pumps (Boehmer, 1988:3-4).

Every year groundwater development is calculated block wise by the Groundwater Department in Uttar Pradesh. This calculation is based on the groundwater balance of the block, and is expressed as the annual draft as percentage share of the net recoverable recharge (see Appendix 1). The state of groundwater development in the project area varied around 30 % of the net recoverable recharge. Ground water extraction in district Bahraich was 23 % of the net annual recharge, while in district Ballia the state of development reached a maximum of 38%. It was concluded that the 8 districts still had a considerable potential for further groundwater development. Two blocks in Faizabad district had a very high degree of groundwater development of more than 90 % of the net recoverable recharge. Fifteen other blocks had reached a groundwater development level of 65 - 85 % of the net recoverable recharge. All other blocks had lower groundwater development level. Groundwater quality was excellent all over the project area with TDS values well below 1000 ppm, and groundwater with TDS > 1000 ppm was found only in small isolated pockets (Boehmer, 1988:7-8).

2.2.3 Agricultural conditions

In terms of agricultural production, Uttar Pradesh is one of the most important states of India, and with one fifth of the national foodgrain production, the most important food grain state in India. Wheat is the most important crop in India, and UP is responsible for one third of the national production. Sugarcane production in UP accounts for more than 40 % of the national production (Directorate of Economics & Statistics, 1992). Uttar Pradesh has a net cultivated area of 17.2 million ha, most of it located in the Gangetic plain. This net cultivated area has been relatively stagnant in the past decades, expansion seems hardly possible. An overview of the major crops grown, and their relative share in the gross cultivated and gross irrigated areas is given in Table 2.2.

In rabi, about half of the net cultivated area is planted with wheat, most of which is irrigated. The second main crop is paddy, which is grown in kharif on about 30 percent of the net cultivated area. Crops grown on smaller acreages are millet, maize, pulses, oil seeds, potatoes and sugarcane.

Table 2.2 Major crops grown in Uttar Pradesh in 1993 (Directorate of Economics & Statistics, 1995)

Areas (million ha)	% of Gross Cultivated Area						
Gross Cultivated	Wheat	Rice	Coarse Cereals	Total Pulses	Oilseeds	Sugarcane	Total
23.82	37.9	22.4	12.6	12.1	7.6	7.4	100
	% of Gross Irrigated Area						
Gross Irrigated	Wheat	Rice	Coarse Cereals	Total Pulses	Oilseeds	Sugarcane	Total
14.01	57.7	16.5	4.2	5.0	6.0	10.6	100

Cropping pattern and cropping intensities in kharif season vary over the project area. In areas with young alluvial sediments which are often flooded the dominant crop in kharif is paddy rice. In a Bench Mark survey conducted by IDTP in kharif 1989-1990, villages were found having 90 to 100 percent of the cultivated area used for rice cultivation (BMS Basti, 1990:17). Maize is hardly grown because it is vulnerable for diseases under wet conditions. In higher areas having more sandy soils the cropping pattern is much more diversified for kharif season. Besides the main crops paddy and maize, sorghum is cultivated as a fodder crop and vegetables and other minor crops are grown. In higher areas the cropping intensity during kharif varies from 30 to 60 percent, which is remarkably lower than in low lying areas. Cropping patterns followed during rabi are more uniform in the project area. Besides the main crop wheat, other crops cultivated during rabi are barley, lentil, mustard and gram. Perennial crops are hardly grown in the project area. On higher areas some pigeon pea is cultivated, but cultivation of sugarcane is almost absent. Due to the intensive cultivation of rice in kharif in low lying areas, annual cropping intensities which vary from 75 to 90 percent are higher than in elevated areas varying from 65 to 75 percent (BMS Basti & Sultanpur, 1990).

Average rice yields in Uttar Pradesh are 2.1 t ha^{-1} for irrigated paddy and 1.0 t ha^{-1} for rain-fed paddy. Maize yields varies from a maximum of 1.5 t ha^{-1} in western UP to a minimum of 0.2 t ha^{-1} in eastern UP. Irrigated wheat yields average 1.8 t ha^{-1}, and rain-fed wheat yields are on average 1.0 t ha^{-1} (World Bank, 1983b:38-40). In general yields of main crops as wheat, rice and maize are on average lower in eastern UP than in western and central Uttar Pradesh. Only for barley and sugarcane, yields in the central region are lower than in the eastern region. The use of High Yielding Varieties seeds (HYV) was limited in Uttar Pradesh. For example, in 1979-1980, 40 % of 5 Mha rice was sown in with HYVs and another 30 % with high yielding local varieties (World Bank, 1983b:37). In a bench mark survey of project villages in 1989-1990, transplanted HYV paddy yields are found of 3.3 t ha^{-1}. Wheat yields based on HYVs in rabi average between 1.7 and 2.1 t ha^{-1}. However a major share of the cultivated area was sown in with local varieties of wheat and paddy rice. Local variety wheat yields approx. 1.2 t ha^{-1} and local variety rice yields vary between 1.4-1.8 t ha^{-1} in the project area (BMS Basti & Sultanpur, 1990).

A major physical constraint in obtaining higher yields is often the shortage of irrigation water especially at the tail ends of the canals (van Aart *et al.*,1987:38). But it should be realized that, especially in Eastern UP, problems of flooding and inadequate drainage are serious bottlenecks as well.

2.3 Development of groundwater irrigation in Uttar Pradesh

2.3.1 Irrigation in Uttar Pradesh

From 1960 to 1982 the total net area under irrigation in UP increased from 5 Mha to nearly 10 Mha. Table 2.3 shows that this increase was mainly due to expansion of the area irrigated by tubewells, which increased from 0.5 Mha in 1960 to 5.4 Mha in 1982. The larger part of these were private shallow tubewells. The net area irrigated under surface irrigation systems increased from 2.0 Mha in 1960 to 3.3 Mha in 1982. More recent data was not available, but estimates for 1990 would yield some 3.5 Mha under surface systems and some 6.6 Mha under tubewells.

Table 2.3 Net irrigated area (Mha) in Uttar Pradesh from 1960 till 1982 (State Planning Institute Uttar Pradesh, 1984)

Type of irrigation	1960	1970	1980	1982
Surface irrigation	2.0	2.5	2.8	3.3
Tubewells	0.5	2.3	4.8	5.4
Dug wells	1.8	1.7	0.9	0.7
Tanks, lakes and ponds	0.7	0.7	0.4	0.3
Total	5.0	7.2	8.9	9.7

2.3.2 Types of wells

The utilization of groundwater through *dugwell irrigation* is an indigenous form of irrigation in Uttar Pradesh. A dugwell is a shallow well, with its bottom on a fair depth below the water table. So that water from the surrounding aquifer accumulates in the well. Water collected in the well is lifted to ground surface through a water lift. The masonry lined dugwell usually yields 7 to 8 m^3 per hour (approx. 2 l s^{-1}) when operated with a Persian wheel, which is the case for about 20% of the masonry wells. The remainder of the dugwells are equipped with leather or metal buckets and the water is lifted by animal power, usually bullocks. These wells have very limited discharge rates.

Shallow tubewells are drilled to penetrate a shallow aquifer and are usually less than 30 m deep. This depth is only possible when the tubewell is placed at the bottom of a dugwell, so that it is a deep set shallow tubewell. Shallow tubewells are usually equipped with a small centrifugal pump. The electric or diesel motor is directly connected to the pump by a belt drive. The centrifugal pump is placed at the surface level and operates mainly in suction mode. These wells usually have a capacity of 20 to 30 m^3h^{-1} (approx. 7 l s^{-1}).

Medium tubewells are small diameter submersible tubewells equipped with a strainer section. These wells are usually about 45 m in depth although they may be deeper depending on the depth of the aquifer and the capacity desired. They usually have capacities of about 30 to 40 m^3h^{-1} (approx. 10 l s^{-1}) and are equipped with centrifugal pumps. Water distribution from these wells is through small unlined channels with the following lengths: masonry wells -- 30 m; shallow tubewells -- 200 m; and medium tubewells -- 400 m (World Bank, 1983b:170-171).

Deep tubewells have a large diameter and vary in depth from 40 to 300 m. Pumps are sunk into the well, operate in force mode, and are driven by submersible electric engines or by shafts connected to engines at the surface. Deep tubewells have a large discharge capacity varying from 150 to 300 m^3h^{-1} (40 to 80 l s^{-1}). As discharge capacity increases, the length of the water distribution channels increases accordingly. For example a command area of 100 ha is served by a water distribution system of 4 kms. In old state tubewell commands, water is distributed through unlined earthen channels. A detailed design of deep tubewells constructed by the IDTP project is presented in section 2.2.4

2.3.3 Irrigation from public tubewells

From 1935 onwards, the Government of Uttar Pradesh invested in the construction of State or public tubewells. In 1940 some 1,471 public tubewells were in operation, serving a gross irrigated area of 240,000 ha. The number of public tubewells expanded slowly. By 1950 around 2,000 public tubewells were in operation, irrigating some 360,000 ha gross. The program was then accelerated, which doubled the served area to about 730,000 ha gross in 1960 (Dhawan, 1982).

The importance of private tubewells for irrigation was negligible up to the 1960s. According to Dhawan (1982), a large scale adoption of private tubewells was hampered by the fact that private tubewells could only produce water at a cost comparable to that of the traditional dugwell, when the owner's holding was very large, consolidated in one plot and when the private tubewell could run the year around without any serious breakdown. The benefits generated by the private tubewell investment increased in the 1960s because agriculture became more intensive due to the introduction of the Green Revolution technology. Table 2.4 shows that the area under private wells increased rapidly from some 50,000 ha in 1960 to about 4 Mha in 1980.

Performance of public tubewells declined. Though the number of public tubewells in operation doubled between 1970 and 1980, the irrigated area served by public tubewells hardly increased. By 1980, some 17,000 public tubewells were in operation, covering a net irrigated area of 770,000 ha. So compared to 1960, the situation in 1980 was completely reversed. Instead of public tubewells, privately managed tubewells were the most important technology in exploiting UP's groundwater resources. The greater part of the increase in private tubewells took place in the western part of the state, which is wealthier than the eastern part. Progress in private tubewell development in the Eastern part of UP was rather slow (World Bank, 1983b:168).

Table 2.4 Private and public tubewell development in UP, 1960-1980 (Dhawan, 1982, World Bank, 1983 and 1985)

	1960		1970		1980	
	nrs (x 10^3)	Irr. area (10^3 ha)	nrs (x 10^3)	Irr. area (10^3 ha)	nrs. (x 10^3)	Irr. area (10^3 ha)
State tubewells	6.3	733	9.0	877	17.0	770
Private tubewells	5.0	48	120.0	1.522	1218	4.098
Total	11.3	781	129.0	2.399	1,235.0	4.868

2.3.4 Improved design of public tubewell systems

A conventional public deep tubewell, constructed between 1935 and 1980, consisted of a deep tubewell with an electric connection to existing 11 kV rural power lines. The deep tubewell had an average well capacity of 250 m^3h^{-1} and an average command area of 150 ha, which comes down to a supply of 0.46 l s^{-1}ha. Water was distributed by open field channels. A typical deep tubewell was designed to provide irrigation water for a low annual irrigation intensity (about 80%) and with low water application of 2-3 irrigation gifts (World Bank, 1983b:169). The declining performance of the public tubewells between 1970 and 1980 was caused by an inadequate power supply, low water conveyance efficiency, ineffective water allocation procedures and poor maintenance. To overcome these deficiencies, several improvements were made, which were incorporated in an improved design adopted by the World Bank UPI project (World Bank, 1983a:2).

According to Campbell (1984) availability of groundwater was a limiting factor in UP. Therefore the benefits of irrigation should be spread over as many farmers as possible. Consequently, the water supply of the public tubewell would not meet the crop water requirements to its fullest extent in the command area. The total cultivable command area of 100 ha was served by a deep tubewell with a discharge of 150 m^3h^{-1}, or 0.42 l $s^{-1}ha$. The public tubewells have an average depth of 65 to 90 m. Within this depth some 30 to 40 m of medium sand could be found. With a screen of 200 mm diameter, this aquifer would yield water for a tubewell capacity of 150 m^3h^{-1} (see Appendix 2).

