His Majesty's Government

National Planning Commission Secretariat

Singha Durbar, Kathmandu, Nepal

FINAL REPORT

STUDY OF EFFECTIVENESS OF INVESTMENT IN GROUNDWATER DEVELOPMENT

MENTOR CONSULTANT P. LTD.

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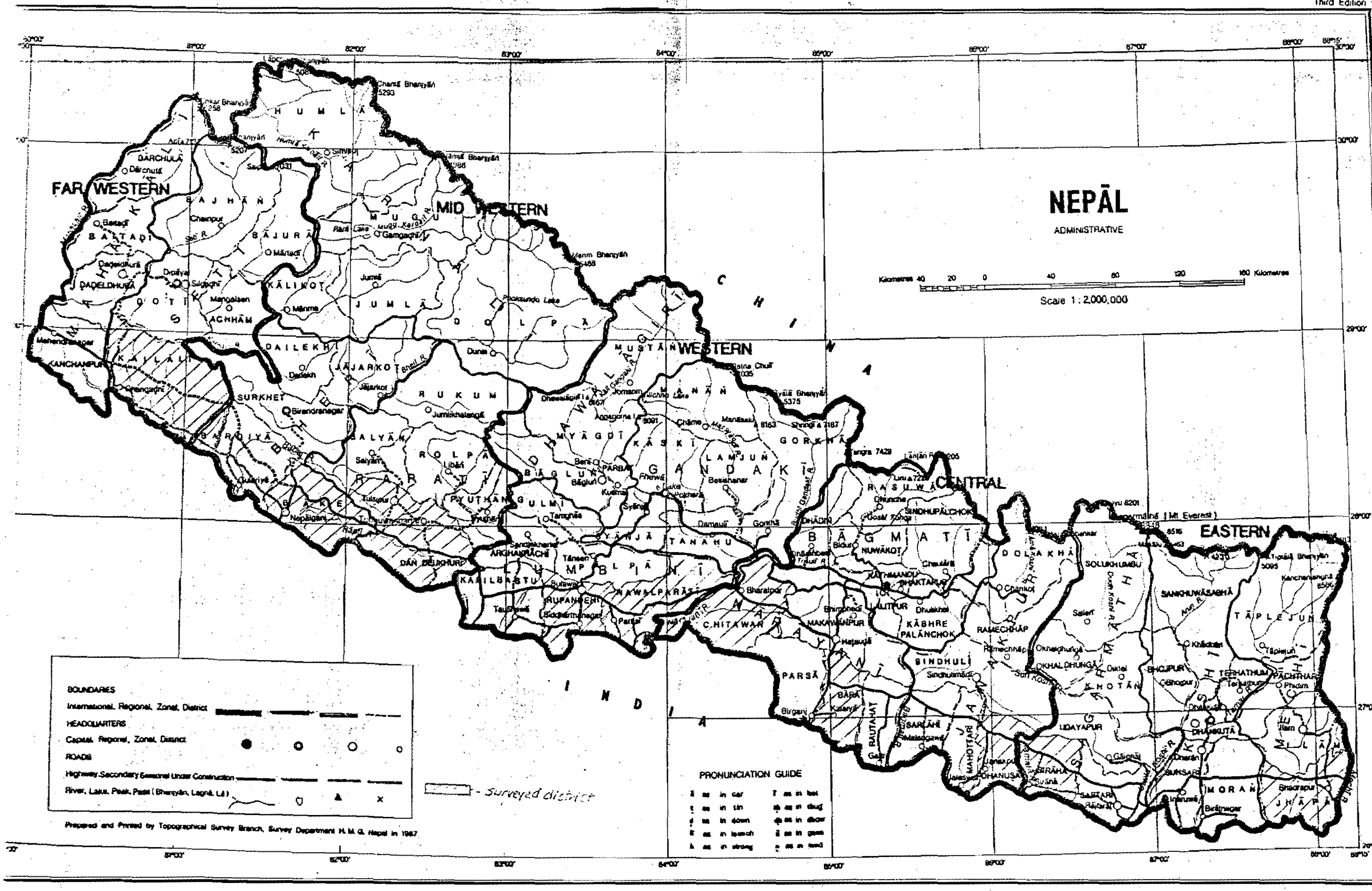

Third Edition
NEPĀL
ADMINISTRATIVE
Scale 1 : 2,000,000
FAR WESTERN
MID WESTERN
WESTERN
CENTRAL
EASTERN
CHINA
INDIA
BOUNDARIES
International, Regional, Zonal, District
HEADQUARTERS
Capital, Regional, Zonal, District
ROADS
Highway, Secondary, Seasonal, Under Construction
River, Lake, Peak, Pass (Bhanjyān, Lagnā, Lā)
- Surveyed district
PRONUNCIATION GUIDE
Prepared and Printed by Topographical Survey Branch, Survey Department H. M. G. Nepal in 1987

ABBREVIATIONS

ADBN	-	Agriculture Development Bank, Nepal
ADPJ	-	Agriculture Development Project, Janakpur
APP	-	Agriculture Perspective Plan
ATW	-	Artesian Well
AVG	-	Average
BLGWP	-	Bhairahawa Lumbini Ground Water Irrigation Project
CDO	-	Chief District Officer
CSTP	-	Community Shallow Tubewell Project
DOA	-	Department of Agriculture
DOI	-	Department of Irrigation
DTH	-	Driving Through Hammering
DTW	-	Deep Tubewell
GDC	-	Ground Water Development Consultants
GDP	-	Gross Domestic Product
GW	-	Ground Water
GWIS	-	Ground Water Information System
GWRDP	-	Ground Water Resources Development Board
Ha	-	Hectare
HP	-	Horse Power
IDE	-	International Development Enterprises
IFAD	-	International Fund for Agricultural Development
ILC	-	Irrigation Line of Credit
JADP	-	