It was assumed that power constraints would limit daily operation to about 16 hours, therefore average discharge was expected to decrease to 0.28 l $s^{-1}ha$. It was further assumed that the tubewell irrigation systems would be able to operate for about 3,500 hours per year when they were provided with a dedicated power supply. Thus, a 150 m^3h^{-1} water point serving a CCA of 100 ha would be able to provide 525 mm per annum to this area. A public tubewell would provide water to irrigate 34.5 ha in rabi and 56.5 ha in kharif in a command area of 100 ha. The cropping intensity, which includes kharif, rabi and perennial crops, in the tubewell command areas was expected to increase from 120% to 140% over a 20 years period. In the same period the irrigated cropping intensity was estimated to reach 97% on average (World Bank, 1983:41). A typical public tubewell system consists of a well, submersible electrical pump and a brick-built pumphouse. From the well, water is pumped into a tank or so called elevated distribution chamber, from where it flows in a buried PVC pipe distribution system, which has the form of two closed loops each serving about 50 ha (see Figure 2.2). On the pipe systems alfalfa outlet valves are constructed each serving about 5 ha and operated by farmers. Every tubewell system has around 20 outlets. The length of the field channels remains limited to 150 m. Public tubewells are grouped together in a cluster

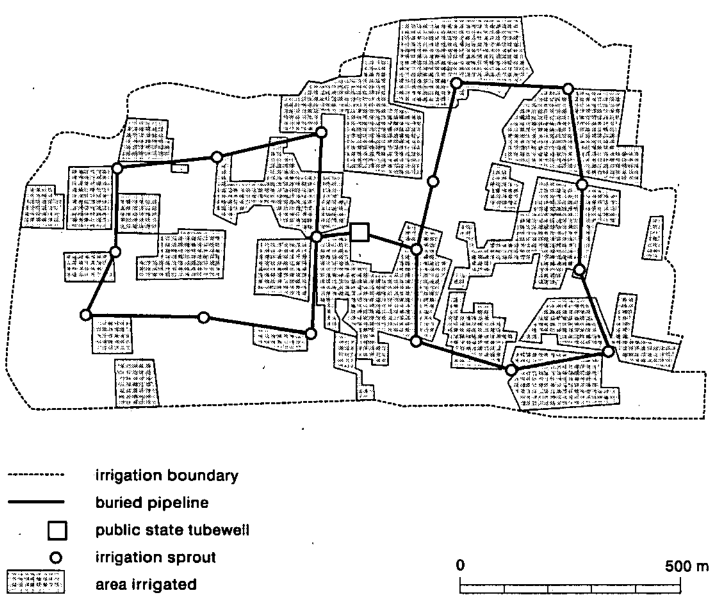


Fig 2.2 Water distribution system of public tubewell

of some 20 to 30 wells. One cluster has one independent electrical feeder line, which connects all wells to one sub-station.

The operation of the system was envisaged as follows. The two or more loops would in principle be supplied simultaneously. Within a loop, the command area of about 50 ha was divided into seven sub-commands of about 7 ha each, which were called *area-day* commands. The idea was that such area would get the total water supply (75 m^3h^{-1}) for one day, the other 6 areas not getting water on that day. Farmers within each area-day command would form a committee and elect a leader. The area-day committee would organize the internal water distribution, with allocation times proportional to the holding sizes. The leader would supervise the water distribution within the area-day command area. Leaders of the area-day committees would elect five representatives to form a Tubewell Management Committee (TMC) for each tubewell. The TMC would be responsible for coordination and cooperation among area-day committees, for solving disputes and for advising the concerned Junior Engineers of the DoI in working out a rotational water allocation schedule. The President of each tubewell comittee would represent the tubewell farmers on a Tubewell Cluster Committee. Operation of the tubewell was assigned to a tubewell operator employed by the Department of Irrigation (World Bank, 1983a:40).

In the period 1980-1983, the World Bank UPI project constructed 559 improved public tubewells in Uttar Pradesh. According to the World Bank (1985b), the project was implemented successfully. The new public tubewells constructed were a major improvement over the traditional State tubewells. The Economical Rate of Return (ERR) of the project was estimated at 26%. However, an agricultural impact analysis was not made, because the Monitoring and Evaluation Unit was understaffed and restricted its activities to the collection of engineering and irrigation data at the well points.

2.3.5 Sources of irrigation water in the project area

Table 2.5 shows that during 1983-1984 the net irrigated area in the project districts varied between 56 and 68 % of the net cultivated area. The use of public tubewells was limited. The net irrigated area served by public tubewells varied between a minimum of 7 % (Gonda) and a maximum of 15 % (Basti). In Deoria and Sultanpur approximately 40 % of the net irrigated area was served by surface irrigation systems. Another 40 % of the net irrigated area was covered by private tubewells in these districts. In the northern districts Basti, Bahraich and Gonda surface irrigation served a minor portion of the net irrigated area. In Gonda and Bahraich most irrigation water was provided by private tubewells, 78 and 86 %of the net irrigated area. In Basti, 52 % of the net irrigated area was served by private tubewells and 28 % by minor sources as dugwells and other water lifting devices.

Table 2.5 Net irrigated area and sources of irrigation water per district in 1983-1984 (ha x 100) (Appraisal Mission 1986 & Formulation Mission 1987)

District	Net cultivated area (NCA)	Net irrigated area (NIA)	% of NCA irrigated	Sources in % of NIA			
				Canal irrigated	Public tubewells	Private tubewells	Other sources
Deoria	4,377	2,725	62	42	10	38	11
Basti	5,647	3,366	60	5	15	52	28
Gonda	n.a.	1,986	--	0	7	86	7
Bahraich	n.a.	853	--	1	8	78	13
Sultanpur	2,864	1,592	56	40	8	43	9

2.4 Farm households

About 70 percent of the working population in Uttar Pradesh is involved in agriculture. Approximately 17.8 million farming families cultivate annually some 17.2 million hectares. Roughly 70 % of the land holdings is smaller than 1 ha (12.5 million households), covering only 25 % of the total cultivable area (4.3 Mha) in Uttar Pradesh. (Appraisal Mission, 1986:16). In the eastern region of Uttar Pradesh the total number of holdings was 7.2 million cultivating an area of 5.5 Mha. (Formulation Mission, 1987:6) Eastern Uttar Pradesh has the lowest average holding size of 0.9 ha against 1.1 ha in the Central region and 1.4 ha in the Western region. Small and marginal farmers are pre-dominant in the selected project districts, with around 75 % of the households having less than 1 ha, and more than 90 % of farm households having a land holding smaller than 3 ha (World Bank 1983b:33).

Detailed data on household incomes in several project villages were taken for a Benchmark Survey conducted by IDTP in 1989-1990. It was concluded that in the project village Lambhua, households having a farm size lower than 2.0 ha, had annual incomes which were well below the poverty line (BMS Sultanpur, 1990:18) Annual household incomes in Uskar were lower than in Lambhua (BMS Basti, 1990). The assumption being that these villages are representative of the situation in the project area, it would mean that in 1989-1990, more than 90 percent of the households living in the project area had annual incomes which fell below the poverty line.

3 FORMULATION AND IMPLEMENTATION OF IDTP

3.1 Appraisal and formulation of the project

In August 1984, the Government of India (GoI) requested support from the Government of the Netherlands (GoN) in the framework of the Indo-Netherlands Bilateral Aid program. A proposal was submitted by GoI to GoN for assistance in the development of tubewell irrigation in Uttar Pradesh, through a deep tubewell construction project (DoI/UP, 1984). The requested assistance consisted of the construction of 750 new tubewells of 150 m^3h^{-1} and the rehabilitation of 325 old tubewells, all constructed in eight districts, situated in the central and eastern part of Uttar Pradesh.

GoN was in principle willing to provide financial assistance for such a project. However, it was of the opinion that a better integration of technical and non-technical issues such as beneficiary involvement, would be essential for the success of the project. Also, it was stated that financial assistance by GoN could only be provided in combination with Netherlands technical assistance (TA) in India. In December 1985, when this was agreed upon, GoN send an Appraisal Mission, which concluded that the project proposal was technically and financially feasible (Appraisal Mission, 1986:1-3). However, the Appraisal Mission expressed doubts whether small and marginal farmers and women would benefit sufficiently from the construction of public tubewells. In 1986 an Indo-Dutch Formulation Mission visited UP to plan the details of the project and to formulate supporting project activities, with the objective to reach the target groups, i.e. small farmers and women.

3.1.1 Definition of objectives and physical targets of the project

The objective of the Indo Dutch Public Tubewell Project was formulated as (Formulation Mission, 1987b:1):
The purpose of the Indo-Dutch U.P. Tubewell Project is to increase the agricultural production and improve the living conditions of farm households by providing irrigation water through tubewells of improved design and by the provision of supporting activities.

The technical components of the project were: (a) the construction of 750 public tubewells, (b) the modernization of 125 old public tubewells, (c) the improvement of 200 old public tubewells located in the proximity of the new tubewell clusters.
The non-technical components were: (a) supporting activities in agricultural extension and development and agricultural research, (b) the training of women extension workers, (c) the creation of an external Monitoring and Appraisal Cell (MAC).

The total duration of the project was proposed to be three years. The extension and research programme would continue an additional two years to provide services for the last public tubewells, the construction of which would be finished in the third year after project start. The total command area of the tubewells to be constructed by IDTP would be approximately 100,000 ha and it was estimated that 180,000 farm households would benefit from the project. As shown in Table 3.1, in the first year project activities would primarily focus on planning and procurement of materials and only a limited number of tubewells would be constructed. Major part of construction works was planned for the second and third year.

Table 3.1 Implementation Schedule of technical component IDTP (MAC/IDTP Inception report, 1988)

	Year 1	Year 2	Year 3	Total
Construction of PTWs	75	375	300	750
Modernization of PTWs	10	75	40	125
Improvement of PTWs	20	120	60	200

3.1.2 Project components and institutional framework

Construction component: planning and design

Selection criteria of public tubewell cluster areas were formulated to exclude areas where public tubewells were not viable (see Appendix 4). Important selection criteria were: (a) public tubewells should be located in areas where the watertable is too deep or the farms too small for private tubewell development, (b) the cluster areas should not be served by surface irrigation systems, (c) the area cultivated under private tubewells should not exceed 20% of the cluster area.

The new deep tubewells would be constructed according to the design of the improved public tubewells as presented in Section 2.3.4. Both modernized and improved old tubewells would be technically upgraded to the same standard. The difference between old tubewells selected for *modernization* and *improvement* was their basic design. An old public tubewell to be *modernized* had only a pump house with no elevated distribution chamber and an open water distribution system. Modernization work would focus on the construction of a new closed water distribution system, modification of pump house, construction of elevated distribution chamber and changing of pump sets. Old tubewells to be *improved* had a delivery tank and closed distribution system. Construction would concentrate on upgrading of pump houses and water distribution system and reconditioning or changing of the old pump sets. All old tubewells were connected to a so called *dedicated* power supply line and when required the tubewell bores were redeveloped.

The Uttar Pradesh Department of Irrigation (DoI) was responsible for the overall coordination and supervision of construction work. Part of the construction work was transferred to Nalkoop Nigam a semi-government state tubewell corporation. Construction work was done by the Tubewell Wing of DoI. Operation and maintenance of the tubewells was conducted by the O&M Division of DoI. The Uttar Pradesh State Electricity Board (UPSEB) was responsible for the energization of all tubewells with dedicated feeder lines.

Agricultural extension and research

A supporting research component was formulated, aiming at assisting DoI with the modification of design and layout of tubewell command areas, farm household surveys and on-site research regarding plant-soil-water relations. This programme would be conducted by the Narendra Deva University of Agriculture and Technology at Faizabad (NDUAT). An extension component was formulated, which would be implemented by the Uttar Pradesh Department of Agriculture. The following activities were planned: demonstrations on multiple cropping, water management, vegetable growing and field testing of irrigation systems and water conveyance systems.

Training of women extension workers

In December 1986/January 1987 the impact of irrigation on the position of women was studied. It was found that (a) the public tubewell project would not result in an improved status for women (b) though women had interest in agricultural extension service extension activities were directed to men only. A supporting project component was formulated, in which women agricultural extension workers would be trained by a non-governmental organization the Krishi Vigyan Kendra (KVK), Sultanpur. The objectives of this three year project component were: (a) to build-up a cadre of women extension workers, (b) to organize functional groups of farm women who had small and marginal households, (c) to identify farm women needs and to develop action programmes to assist these women.

Creation of Monitoring and Appraisal Cell

An independent Monitoring and Appraisal Cell (MAC) was created, which consisted of a team of experts of UPDESCO (UP Development Systems Corporation Ltd.), who conducted the evaluation of the World Bank tubewell project UPI in 1985. Together with technical assistance provided by a Netherlands consultancy firm, in the form of two experts permanently based in Uttar Pradesh. The main tasks of MAC were: (a) monitoring of the actual application of cluster selection criteria, (b) the monitoring of project implementation and (c) project impact assessment.

Organization of water management in the PTW command areas

The Formulation Mission found that the organization of water distribution and the management thereof in the public tubewell command areas, required more in-depth study to come forward with practical suggestions for improvement (Formulation Mission, 1987a:17-19). The main focus of the study would be to design the formation of farmers committee's in such a way that small and marginal farm households would be represented and would have an effective say in the distribution of water. This study was sub-contracted to a local research institute, the Giri Institute of Development Studies.

3.1.3 Expected Costs & Benefits of the project

Projected investment costs were Rs 541.8 million, of which Rs 527.6 million would be financed by the Government of The Netherlands and Rs 14.2 million by GoUP. This meant that in 1988 the Netherlands Government agreed to provide funds up to NLG 90.0 million. The total cost involved in constructing a new public tubewell would be Rs 557,900, which is equivalent to approx. NLG 95,000 per new tubewell. Approximately 55 per cent of the total cost of construction of a new tubewell was covered by the purchase of pvc pipes for the closed water distribution system and electrification (see Appendix 5).

Roughly NLG 85 million, which is about 95 % of the projects budget, was spend on construction alone. The Economical Rate of Return was calculated as 23 %, therefore it was concluded that the investments made in public tubewells was a sound economic activity (Appraisal Mission, 1986:82). A calculation on the long term financial effects of public tubewell development on farm incomes for three kinds of farm households showed that public tubewell irrigation was beneficial for the small and marginal farmers (Appraisal Mission, 1986:50-55).

3.2 Project implementation phase 1 and 2: April 1988 - June 1993

During implementation of IDTP, several missions visited the project to monitor and evaluate progress of on-going activities. Table 3.2 gives an overview of important events during this period.

Table 3.2 Salient events during the implementation of IDTP

Apr	*1988*	*Start of project*
Mar	*1990*	*Mid-term Evaluation Mission*
Nov	*1990*	*Review Mission*
May	*1991*	*End of first phase*
June	*1991*	*Start of second phase*
Aug	*1992*	*Evaluation Mission*
June	*1993*	*End of second phase*
July	*1993*	*Continuation of IDTP as the Indo-Dutch Integrated Tubewell Project*
Oct	*1994*	*Termination of the project*

3.2.1 Selection of public tubewell clusters

A step-wise procedure for the selection of public tubewell cluster areas and public tubewell sites was formulated, consisting of three phases. A general inventory in phase 1, followed by the planning of tubewell locations in phase 2 and the design of the water distribution systems of the public tubewells with electrical feeder lines in phase 3. Drilling could start when phase 2 was approved. The construction of the distribution network loops and outlets could start when phase 3 was approved.

The first activity of DoI was the selection of public tubewell areas. By September 1988, 20 proposals were prepared and presented to the Monitoring and Appraisal Cell (MAC), which was responsible for examining the proposals based on the selection criteria as mentioned in Section 3.1.2. The first tubewell cluster was approved in December 1988, shortly followed by the start of drilling of the wells. In March 1990, 65 proposals were presented to the MAC, who approved 15 proposals but also found that 34 were unacceptable. Reasons stated for disapproval were: (1) a large part of the cluster area was already irrigated, (2) farm sizes in the cluster areas were larger than 0.65 ha and (3) technical reasons (MAC QPR 9, 1990). MAC disapproved 25 proposals for the reason that too many private tubewells were located in the public tubewell command area. MAC and DoI had different interpretations of the maximum number of private tubewells allowed in a public tubewell command area. Which was solved by reformulation of the selection criterion in 1989. In the first two years of the project no tubewells for rehabilitation were selected. The Mid-Term Evaluation Mission pointed at this fact and progress in selection activities was satisfactory from that moment onwards. By March 1993, 33 tubewell cluster proposals were approved.

3.2.2 Progress in construction

During 1988, construction concentrated on three districts Deoria, Faizabad and Sultanpur. Till July 1989, 72 tubewells were drilled and 26 pump houses were constructed. Construction of the water distribution system had not started, no tubewells were energized, and rehabilitation activities were not started. Target for the first year was the construction of 75 new tubewells (Table 3.1), which means that construction was behind schedule. Targets for the first two years were the construction of 450 new tubewells, modernization of 85 old tubewells and the improvement of 140 old tubewells. But as is shown in Table 3.3, construction was delayed substantially. Some 300 new tubewells were drilled, 50 % of these tubewells had pumpsets installed and the closed water distribution system constructed. Only 20 % of these tubewells were declared in operation. For a complete overview see Appendix 6.

During the first two years of IDTP no old public tubewells were improved or modernized by DoI. The Mid-Term Evaluation Mission (MTEM) took two measures to adjust the construction component's schedule. First it proposed to extent the project at least for one year, since construction targets could not be met in three years time. Therefore a new implementation schedule was presented (see Table 3.4). More than 300 new tubewells should be drilled, energized and in operation, and 150 old tubewells should be rehabilitated before April 1991. During the second year all other construction works should be finalized. Secondly, the MTEM made the extension of IDTP in 1991 conditional to a substantial progress in the rehabilitation of old tubewells. In six months time DoI should start the rehabilitation of 80 old tubewells.

Therefore a Netherlands Review Mission visited the project in November 1990. A number of clusters were selected with 37 old tubewells of which rehabilitation was in progress. Though the target set by the MTEM was not met, the Review Mission concluded that the project could be extended. Construction of new tubewells made good progress, only the energization of the public tubewells by UPSEB was still delayed.

Table 3.3 Progress of tubewell construction in Phase 1 (MAC/IDTP Quarterly Progress Reports 8, 10 and 12)

	Achieved 01.04.90 Mid-term evaluation	Achieved 10.10.90 Review Mission	Achieved 31.03.91 End of phase 1
Clusters approved	15	23	28
Sites selected	380	667	728
New public tubewells selected	316	667	728
Declared in operation	59	116	244
Old PTWs selected for modernization	64*	129*	150
Declared in operation	0	0	28
Old PTWs selected for improvement	64*	129*	71
Declared in operation	0	0	14

* Old tubewells to be modernized and improved. QPR 8 and 10 do not distinguish these categories.

Table 3.4 New implementation schedule made by MTEM (MTEM Report, 1990)

Activity	Achievement per 28/02/90	Prop. schedule per 31/03/91	(cumulative) per 31/03/92
Drilling new tubewells	265	600	750
Energization	93	375	750
Operation	12	330	750
Modernization/Improvement	0	150	325

The Netherlands Embassy emphasized the need to complete the construction of farm outlets and field channels. Before new drilling could start, a substantial number of tubewells in clusters under construction would have to be in operation, or the new clusters would have a large number of old tubewells for rehabilitation. To avoid that a large number of unfinished tubewells would be left over when the project would end, the Netherlands Embassy approved start of construction of only 28 clusters, while actually 36 clusters were needed to meet the target number of 1075 public tubewells constructed and rehabilitated.

By the end of the first phase of the Indo-Dutch Tubewell Project in April 1991, some 514 new tubewells were under construction and around 60 old tubewells were in the process of rehabilitation. Rehabilitation was still behind schedule but received more attention in 1992. As shown in Table 3.5, when the Evaluation Mission arrived in September 1992, around 90 percent of the 547 new tubewells were declared in operation. Tubewells were declared in operation when they had been tested and had run for more than 200 hours.

The Evaluation Mission concluded that progress in construction was satisfactory, but gave a negative advice for the continuation of the project (see Section 3.2.5). Therefore the planned construction of 750 new public tubewells was not completed. During the Evaluation Mission's visit, rehabilitation works concentrated on 160 old tubewells, and some 100 rehabilitated tubewells were in operation. In the last year construction focused on the rehabilitation of old public tubewells.

Though no old public tubewells were rehabilitated during the first two years, from 1991 to 1993, 128 old public tubewells were modernized and 101 old public tubewells were improved by the project. Together with 547 newly constructed tubewells, 72 % of the target of 1,075 newly constructed and rehabilitated public tubewells was reached by 1993. The average time needed to construct a public tubewell was 1.5 years.

Table 3.5 Progress of tubewell construction till end of phase 2 (MAC/IDTP Quarterly Progress Report 17 and 21)

	Achieved 01.07.92 Evaluation Mission	Achieved 30.06.93	Progress over 01.07.92 - 30.06.93	Target	achieved in %
Clusters approved by MAC	33	28	0	36	
Sites selected	780			1,075	78
New public tubewells selected	547	547	0		
Declared in operation	498	547	49	750	73
Old PTWs selected for modernization	133	128	-5		
Declared in operation	68	126	58	125	101
Old PTWs selected for improvement	100	101	1		
Declared in operation	32	100	68	200	50

The quality of construction of the well, the drilling of well, the placing of pump, the construction of pumphouse and elevated tank was found to be fair to good. However, according to several reports such as MAC (1991), MAC Occasional Paper (1992a), Evaluation Mission (1992), IDITP Final Report (1994) the construction quality of the water distribution system, the loopsystem, outlets and field channels was poor. Trenches dug to install the distribution pipe were often not straight and in certain places not deep enough. Pipe laying for the closed loop system was not done properly, leading to leakages. Foundation of outlets and masonry work was poor, and in many cases field channels were absent. MAC (1990) found that the Construction Division of DoI declared public tubewells in operation, without finalizing the construction of field channels. Construction quality of the closed water distribution system was poor, while this system accounted for 60 per cent of the total construction costs of a public tubewell.

3.2.3 Operation and Maintenance

Actual operation per season of public tubewells constructed by IDTP is shown in Table 3.6. Average running time of 120 public tubewells during rabi 1990-1991 was 455 hours, while for rabi 1992-1993 average running hours of 749 public tubewells was 955 hours. Average running hours for rabi 1991-1992 and rabi 1993-1994 are slightly lower, because this figure represents only the first three months of the season. Figures for kharif and zaid are scarce. For kharif 1991, average running time for 323 public tubewells was 489 hours irrigating on average 18.1 ha. In zaid 1992, public tubewells were on average 402 hours in operation, irrigating on average 10.1 ha. For two rabi seasons 1990-1991 and 1992-1993 complete figures are available. These figures show a positive trend in an increasing number of running hours and a larger area irrigated. However taking into account the targets set for this season, 2500 running hours and an irrigated area of 56.5 ha, operation of the public tubewells did not meet the desired level.

Table 3.6 Running hours and net area irrigated per public tubewell (MAC QPR 12, 14, 15, 17, 20 and IDITP QPR2)

	PTWs on which running hours received.	Average running time (hours)	Net irrigated area (ha)
RABI Oct 90 - March 91	120	455	25
KHARIF July - September 91	323	489	18.1
RABI Oct-Dec '91	373	364	19.6
ZAID Apr-Jun '92	466	402	10.1
RABI Oct 92 - March 93	749	955	36.5
RABI Oct - December 1993	774	377	18.7

According to the Evaluation Mission (1992) the maintenance requirements of the public tubewells were considerable in terms of variety, complexity, costs and location. Maintenance of the public tubewells showed several shortcomings. Electricity supply fluctuated in voltage causing frequent breakdowns of the transformer. The motor appeared to be very vulnerable, 20 % of the tubewells had motor failures. The water distribution system was not functioning properly due to leakages and defects on the outlets. It was found by MAC that during the beginning of kharif 1992, 10% of the public tubewells had run less than 100 hrs. This implied that, of the 340 PTWs of 14 clusters, 34 were out of order for most of the time. (MAC, 1992:10) The annual maintenance requirements could not be met by the O&M divisions budget. The Evaluation Mission (1992) found that only Rs. 7,000 per public tubewell per year was available for maintenance while approximately Rs. 12,000 per public tubewell per year was required. Delayed maintenance and loss of effectiveness of the PTW was the result. To emphasize the role of O&M for the sustainability of the project, MAC tried to find the procedures as prescribed and actually followed by the Department of Irrigation. However, MAC could not find any written procedure for O&M or for the handing over of public tubewells available with DoI. (MAC QPR 17-11)

3.2.4 Supporting project components

Monitoring and Appraisal Cell

Activities undertaken by MAC during implementation of IDTP were monitoring of IDTP, impact assessment of project components, research activities, identifying and recommending project improvements and the review of selection criteria.
The review of selection criteria took quite some time during the first years of IDTP. MAC proposed a reduction of the public tubewell command area to 60 ha. Because this was the maximum irrigated area possible using only public tubewell water. DoI did not accept this proposal and continued construction of public tubewells under the conditions as described in

the Plan of Operations.
MAC developed a standard for reporting the quantitative progress of the project, but was dependent on data provided by DoI, UPSEB and other institutions. Regarding the qualitative progress of IDTP, MAC paid field visits to check works in progress. Recommendations of MAC regarding the development of a tamper proof outlet were successfully followed by DoI.

Women Agricultural Extension Programme

From 1988 onwards, gradually 50 Female Extension Workers (FEWs) were trained and posted in public tubewell commands in two Districts of the project area. Every FEW was responsible for extension in three public tubewell command areas. According to several missions (MTEM 1990 & EM 1992) the results of this programme, though limited in scale, were good. The WAEP programme aimed at providing an agricultural extension service especially directed at women, who were among the potential users of the public tubewells. Over the years, elements like the introduction of smokeless ovens (chulas), family planning, education and various income-generating activities were incorporated into the WAEP programme. The extension programme gradually developed in an integrated rural development programme, especially aimed at women. However, incorporation of WAEP, after termination of IDTP, in ongoing activities of government departments as the extension programme of the Department of Agriculture was not possible.

Farmers Participation Pilot Project

The Formulation Mission (1987) emphasized the importance of the development of farmers organizations in the public tubewell command areas. A first report on water distribution and management conducted in World Bank (WB) tubewell commands by Dr. Pant of the Giri Centre for Development Studies, was received in December 1988. It was concluded that due to an uncertain electricity supply, and mechanical/electric defects, actual water distribution practices in the public tubewell commands differed from what was designed by the WB project. According to Pant (1988), the water distribution schedule and day-unit committees remained a paper issue and the proposed water delivery principles were rarely practised. Command area farmers were by and large ignored in tubewell pre-installation discussions. The study revealed also the existence of a tremendous water market in the command areas of the World Bank tubewells.

MAC decided to start a second study on the subject of water markets in World Bank tubewell command areas. According to Pant (1991), rich farmers were using all modes of irrigation, preferably public tubewell water, whereas poor farmers depended mostly on purchase of water. About 60 % of the marginal farmers were buying water from owners of private pumpsets, mostly medium farmers, and some 80 % of private pumpset owners sold water. In public tubewells, operators charged considerably extra for irrigation water compared to the prices paid for irrigation water from public sources.

More often than not the poor and low castes got water only after the big farmers or the high castes had fulfilled their water requirements. Similarly, the tail enders did not get water when they needed it. When they got water the discharge was small in relation to their requirements. The report concluded that the public system water distribution was highly inequitable and out of the reach of the poor, low castes and tail-enders. Rich and high caste farmers and head enders were major beneficiaries of the public tubewell systems. The water markets were the mainstay of poor farmers' agriculture (Pant, 1991:119).

In June 1989 a proposal for Farmers Participation was drafted. The proposed program consisted of an extension education programme for male and female farmers in every tubewell command area and a training programme for farmers representatives. The Farmers Participation Pilot Project (FPPP) supervised by an Indian NGO started in December 1991 in two clusters of Sultanpur district. The Farmers Participation Unit consisting of 6 core staff members, organised the democratic election of 34 Tubewell Management Committees. A methodology was developed which ensured orderly elections by nomination and representation. It was found by several missions that the results of the FPPP were quite positive, although the real impact of the pilot project remained limited. DoI was found to be more sensitive towards farmers participation in the last phase of the project. But continuation of the farmers participation component in on-going programmes of Government departments was unlikely after the projects end.

Agricultural Research and Extension activities

In the first months of 1989 it was agreed that the following programme would be implemented by Department of Agriculture (DoA) and Narendra Deva University of Agriculture & Technology (NDUAT): (a) demonstrations on multiple cropping cum water management and on vegetable cultivation (b) field testing of irrigation system and water conveyance (c) fellowships on water management and rural extension (d) study on water use and its relation to crop production, and (e) an agro-economic study. The studies would be conducted by the University while extension and demonstration activities would be undertaken by DoA.

Implementation of the programme was delayed, the first research and extension activities started in December 1989. This delay was caused by an understaffing problem at DoA, which was supposed to create a special extension wing for the IDTP. In October 1991 all staff positions in DoA Wing were filled and from that moment the extension and demonstration activities went on in full swing. Still, as presented in Table 3.7, the number of extension workers in the field remained limited to 55 in 1992-1993, which was around 25 % of the target of 210 field workers.

Table 3.7 Progress in extension activities of Department of Agriculture (MAC/IDTP Quarterly Progress reports 12, 17, 20)

	1990-1991	1991-1992	1992-1993
Extension Workers in the field	4	53	55
Agricultural Extension Officers in the field	2	2	2
Tubewells covered	54	357	357
Kharif demonstration fields	15	280	302
Rabi demonstration fields	54	598	343

The Agricultural Development Programme had a target of 6,450 demonstration fields laid out during the project. Every Tubewell command area would have a demonstration plot. In the period from kharif 1990 to rabi 1993 approx. 1,600 demonstration plots were laid out, which is roughly 25 % of the target. About 50 percent of the public tubewells constructed were covered by the extension programme. With limited staff in the field, the set targets could not be reached. The studies which should have been conducted by the Agricultural University NDUAT in the project did not produce the expected results. According to the Final Report of the first phase (1991), the purposes of the field studies were not understood by the university staff, leading to proposals which were unacceptable. Eventually MAC conducted the agro-economic study by itself. The lay-out of the field studies were found to be of a poor quality. Research teams were understaffed, reporting was constantly delayed, and as a consequence of the poor working methods in the field the results were found to be unreliable.

3.2.5 Termination of phase 1 and 2

In August-September 1992 the project was visited by an evaluation mission. The evaluation mission (1992) concluded that although DoI and MAC achieved their objective in terms of progress of construction work, the project should be terminated for the following reasons:

1) There was no explicit technical justification for public tubewell development, since groundwater in eastern UP was generally shallow.
2) Performance of public tubewells was below targets, because of insufficient and unreliable powersupply;
3) Because of a low performance of the public tubewells, IDTP was economically and financially unfeasible;
4) A much greater number of farmers could be reached using the same financial resources for private shallow tubewell development, providing water in a more efficient way. In practice, water distribution in public tubewell command areas seemed to be in favour of more influential farmers;
5) The financial sustainability of deep tubewells was doubtful, because the maintenance of

the public tubewells put a heavy burden on the state budget;

6) Privatization of the public tubewells was not a sustainable solution, because maintenance of an unreliable and complicated water resource would probably be too difficult for the owners.

7) The provision of cheap water to areas which were partly irrigated by shallow tubewells was inefficient from an economic point of view. The construction of public tubewells was often hindering further development of shallow private tubewells.

The evaluation mission concluded that the project should be terminated in June 1993.

3.3 Phase 3: Indo-Dutch Integrated Tubewell Project: July 1993 - October 1994

The Netherlands Embassy decided to investigate alternative project strategies for a third phase of the project. MAC proposed to look at the possibilities of an intermediate tubewell design, the *electric shallow tubewell* (ESTW). The design discharge of the ESTW would be 50 m^3h^{-1}, which was one third of the discharge of a public tubewell and more than the discharge of a shallow tubewell. The command area of an ESTW would be limited to 18 - 22 hectares. The distribution system consisted of only 250 meter lined channel and 1500 meter of field channel which provided access to every field. The ESTWs were connected with rural electric feeder lines only. Compared to the public tubewells, investment costs would be reduced to about 50 percent, which would improve the Economical Rate of Return of the project. The recurrent energy costs would be higher. Another advantage was the smaller group size of 30-40 farmers in an ESTW command area. The smaller group could be more homogeneous and thus the chances of social conflicts between farmers would be reduced. The ESTWs would be constructed with full farmers participation through the formation of a Cooperative. Farmers should be responsible for construction of the lined channel and the field channels. The elected committees should be willing to operate the ESTW themselves.

Objectives of IDITP

From 1st of July 1993, IDTP continued as the Indo-Dutch Integrated Tubewell Project IDITP). The main objective of the project was: to identify, assess and to establish the processes, by which farmers could be made responsible for the full management of the ESTW schemes. In addition, the project would assess whether responsibility for the public tubewell schemes, too, could be handed over to the farmers. As shown in Table 3.8 IDITP concentrated on four project components.

Table 3.8 Project components of the Indo-Dutch Integrated Tubewell Project (DoI,1993)

Project component	Activities:
Construction of Electrical Shallow Tubewells	Motivation of farmers to establish and register ESTW Cooperatives at the Cooperatives Department and the construction of maximum 50 ESTWs.
Increasing operational performance of existing public tubewells	Motivation of farmers to establish and register public tubewell Cooperatives at the Cooperatives Department and the improvement of a maximum of 100 public tubewells to be handed over.
Technical assistance for agricultural extension	Agricultural extension on all existing IDTP wells and on ESTWs constructed during the interim phase.
Rural integrated development activities	Interventions in the field of social forestry, fisheries, land development, employment generating activities, domestic water supply and sanitation and other felt needs of the farmers related to agricultural development.

Achievements of IDITP

The registration procedure for the tubewell cooperatives caused delays. In the first six months several groups submitted their application, but none of them was officially registered. Apparently it was not clear which precise procedures had to be followed. After discussion between MAC, DoI and the Cooperatives Department several farmers groups were in the process of registration. But this came to a halt in the first months of 1994 when new guidelines for the registration of cooperatives were issued. By March 1994, 15 ESTW cooperatives were registered, 40 ESTW commands were found technically feasible, and 40 public tubewell committees were officially registered (IDITP, QPR 3).

Though tubewell committees were registered, the construction of the ESTWs never took off. The reason was that, though pre-liminary agreements existed between GoI and GoN, the *side letter*, in which the final terms for the project were described officially, was not signed. The draft of the Side letter, which was sent to the Ministry of Water Resources in Delhi for comments, contained a few passages to which DoI raised objections. In the absence of a formal agreement and final approval by the Government of India, DoI stated its inability to start drilling, even though a rig had been moved to Bahraich, where the first construction work was planned (IDITP, QPR 2:1). Other project activities involved the improvement of old IDTP public tubewells, but only one was actually handed over to a public tubewell committee. In kharif 1993 extension of DoA concentrated on 282 rice demonstration plots, and the Agricultural University continued it's research activities. An inventory was made of possible integrated rural development activities and training courses for chairmen and secretaries of the tubewell committees were conducted. However due to the absence of a *side-letter*, a formal agreement between GoI and GoN, it was decided by DGIS and the Netherlands Embassy to terminate the project activities. In October 1994, project units were dismantled and the Netherlands consultants left India (IDITP FR:1)

4 CONSTRAINTS IN ACHIEVING PROJECT OBJECTIVES

4.1 Technical aspects

4.1.1 Irrigated area

Table 4.1 shows the average running time and net irrigated area per public tubewell in two rabi seasons. In 120 public tubewell commands in rabi 1990-1991 was 25 ha. In rabi 1992 -1993 the net irrigated area in 749 public tubewell commands was on average 36.5 ha. This increase in irrigated area can be explained by a substantial rise of recorded running hours of the public tubewells. In rabi 1990-1991 this was on average 455 hrs and in rabi 1992-1993 this was on average 955 running hours per public tubewell.

Table 4.1 Average running time and net irrigated area per public tubewell in rabi 1990-1991 and rabi 1992-1993 (MAC, QPR 12 and 20)

	Nr. of public tubewells	Average running time (hrs)	Net irrigated area (ha)
RABI Oct 90 - March 91	120	455	25
RABI Oct 92 - March 93	749	955	36.5

As shown in Table 4.2, in rabi 1990-1991 the average irrigated area in 375 public tubewell command areas was 30.9 ha. This varied from a minimum of 10.9 ha for Bhatparani cluster to a maximum of 47.7 ha for Jamunaha cluster. In rabi 1992-1993 the average irrigated area was 43.2 ha, an increase of 40 percent compared to rabi 1990-1991. The minimum average irrigated area was 26.3 ha in Uska II, and the maximum was 64.8 ha for Pharendra cluster. All 13 clusters monitored showed an increase in the irrigated area, except for Jamunaha cluster which showed a decrease of 10 ha (see Appendix 8).

Table 4.2 Irrigated area in ha per tubewell in IDTP clusters in two Rabi seasons (MAC, 1992 & MAC QPR 20, 1993)

Cluster	Rabi 1990-1991	Rabi 1992-1993
Pharendra	46.7	64.8
Uska II	17.9	26.3
Jamunaha	47.7	37.3
Bhatparani	10.9	47.8
Average	33.0	43.2

No data was available on the actual number of irrigation gifts. An evaluation study conducted by Pant (1994) showed that for World Bank public tubewells the net irrigated area during kharif varied between 8.6 and 23.5 ha, whereby the number of irrigation gifts per tubewell varied between 1.4 and 1.7. During rabi the net irrigated area varied between 34.8 and 47.5 ha, and the number of water gifts varied between 1.1 and 2.1. Target irrigation gifts were 2-3 in kharif and 4-5 in rabi season. The World Bank public tubewells are similar to the public tubewells constructed by IDTP. This would mean that (a) actual irrigated areas in IDTP public tubewell commands were smaller than designed, and (b) the actual number of water gifts to this area would be lower than expected.

4.1.2 Running hours

Average actual running hours for six seasons are presented in Table 4.3. The availability of electricity varied from 8.5 to 14 hours per day which is well below the target of 16 hours per day. Actual running hours varied between 2.5 and 7.5 hours per day. Which means that on average 29 to 58 percent of the time electricity was available, it was actually used to operate the public tubewells.

Table 4.3 Running hours of public tubewells constructed by IDTP (MAC QPR 21, 1993)

Season	No. of public tubewells	Electricity Available ($h\ d^{-1}$)	Running hours ($h\ d^{-1}$)	Running hours/ Elec. Available (%)
Rabi 90/91	137	9.5	3	29
Kharif 91	222	10	2.5	40
Rabi 91/92	224	14	6.5	58
Kharif 92	224	11	5	56
Rabi 92/93	224	13	7.5	56
Kharif 93 up to 10/6	224	8.5	4	45

As shown in Table 4.4, half of the time that power was available, the tubewell was running. During 16% of the time when electricity was available, it was not used due to defects of the tubewell. During the remaining hours in which the public tubewell was not running this was registered as "No demand". This term is rather vague and is related to the way tubewell operators register the periods when public tubewells are not in operation. Pant (1994) found three reasons for the registration of no demand periods in public tubewells in UP . First, in periods when voltage was too low or too high the tubewells were not running, which was registered as no demand. Secondly, a case was found were an electricity line was not working, but the tubewell operator did register this period as no demand. Thirdly, tubewell operators did not record all running hours while the tubewell was actually running, in these periods tubewell operators could earn some extra money by selling the water.

Table 4.4 Use of available power during rabi 92/93 (MAC QPR 20, 1993)

Running hours	52%
Closures, of which:	16%
- Mechanical defects	5%
- Hydel defects	9%
- Civil defects	2%
No demand	32%

MAC (1992) concluded that based on an average electricity supply of 11 hours a day and assuming the full use of electricity for operation of the public tubewell, the average irrigated area in a public tubewell command would come to about 60 ha per year. As shown in Table 4.5, especially in rabi season this would lead to a substantial reduction in irrigated area to about 25 ha.

Table 4.5 Area irrigated annually with limited power supply of 11 hours daily (Working Paper 12, 1992)

kharif	: 28 ha (of which 18 ha paddy)
rabi	: 25 ha (of which 18 ha wheat)
zaid	: 3 ha
perennial	: 4 ha (all sugar)
total	: 60 ha

MAC concluded in 1989 that the demand for power in UP was at that time 35% higher then power supply. Electricity supply was inadequate and uncertain. The prospects for the near future were even worse, the demand would increase in the decade to come while supply of electricity would remain stable. Power shortages would increase, and it would become difficult to maintain the performance of public tubewells. However the problem of power shortage could only be countered by measures of the Government of Uttar Pradesh. Measures taken by MAC were directed at compensating the negative effects of power shortages on the small and marginal farmers in the project area (MAC: Working Paper 1, 1989:8).

4.1.3 Construction

As was presented in Section 3.2.2, a total number of 776 public tubewells (70 % of the target) were newly constructed and rehabilitated. It was planned to finish construction works of

1,075 public tubewells in 3 years but it took 5 years to finish construction of the 776 public tubewells. On average it took almost 1.5 year to construct a public tubewell.

In the first years of IDTP, DoI and Nalkoop Nigam tended to start drilling new wells without finishing of the water distribution system of the public tubewells under construction. In the same period, progress in rehabilitation of old tubewells was minimal. Regarding the quality of construction, all activities at the well point seemed to be implemented in a fairly good state. However the construction of the water distribution system, the closed pvc pipe system, the outlets and the field channels were subject of concern. It was reported that much of the work was not properly done and the following comments in the Quarterly Progress Report 15 were given (QPR 15, 1991:1-9):

Water distribution system

- Some fields were left out of the command, resulting in *bitterly complaining* farmers;
- On the other hand, sometimes the number of outlets was insufficient, resulting in too large areas commanded by an outlet;
- In some command areas it was obvious that no effort was spared to save on costly pvc pipes, thus reducing the command area by 10 percent;
- Often, field channels either not existed at all, or where not in accordance with design.

PVC pipes

- Nowhere had the trenches the prescribed dimensions;
- Trenches were generally not straight and even of the wrong depth;
- Pipe laying was not done in the proper way, for instance no sand paper was used;
- Most pressure release pipes were broken or stolen;

These problems were confirmed by the evaluation mission by observations made during field visits (EM, 1992:5-6). In 1993, with support from the Farmers Participation Pilot Project, Tubewell Management Committees began digging field channels by themselves. The construction quality of the closed water distribution was poor, taking into account that the special underground pvc system accounted for 60 percent of the total costs for the construction of a public tubewell. It is doubtful, whether under these conditions, an adequate and reliable water supply could be ensured to farmers in the public tubewell commands.

4.1.4 Maintenance

Maintenance requirements of public tubewells were considerable. In a survey conducted by MAC (EM, 1992), public tubewells which were fairly recently installed already suffered from the following maintenance problems (a) hydel defects, causing an average breakdown of 15 days per tubewell in a year, (b) mechanical defects, in 20% of the public tubewells the motor broke down and it took on average one month to repair it, and voltage controller was malfunctioning, and had an average breakdown of 15 days per year, (c) on average 8-9 leakages were observed in the distribution system caused by construction errors and farmers interference, and on average 6-7 defect outlets were observed per public tubewell

Public tubewells were vulnerable for mechanical and electrical defects. Defects of the distribution system could be related to inproper construction as was mentioned in the foregoing section. The project was scattered over remote areas, causing additional delays in conducting necessary repair works. All in all, for a proper functioning of public tubewells without long waiting periods for maintenance an effective Operation and Maintenance system is required which did not exist. Annual maintenance requirements could not be met by the available budget for the O&M Division and procedures for O&M seemed not to exist at all. The above mentioned defects and the delays in repairing them resulted in a loss of effectiveness of the public tubewells.

Conclusions

Summarizing this section, we can conclude that the technical performance of the public tubewells constructed by IDTP was below expectations. The irrigated area in public tubewell commands was smaller than designed. This was mainly caused by an inadequate power supply, which was significantly lower than the anticipated 16 hours a day during design of the system. Construction focused on drillling and construction of the well point. The construction of the water distribution system did not get the attention required for a high quality system. In a number of cases, field channels were absent in the command area. Public tubewells required much maintenance, but due to low budgets and inefficient O&M organization, long delays were the result. This situation lead to an ineffective use of the public tubewells, and lead to an unreliable and inadequate water supply to farmers. This may have lead the farmers to interfere in the system by tampering with outlets to get water, or to turn to alternative sources of irrigation water.

4.2 Institutional aspects

4.2.1 Farmers organizations & the target group

Though the need for farmers involvement in the public tubewell project was emphasized by the Formulation Mission in 1986, the farmers participation component was implemented in one cluster in December 1991. As discussed in Section 3.2.4, 34 Tubewell Management Committees were elected guided by the Farmers Participation Unit. By the time the project was going into the third phase, the Farmers Participation Pilot Project existed 1.5 year. During phase 3 farmers were organized into Farmers Cooperatives but these Cooperatives never became effective. No ESTWs were constructed and only one public tubewell was handed over to the farmers. Achievements of this supporting project component were thus limited.

It can be questioned whether the TMCs and Tubewell Cooperatives, facing the technical constraints as identified in the former section, would have a positive impact on the sustainable operation and management of public tubewells. The Formulation Mission emphasized the need for water management organizations in the public tubewell command areas especially to involve small and marginal farm households in the decision-making process on distribution of water. It was expected that with the incorporation of an institutional support component, small and marginal farm household would get an assured access to tubewell water, which was the main objective of the project. The achievements, however, are limited and not well documented. A field study on water distribution practices in the IDTP public tubewell command areas, comparing small and larger farmers' access to water was never conducted. Pant (1991) conducted a qualitative study in World Bank tubewell command areas regarding this aspect. As discussed in Section 3.2.4, water distribution in the World Bank public tubewell systems was inequitable and out of the reach of the poor, low castes and tail-enders. In several project documents statements are made about the access of small and marginal farmers to tubewell water, which seem to be based on this study.

MAC (1992) reports that: *...there are indications that the richer farmers (who presumably own the bigger fields) take greater advantage from the wells than the marginal ones.* According to the same report, there are two technical causes for an unequal water distribution in the command area (MAC, 1992a:7): (a) the tubewell cannot provide sufficient water for the entire command area. The cheap tubewell water is thus in short supply, which is almost bound to lead to a distorted distribution pattern, abuse of power and social conflicts. The *rich* farmers, with land near the outlets, may not let the water pass their land if they want it (or wish to monopolize its use), (b) the actual distance of the field channels may be much greater than the 150 meters assumed. Because of the irregular shape of the command areas and the necessity to situate outlets at the highest point of the service area. This not only increases the seepage losses in the field channels, but also makes it less likely that the farmer at the tail end will actually get water, unless he is a sufficiently powerful figure in the community, when he may even manage to divert water out of the command area. Unfortunately for one reason or another most tail-enders do not belong to that category.

The Evaluation Mission (1992) stated that: relatively richer farmers prove to have access to both public tubewells and private shallow tubewells, whereas poorer farmers continue to depend on buying the water from wealthier farmers. The report continues by stating that: there is evidence that larger farmers have more influence in the tubewell management committees and often succeeded in obtaining more water, specifically in periods of water scarcity. Furthermore the water distribution is highly dependent on the tubewell operator. They are normally selected among persons of higher castes and tend to favour wealthier farmers (EM, 1992:20).

The statements as presented above are repeated in two reports of the Netherlands Development Corporation: (a) *Since public tubewells operate rather irregularly, due particularly to erratic power supplies and poor maintenance, many small and marginal farmers have hardly benefitted* *from them. There is evidence that larger farmers suffer less from these problems* (NDC, 1994:234), and (b) the Indo-Dutch Tubewell Project .. *benefitted large landowners rather than smallholders because the former had acquired a strong position on the tubewell management committee* (NDC, 1996:64).

The water supply of the public tubewells to the total farm population in the command areas was inadequate, unreliable and inefficient. Even if these technical constraints could be compensated and water supply could be assured there is no reason to believe that small and marginal farmers could get assured access to public tubewell water. If public tubewells are operating efficiently only part of the command area of 100 ha can be irrigated optimally, i.e. 56.5 ha can be irrigated in rabi. The rest of the command area is still dependent on more expensive private tubewell water. Cheap public tubewell water is still scarce. The reports mentioned above suggest that in this situation rich farmers would capture a larger part of the public tubewell water, while poor farmers would remain dependent on buying relatively expensive private tubewell water. Inequity in access to public tubewell water would continue. The organization of Farmers Cooperatives by democratic elections was a good step forward in providing smaller farmers equal access to public tubewell water. Unfortunately the Farmers Participation Pilot project was not integrated in IDTP from the project start onwards. Because of the limited time available the farmers participation approach could not prove itself in the field.

4.2.2 Role of project organizations

Department of Irrigation

Tasks and responsibilities of the Department of Irrigation in the Indo-Dutch tubewell Project were the following: (a) selection and submission of public tubewell cluster proposals, (b) drilling and developing of the well points, (c) pump installation, (d) construction of pumphouse, distribution system and field channels and (e) the Operation & Maintenance of the public tubewells. The progress in construction was generally found to be good. However, the construction work by DoI remained limited to the well points. The water distribution system in the command areas did not get enough attention. Rehabilitation activities were severely delayed in the first years of the project, only after strong pressure from Netherlands review missions the first old public tubewells were rehabilitated. Public tubewells were quickly declared in operation and handed over to the O&M Division, while at the same time field channels were absent. No O&M plan was available at the DoI, and the O&M year budgets were inadequate to meet the necessary repair work. The Department of Irrigation underestimated and/or neglected the Operation and Maintenance of the public tubewells.

During a Farmers Participation Symposium organized by the Farmers Participation Unit in 1992, DoI stressed the importance of farmers involvement in public tubewell development. However, action was never undertaken by DoI to integrate farmers participation in the design, construction and management of the public tubewells. Given the above mentioned facts it may be concluded that DoI had a *construction-oriented approach*. This is not a surprising conclusion for the approach followed in the irrigation sector in the 1980s. For example Chambers (1988) notes that in the this decade the poor performance of canal irrigation systems led to heavy investments in rehabilitation, on-farm water management, canal lining etc. And states that the emphasis was put on the hardware of construction more than the software of management and training. A major shift within DoI towards more emphasis on O&M seems necessary. Without such a policy change the implementation of sustainable technical projects seems hardly possible.

Monitoring and Appraisal Cell

During implementation of IDTP MAC was responsible for: monitoring of the project, impact assessment of project components, research activities, identifying and recommending project improvements and the review of selection criteria.
The review of selection criteria took quite some time during the first years of IDTP. MAC proposed changes in the design of the Public Tubewell system and stricter criteria for site selection. DoI did not accept these proposals. MAC took the initiative to pay more attention to farmers participation, extension, environment, and gender related subjects. Subsequently IDTP became a technical project with socio-economic components in the second phase. These socio-economic components were not always directly related to the project. During the last phase an integrated approach was followed. Construction had to go hand in hand with socio-economic project activities as planting of orchards/fruit trees and fish farming and environmental issues as land rehabilitation (*usar*). Guided by MAC, the emphasis shifted from construction oriented project components to integrated project activities.

MAC published in 1989 two Working Papers. It was concluded that the electricity supply was inadequate and uncertain and that in the near future no solution for this problem could be expected. Taking this aspect into account the economical and financial analyses showed that the project could not be considered a sound financial undertaking (see Section 4.3.2). One should expect that drastic measures were taken by MAC to counter the negative trend reported. Taking into account the technical reasons for low performance of the public tubewells as identified in Section 4.1, the introduction of farmers participation only seemed insufficient. There is no reason to believe that technical mal-functioning of a system can be corrected by socio-economic incentives alone.

Regarding project monitoring, the bench mark survey of project villages conducted in 1989-1990 should have been followed by an impact survey for evaluation at the end of the project. This study was started in rabi 1993-1994, but was not completed and did not produce results which could be used for an agricultural impact assessment. According to Kliest (1995) ... *the impact of project activities on the target group(s) is rarely subjected to in-depth analysis.* One should expect that such an impact assessment is conducted in line with a project evaluation or project review, but in a study on evaluation missions results, the Netherlands Development

Corporation (1995) concluded that ... *evaluations are more concerned with the achievement of technical objectives than with social and economic goals. They are generally snap-shots of projects in progress, which rather than analysing their immediate and wider effects, emphasize implementation and management.*

Other project organizations

At project start no agreements existed between Department of Agriculture, the Agricultural University NDUAT and MAC. In the first year much time was spend on negotiations. In kharif 1991 the first field demonstrations were conducted by DoA. Due to limited field staff, only 25 % of the planned field demonstrations were conducted. The Narendra Deva University of Agriculture and Technology conducted field studies. But the results were found to be unreliable (EM, 1992:39).

Main activity of the Women Agricultural Extension Programme (WAEP) was the training of 53 Female Extension Workers who were posted in the field. Main objective of the WAEP (MAC, 1989:31) was to provide an agricultural extension service especially directed at women. Over the years, elements like the introduction of smokeless ovens (*chulas*), family planning, education and various income-generating activities were also incorporated into the WAEP programme. The programme covered rural development activities beyond the scope of IDTP, which was essentially an irrigation project. WAEP could have become an independent Women in Development project extending its activities to other districts in UP as well. At the end of IDTP, the programme could not be incorporated in ongoing activities of government departments, such as the extension program of DoA.

Conclusions

DoI and MAC, as the main counterparts in IDTP, played very distinctive roles in the project, which seems to be based on a difference in objectives. DoI as the leading representative of the GoUP, seemed to be focused on the creation of higher agricultural productivity as soon as possible by developing ground water resources in Uttar Pradesh. MAC, being the representative of the Netherlands Development Corporation with two Netherlands experts on their team, stressed the importance of the development of small and marginal farmers in Uttar Pradesh.

MAC represented the social side of the project objective (see Section 3.1.1) focusing on the improvement of living conditions of farm households. DoI represented the economic side of the project objective, focusing on an increase of agricultural production in Uttar Pradesh. Instead of working towards a mutual goal, by following a balanced approach consisting of social and economic support measures, it seems that both organizations worked with separate agendas and approaches. In this case the different project approaches affected the project results. For example, a different interpretation of the cluster selection criteria led to delays in the selection process.

4.3 Economic aspects

4.3.1 Impact on agricultural production

In 1989-1990 a bench mark survey was conducted by MAC (see Chapter 2), and a follow-up study started in rabi 1993-1994 to quantify the agricultural impact of the project. However the study was not completed as the project was abruptly ended in October 1994. Data available are the results of the agricultural extension program, which laid out demonstration fields and made crop cuttings in farmers fields.

The only comparison, that can be made for the impact assessment, is the wheat production in the project area. For three clusters a comparison was made by MAC (MAC QPR 21, 1993:12-13) in wheat yields between: (a) benchmark yield over Rabi season 1989-90, which varied between 16-22 quintals/ha, (b) crop cutting yield from 1992 onwards, which varied between 23-32 quintals/ha and, (c) demonstration yield conducted by DoA, which varied between 43-49 quintals/ha. The comparison of benchmark and crop cutting yield data indicate an increase in yields of about 42 percent due to project intervention. The comparison of crop cutting and demonstration yield data, show that there is a wide gap between present and potential yields. This gap could be narrowed to some extent through adoption of improved agricultural practices.

In Table 4.5 yields for different crops of WAEP demonstration plots are presented. *Improved* refers to the part of the demonstration plot where spacing, seed and other inputs were applied in accordance with recommended agricultural practices. *Farmers* yields refer to the other part of the plot where farmers follow their own practices. There is a large gap of 44 to 49 percent in crop production for rape, mustard and gram between *improved* and *farmers* practices. For wheat this is only 29 percent which is smaller compared to the results of the DoA extension programme (MAC QPR 21:13).

Table 4.5 Average yields in 154 public tubewell command areas rabi 92/93 (MAC QPR 21, 1993)

Average yield (x 100 kg per ha)	Rape	Mustard	Gram	Red beans	Wheat
Improved	14.0	15.2	19.1	12.0	38.8
Farmers	9.4	10.6	13.2	-	30.1
Difference (%)	49	44	45	-	29

Unfortunately no similar data are available for rice. Yields in demonstration plots varied between 3.0 - 5.9 t ha^{-1}, but since there is no data from farmers fields, no comparison is

possible. Crop yields of demonstration plots may be high under guidance of extension workers, since fertilizers, HYV seeds and water supply can be optimal under their supervision.
No data was available of cropping patterns, cropping intensities and the financial impact on household incomes.

4.3.2 Economic feasibility

At project appraisal in 1986 the Economical Rate of Return for the development of tubewell irrigation in Uttar Pradesh was estimated at 23 percent (Appraisal Mission, 1986:1) However due to the poor performance of the public tubewell systems this ERR dropped considerably. The ERR and FRR were recalculated based on the actual performance of the public tubewells by MAC in 1988. MAC developed two scenarios, which are presented in Table 4.6. In the first scenario, the maximum area irrigated per year is 130 ha, while in the second scenario this is 87 ha.

Table 4.6 Feasibility scenarios IDTP (MAC Working paper 2, 1989)

		Scenario 1	Scenario 2
Irrigated area (ha)		130	87
of which:	wheat	55	45
	paddy	55	25
	other	20	17
FRR (%)		16.1	8.8
ERR (%)		19.3	9.1

In the most optimistic scenario the Financial Rate of Return was estimated at 16.1 % and the Economic Rate of Return (ERR) at 19.3%. However considering the experience of earlier World Bank public tubewell projects implemented in Uttar Pradesh, it was found more realistic to follow a more pessimistic scenario in which the ERR was calculated at 9.1 % and FRR to 8.8%. Considering the prevailing interest rates in India of 10 - 12%, the implementation of a public tubewell could not be considered a sound economical undertaking.

Conclusions

The bench mark survey conducted in 1989-1990 was not followed by a second survey after the end of the project. Therefore no data was available to analyse the agricultural impact of the project. Crop demonstrations for example on wheat suggest that crop production could be increased substantially in public tubewell commands. Given the technical constraints of public tubewell operation as identified in Section 4.1, it is not likely to find a positive impact on agricultural production of public tubewell implementation. Taking into account the study of Pant (1991), who concluded that water distribution in public tubewell command areas was in favor of head-enders, rich farmers and high caste farmers substantial rises in household incomes of the small and marginal farmers due to the project are not likely to be found. A re-estimation of the economic feasibility of IDTP, taking into account the actual performance of the public tubewells, showed that IDTP was economically not feasible.

According to the Evaluation Mission, the low performance of public tubewell technology changed the situation in 1992 in favour of private shallow tubewell technology. Shallow tubewells were found to be a cheaper alternative compared to deep tubewells. However it should be noted that a comparison of benefits of private shallow tubewells and public deep tubewells was not made, because reliable field data on the agricultural and economic impact of both tubewell systems was not available. Groundwater development using private shallow tubewell technology seems to be a more viable option for the future (World Bank, 1991:11).

5 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

(i) The project resulted in the construction of 547 new tubewells, the modernization of 128 old tubewells and the improvement of 100 old tubewells. Through these tubewells approximately 77,600 ha of potential irrigated area was created and approximately 130,000 persons had potential access to public tubewell water. Approximately 70 % of the planned construction targets was achieved.

(ii) The actual irrigated area per public tubewell command area was smaller then planned at the time of design. Technical causes for the ineffective functioning of public tubewells were: (1) an insufficient electricity supply to the tubewells, which was significantly lower than the anticipated 16 hours per day at the time of design, (2) unreliability of the public tubewell system, caused by (a) a poorly constructed water distribution system, (b) vulnerability of the public tubewells for voltage fluctuations and mechanical defects, and (c) inefficiency of O&M organization and inadequacy of O&M budgets.

(iii) The Women Agricultural Extension Programme trained 53 Female Extension Workers who were posted in the field. The programme provided agricultural extension to women and developed other rural development activities as well. According to the Evaluation Mission (1992), the programme was implemented successfully. WAEP could have become an independent Women in Development project extending its activities to other districts in UP as well. Unfortunately the programme could not be incorporated in existing government programmes. It was not possible to continue the programme after termination of IDTP.

(iv) Several documents MAC (1992), Evaluation Mission (1992), NDC, (1994 & 1996) state that the project was not able to reach the target group: the small and marginal farmers in eastern Uttar Pradesh. This is endorsed by Pant (1991), who concluded that water distribution practices in the World Bank public tubewell commands was inequitable and out of the reach of the poor, low castes and tail-enders. Even when technical constraints of public tubewell operation were compensated, social barriers existed which would hamper an equal water distribution among the farmers population.

(v) According to different missions who visited the project (MTEM, 1990 & EM, 1992), the results of the Farmers Participation Pilot Project (FPPP) were good. The project component started in 1991 and developed and implemented an approach whereby a representative committee of farmers was democratically elected. The FPPP was a relatively new concept in Uttar Pradesh. The organization of Farmers Cooperatives was a good step forward in the process of giving small farmers an assured access to public tubewell water. Unfortunately the FPPP could not be continued after termination of IDTP.

(vi) Monitoring data of IDTP was available, but was limited to the progress of construction work. A Bench Mark Survey was conducted by MAC in 1989-1990 but this survey did not get a follow-up at the end of the project. Because of this, an in-depth analysis of IDTP including a project review could not be made.

(vii) A major part of the workforce and project budget (95%) was used for the construction of the public tubewells, the *hardware* component. The *software* component of IDTP as O&M, management of the public tubewells and organization of farmers was limited in scale and did not receive the required attention of the implementing organizations. A balanced approach in *software* and *hardware* components would have been more appropriate.

(viii) Taking into account the massive development of private tubewell irrigation in Uttar Pradesh in the recent decades and the disappointing performance of public tubewell systems, ground water development by private shallow tubewell technology seems a more viable option for the future (World Bank, 1991:11).

Recommendations

(i) During the appraisal and formulation of a project assumptions are made regarding project inputs, results and impact. Project designers and planners should assess whether these assumptions are realistic. By verifying these assumptions, more insight in the potential weakness of the project is gained. If gaps in basic data exist, additional studies are necessary before a project is implemented on a large scale.

(ii) Donors and international lending agencies should consider the set up of small-scale pilot projects, where innovative techniques are field tested and evaluated. Only after the newly introduced technique has proven itself in the field, one can consider implementation on a larger scale. By following this approach, large scale introduction of new techniques is based on reliable data and not on assumptions alone. Such an approach requires extra time of donors, aid-receiving governments and implementing agencies which should be seen as a good investment for the future of a larger scale project.

(iii) Monitoring and evaluation is a crucial project activity. It requires: (1) collection of relevant field data, (2) analyses of the data and, (3) formulation of adjustments where necessary. Project monitoring is often used for a presentation of the project's physical progress. However analysis of field data needs more emphasis. A well designed monitoring system of public tubewell project, should provide data for an analysis of the actual water distribution and the agricultural and economic impact of the tubewell system. Monitoring can only be effective if adjustments in the project can be implemented. This requires flexibility in project implementation.

(iv) Projects aiming at agricultural development through technological intervention cannot rely on the technology, the *hardware* component, alone. Important *software* elements should form an integral part of such projects as there are: management, training, extension, research and institutional development. However, projects should not introduce *software* components to compensate for technical constraints. For example, a farmers organization cannot effectively distribute and manage tubewell water, if the public tubewell is not functioning properly due to an inadequate power supply. Both technical and institutional components should be consistently planned and implemented.

REFERENCES

Aart, van R., M.L.M. Kooyman, R. Lageman, and L.H. Sprey. 1987. Public Tubewell Development in the State of Uttar Pradesh, India. ILRI Annual Report 1987, pp 33-49.

Aeron-Thomas, M. 1992. The equity impact of deep tubewells: evidence from the IDA deep tubewell II project. ODI-IMMI Irrigation management network paper 12, pp.18.

Agarwal, R.R. Yadav, J.S.P. Gupta, R.N. 1979.Saline and Alkali Soils of India, Indian Council for Agricultural Research, New Delhi 286 pp.

Aklilu, P and Altaf Hussain. 1992. Pakistan: public and private irrigation development. In: Developing and improving Irrigation and Drainage Systems World Bank Technical paper number 178, pp. 23-34.

Appraisal Mission.1986. Appraisal of the Uttar Pradesh State Tubewell Project under Bilateral Aid Programme. 98pp.

Bäcker C. and van Steenbergen F. 1996. Public or private: reconsidering drainage management in Pakistan. Paper for workshop on drainage management, 4 January 1996, Euroconsult Arnhem, 9pp.

Banerjee S. 1986. Regional imbalances in the agricultural development in Uttar Pradesh. Varanasi: Sudha Publications, 128pp.

Boehmer, W.K. 1988. Groundwater potential. Uttar Pradesh State Tubewell project, India. Indian-Netherlands Joint Programme under the Uttar Pradesh Department of Irrigation. (2nd draft) 12pp.

Biswas B.C., Yadav D.S., Maheswari M. 1985. Soils of India and their management. The Fertiliser Association of India, New Delhi, 2nd Edition, 445pp.

Campbell, D.E. 1984. Pipe Distribution Systems in Groundwater Development. In: Agricultural Administration 16, pp. 209-227.

Chambers, R. 1988. Managing Canal Irrigation: Practical Analysis from South Asia. Wye Studies in Agricultural and Rural Development. Cambridge University Press. 279 pp.

Cunningham. J. 1992. Public and Private groundwater development in India: the case of Uttar Pradesh. In: Developing and improving Irrigation and Drainage Systems World Bank Technical paper number 178, pp. 35-44

Department of Economics and Statistics. 1992. Statistical Outline of India 1992-1993.

Published by: Tata Services United, New Delhi, India.

Department of Economics and Statistics. 1995. Statistical Outline of India 1995-1996. Published by: Tata Services United, New Delhi, India.

Department of Irrigation, State of Uttar Pradesh. 1984. Uttar Pradesh State Tube Well project under the Indo-Dutch bilateral aid programme, 87pp.

Department of Irrigation, State of Uttar Pradesh. 1993. Indo-Dutch Integrated Tubewell Project. Public Tubewells Investigation, Planning, Design and Procurement Circle, Lucknow, 69pp.

Dhawan. 1982. Development of Tubewell Irrigation in India, Agricole Publishing Academy, New Delhi, 208 pp.

Euroconsult. 1991. Final Report on the First Phase of the Indo-Dutch Tubewell Project - UP, India, Arnhem, The Netherlands, 9 pp.

Evaluation Mission. 1992. Evaluation Indo Dutch Tubewell Project (IDTP) India, Uttar Pradesh. Government of The Netherlands, 42pp.

Formulation Mission. 1987a. Uttar Pradesh State Tubewell project. Volume I Mission report. Government of the Netherlands, Ministry of Foreign Affairs and the Government of India, Ministry of Water Resources 43pp.

Formulation Mission. 1987b. Uttar Pradesh State Tubewell project. Volume II Plan of Operations.

IDITP Final report. 1994. Indo-Dutch Integrated Tubewell Project, Interim Period (July 1993 - October 1994), MDP Consultants in association with DHV Consultants, Lucknow, 73pp.

IIMI. 1991. International Irrigation Management Institute Review, Volume 5 No.1 July 1991, Colombo, Sri Lanka, 36pp.

Kliest, T. 1995. Project monitoring and evaluation in Netherlands bilateral development cooperation. In: Controlling Development, Systems of Monitoring & Evaluation and Management information for Project Planning in Developing Countries. Eds: P. van Tilburg and J. de Haan, Development Research Institute, Tilburg University Press, pp. 14-40.

MAC. 1989. Indo-Dutch Uttar Pradesh Tubewell project. Working Paper 8: Introduction to the Project area. Lucknow, August 1989.

MAC. 1992a. Towards Improved Performance. Occasional Paper (restricted circulation)

Indo-Dutch Uttar Pradesh Tubewell Project, Lucknow, India, March 1992, pp.34

MAC. 1992b. Towards More Participation and Greater Efficiency. Occasional Paper (restricted circulation) Indo-Dutch Uttar Pradesh Tubewell Project, Lucknow, India, June 1992, pp.28

Mid-term Evaluation Mission. 1990. Uttar Pradesh Indo-Dutch Tubewell Project: Report of the Mid-term Evaluation Mission, Government of the Netherlands and Government of India, 60pp.

Moench, M.H. 1993. Debating the Options: Groundwater management in the Face of Scarcity, Gujarat, India. VIKSAT/Pacific Institute Collaborative Groundwater Project, 26 pp.

Morton J. 1989. Tubewell irrigation in Bangladesh. ODI-IMMI Irrigation management network paper 89/2d, 34pp.

Nespak & Mott MacDonald. 1995 Feasibility Study National Drainage Programme I - Volume I Main Report. Islamic Republic of Pakistan, WAPDA, IBRD, Population and Human Resources Development Fund Japan, 162 pp.

NDC (Netherlands Development Cooperation). 1994. India, Evaluation of the Netherlands Development Programme with India, 1980-1992. Operations Review Unit (Inspectie Ontwikkelingssamenwerking te Velde), 241 pp.

NDC (Netherlands Development Cooperation). 1995. Evaluation and Monitoring. The role of project evaluation and monitoring in Netherlands bilateral aid. Summary Evaluation Report 1995, Operations Review Unit, Netherlands Development Cooperation. 119pp.

NDC (Netherlands Development Cooperation). 1996. Netherlands Aid Reviewed. An analysis of Operations Review Unit reports, 1983-1994. Evaluation report. Policy and Operations Evaluation Department. 182pp.

Palmer-Jones, R.W. 1995. Deep tubewells for irrigation: Efficiency, Equity and Sustainability. School of Development Studies, University of East Anglia, England 124pp.

Pant, N. 1988. A study of water distribution and management in new design public tubewells in Eastern Uttar Pradesh. Indo-Dutch Public Tubewell Project. Centre for Development Studies, Lucknow, 101 pp.

Pant, N. 1991. Development of Groundwater Markets in Eastern Uttar Pradesh. Indo-Dutch Uttar Pradesh Tubewell Project, Centre for Development Studies, Lucknow, 128 pp.

Pant, N. 1994. Performance of the World Bank Tubewells in India. Ch. 8 In: Groundwater Irrigation and the Rural Poor, Options for Development in the Gangetic Basin, edited by F. Kahnert and G. Levine, World Bank, Washington D.C. pp.119-130

Review Mission. 1990. Review/support mission report. Government of The Netherlands, International Institute for Land Reclamation and Improvement/ILRI, Wageningen, The Netherlands.

World Bank. 1983a. Staff Appraisal Report, Second Uttar Pradesh Public Tubewells Project, India. South Asia Projects Department, Irrigation II Division. Report No. 4167-IN 57pp.

World Bank. 1983b. Staff Appraisal Report, Second Uttar Pradesh Public Tubewells Project, India. South Asia Projects Department, Irrigation II Division. Report No. 4167-IN, Supplementary Data Volume, 203pp.

World Bank. 1985. Staff Appraisal Report West Bengal Minor Irrigation Project, South Asia Projects Department, Irrigation II Division. 105 pp.

World Bank. 1985b. Project Completion Report. India: Uttar Pradesh Public Tubewells Project. Irrigation II Division, South Asia Projects Department.54pp.

World Bank. 1986. Project performance audit report. India: Uttar Pradesh Public Tubewells Project. Operations Evaluation Department.

World Bank. 1991a. India Irrigation Sector Review, Volume 1: Main Report. Agricultural Operations Division, India Country Department, Asia region, 61pp.

World Bank. 1991b. India Irrigation Sector Review, Volume II: Supplementary Analysis. Agricultural Operations Division, India Country Department, Asia region, 61pp.

Quarterly Progress Reports

MAC/IDTP. Indo-Dutch Uttar Pradesh Tubewell Project Quarterly Progress Report no. 8 (January - March 1990)

MAC/IDTP Indo-Dutch Uttar Pradesh Tubewell Project Quarterly Progress Report no.10 (July-September 1990)

MAC/IDTP Indo-Dutch Uttar Pradesh Tubewell Project Quarterly Progress Report no.12 (January - March 1991)

MAC/IDTP Indo-Dutch Uttar Pradesh Tubewell Project Quarterly Progress Report no.14 (July - September 1991)

MAC/IDTP Indo-Dutch Uttar Pradesh Tubewell Project Quarterly Progress Report no.15 (October - December 1991)

MAC/IDTP Indo-Dutch Uttar Pradesh Tubewell Project Quarterly Progress Report no.17 (April - June 1992)

MAC/IDTP Indo-Dutch Uttar Pradesh Tubewell Project Quarterly Progress Report no.20 (January -March 1993)

MAC/IDTP Indo-Dutch Uttar Pradesh Tubewell Project Quarterly Progress Report no.21 (April -June 1993)

IDITP Indo-Dutch Integrated Tubewell Project, Quarterly Progress Report-2 (October - December 1993), Lucknow, January 1994, 22pp.

IDITP Indo-Dutch Integrated Tubewell Project, Quarterly Progress Report-3 (January - March 1994), Lucknow, April 1994, 18pp.

IDTP PAPERS

Bench Mark Survey Basti District, Kharif 1989, Indo-Dutch Tubewell Project, June 1990

Bench Mark Survey Basti District, Rabi 1989/1990, Indo-Dutch Tubewell Project, January 1991

Bench Mark Survey Sultanpur District, Kharif 1989, Indo-Dutch Tubewell Project, June 1990

Bench Mark Survey Sultanpur District, Rabi 1989/1990, Indo-Dutch Tubewell Project, January 1991

IDTP. Working Paper 1. Power Demand and Supply Projections. March 1989

IDTP. Working Paper 2. Economic and Financial Appraisal. May 1989

IDTP. Working Paper 8. Introduction to the project area. August 1989

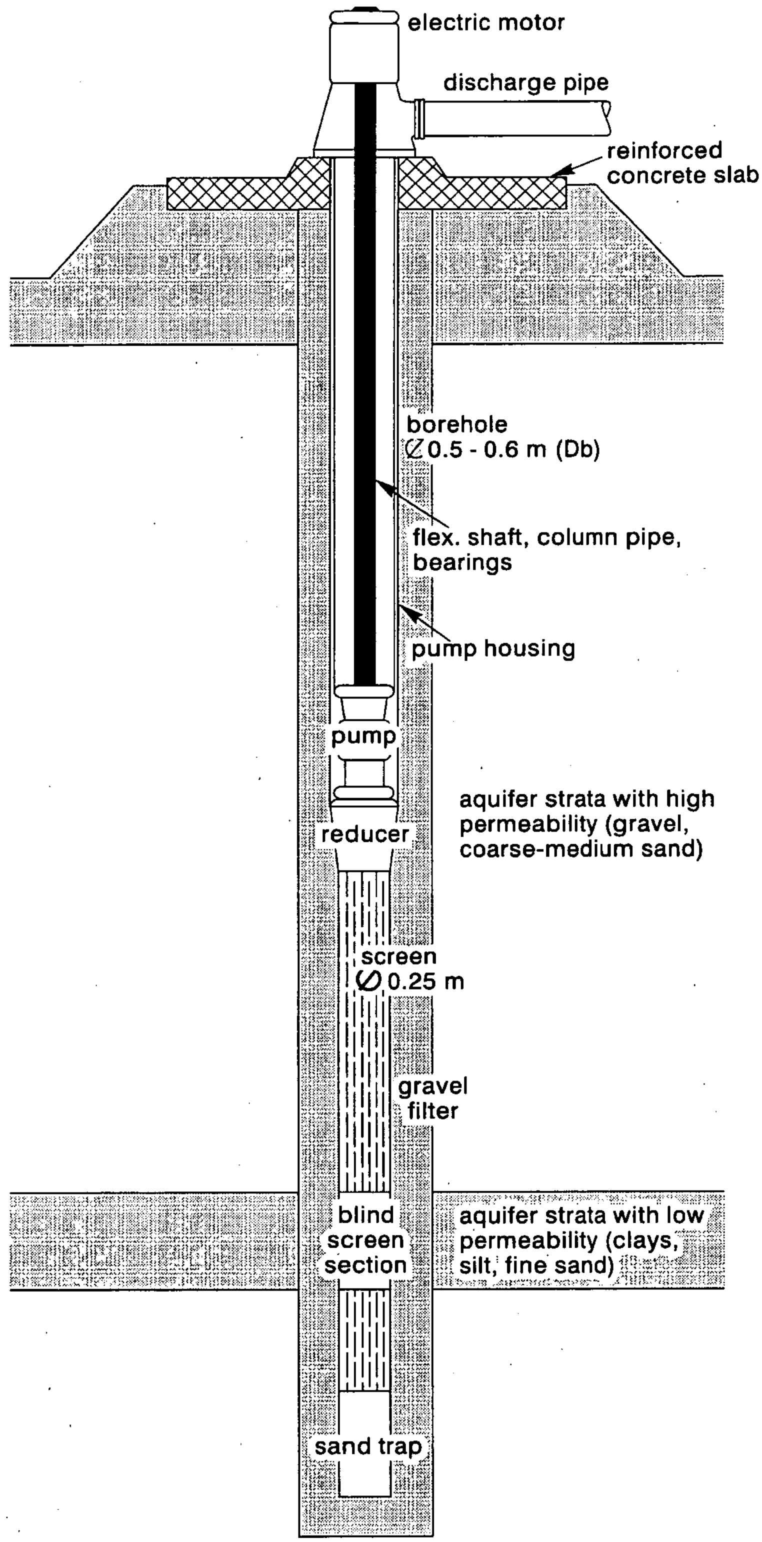
IDTP. Working Paper 12. Crop water requirements and cultivable command area size. Januari 1992

Appendix 1: Net annual recharge and net annual draft in the project area

Net annual recharge and net annual draft in 1986 for eight districts in eastern Uttar Pradesh (Boehmer, 1988)

District	Area (sq.km)	Rainfall 1986 (mm)	Net annual recharge		Recharge as % of rainfall	Draft ($10^6 m^3$)	State of development (%)
			($10^6 m^3$)	(mm)			
Bharaich	6877	909	1845	268	30	429	23
Gonda	7352	1230	2288	311	25	789.	34
Basti	7309	1210	2530	346	29	700	28
Gorakhpur	6316	1200	1980	313	26	670	34
Deoria	5400	1106	1950	356	32	634	33
Faizabad	4427	1208	1573	355	29	420	27
Ballia	3183	830	1064	334	31	399	38
Sultanpur	4424	1252	1440	325	26	460	32

Appendix 2: Design of the well



Appendix 3: Net irrigated area and sources of irrigation in the project area

Net irrigated area and sources of irrigation water per district in 1983-1984 (ha x 100) (Appraisal Mission 1986 & Formulation Mission 1987)

District	Net cult. area	Net irrigated area		Canal irrigated		Public tubewells		Private tubewells		Other sources	
		area	% of NCA	area	% of NIA	area	% of NIA	area	% of NIA	area	% of NIA
Ballia	n.a.	1405	--	359	26	124	9	880	63	43	3
Gorakhpur	4976	3149	64	834	26	273	9	1396	44	646	20
Deoria	4377	2725	62	1136	42	267	10	1024	38	298	11
Basti	5647	3366	60	155	5	500	15	1757	52	954	28
Faizabad	2956	2022	68	505	25	194	10	1232	61	91	5
Gonda	n.a.	1986	--	7	0	141	7	1702	86	136	7
Bahraich	n.a.	853	--	7	1	67	8	665	78	114	13
Sultanpur	2864	1592	56	632	40	130	8	688	43	142	9
UP total	172000	98877	57	33374	34	6224	6	48404	49	10876	11

Appendix 4: Selection criteria for public tubewell sites

Based on experiences of the earlier implemented World Bank projects it was concluded that the selection of tubewell sites needed more attention. The Appraisal Mission(1985:31) redefined the selection criteria for clusters and well sites more exactly and added some new criteria.

- The required quantity of ground water, 150 m^3/h, should be available within 250 m depth of drilling. Preference would be given to those areas requiring less depth of drilling.
- The groundwater quality should be suitable for irrigation and the Total Dissolved Solids (TDS) content should not exceed 1,000 parts per million (ppm). The groundwater quality maps of the shallow and deep aquifers showed that this criterion could not always be met, especially in the districts Lucknow, Rae Bareli and Fatehpur;
- The cluster area should not be prone to flooding or waterlogging, resulting in late sowing of rabi crops. The land should not be salty, uncultivable or stony. An area of maximum ten percent of salt affected land within a tubewell command should not be exceeded;
- The cluster area should not be served by a surface irrigation system and sufficient unirrigated land should be available for clusters of about 20 to 30 tubewells, hence about 2,000 to 3,000 hectares.
- The clusters should be located in areas where the watertable is too deep or the farms too small for private tubewell development. Preference should be given to those areas where the farmers are backward and the average holding would not exceed 0.65 ha.
- The area cultivated under private tubewells should not exceed 20% of the cluster area;
- The distance of the electric sub-station to the cluster should be less than 15 km;
- Preference should be given to the areas where land consolidation has been carried out. (Appraisal Mission, 1985:31)

The criteria of ground water quality was especially defined by the Appraisal Mission, since drainage facilities in the tubewell were absent in the command areas. Criteria related to the surface drainage conditions as such were not mentioned.

Appendix 5: Construction costs of public tubewells

Total cost for construction, modernization and improvement of a public tubewell (x Rs1000) (Formulation Mission, 1987b)

Item	Construction new tubewell	Modernization old tubewell	Improvement old tubewell
Personnel	39.6	27.7	7.9
Land acquisition	18.9	0.8	-
Works	250.8	242.0	35.7
Construction/Rehabilitation	111.2	43.6	32.1
Spec. equipm., vehicles &	20.4	8.2	2.0
tools	9.8	6.8	-
Buildings	3.0	2.1	0.6
office equipment	4.2	3.0	0.5
Audit and account charges	100.0	100.0	100.0
Energization	-	17.2	4.2
Rebate for old material			
GRAND TOTAL	557.9	417.0	174.6
to be financed by			
- Netherlands Government	539.0	416.2	174.6
- Government of Uttar Pradesh	18.9	0.8	-

Appendix 6: Progress of tubewell construction in Phase 1

Progress of tubewell construction in Phase 1 (MAC/IDTP Quarterly Progress Reports 8, 10 and 12)

	Achieved 01.04.90 Mid-term evaluation	Achieved 10.10.90 Review Mission	Achieved 31.03.91 End of phase 1
Approved			
Clusters approved	15	23	28
Sites selected	380	667	728
* new Public Tubewells	316	538	557
* PTWs for modernization	64*	129*	150
* PTWs for improvement	---	---	71
Construction of new PTWs			
Drilled	300	343	514
Handed over to construction division	n.a.	263	401
Pumphouses constructed	187	261	360
Pumpsets installed	155	226	336
Energized through dedicated feeder	114	151	318
PVC-loops constructed	147	213	341
Declared in operation	59	116	244
Modernization of old PTWs			
Re-drilled	2	7	14
Re-developed	0	13	28
Pumphouses modified	0	22	43
Pumpsets changed	0	5	36
New PVC-loops constructed	0	14	33
Energized through dedicated feeder	0	4	35
Declared in operation	0	0	28
Improvement of old PTWs			
Re-developed	0	6	8
Pumphouses modified	0	14	17
Pumpsets changed	0	15	19
Old brick channels re-constructed	0	6	15
Energized through dedicated feeder	0	0	15
Declared in operation	0	0	14

* This is the number of old tubewells to be modernized and improved. QPR 8 and 10 give no specification about the division of tubewells selected among these categories.

Appendix 7: Progress of tubewell construction till end of phase 2

Progress of tubewell construction till end of phase 2 (MAC/IDTP Quarterly Progress Report 17 and 21)

	Achieved 01.07.92 Evaluation Mission	Achieved 30.06.93	Progress over 01.07.92 - 30.06.93	Targe t	achieved in %
Particulars					
1. Clusters approved by MAC	33	28	0	36	78
2. Sites selected	780				
* new PTWs (No.)	547	547	0	750	73
* PTWs for modernization (No.)	133	128	-5	125	102
* PTWs for improvement (No.)	100	101	1	200	51
Construction of new PTWs					
3. PTWs drilled	547	547	0		
4. PTWs handed over to construction division	547	547	0		
5. Pumphouses constructed	546	547	1		
6. Pumpsets installed	545	547	2		
7. PTWs energized through dedicated feeder	540	547	7		
8. PVC-loops constructed	541	547	6		
9. PTWs declared in operation	498	547	49	750	73
Modernization of old TWs					
10. TWs re-drilled	18	25	7		
11. TWs re-developed	45	47	2		
12. Pumphouses modified	99	128	29		
13. Pumpsets changed	85	128	43		
14. new PVC-loops constructed	93	128	35		
15. TWs energized through dedicated feeder	85	128	43		
16. TWs declared in operation	68	126	58	125	101
Improvement of old TWs					
17. TWs re-developed	21	29	8		
18. Pumphouses modified	60	99	39		
19. Pumpsets changed	57	101	44		
20. old brick channels re-constructed	40	99	59		
21. TWs energized through dedicated feeder	60	101	41		
22. TWs declared in operation	32	100	68	200	50

Appendix 8: Irrigated area in ha per tubewell

Irrigated area in ha per tubewell in IDTP clusters in two Rabi seasons (MAC, 1992 & MAC QPR 20, 1993)

Cluster	Rabi 1990-1991	Rabi 1992-1993
Lambhua	42.7	45.4
Dubepur	36.6	41.7
Dostpur	31.8	51.8
Bikapur II	25.0	--
Pharendra	46.7	64.8
Brijmanganj	45.1	54.3
Uska I	13.0	30.1
Uska II	17.9	26.3
Kauwapur	32.9	39.7
Gainsari	26.1	38.9
Kaiserganj	22.4	38.5
Jamunaha	47.7	37.3
Bhatparani	10.9	47.8
Mehdawal	33.0	43.7
Average	30.9	43.2

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6721 HS BENNEKOM

your ref.:
our ref.: 1329
annexes: 1
date: 13 juli 1998
subject: Special Report Public Tubewells

Dear Sir, Madam,

It is my pleasure to offer to you the report titled 'Public Tubewell Irrigation in Uttar Pradesh, India', which was written by a temporary employee of ILRI.

The report discusses the implementation of the Dutch-financed deep tubewell development project 'Indo-Dutch Public Tubewell Project/Indo-Dutch Integrated Public Tubewell Project', which ran over the period 1988-94.

The study provides insight in how implementation projects evolve over the years. The conclusions are of special interest. These include the observation that the two social programmes of the project, the Women Agricultural Extension Programme and the Farmers' Participation Pilot Project, showed promissing results in the last stage of the project.

I expect to have been of your service.

Yours sincerely,

p/o Karin Ketchum

Dr. A. Schrevel

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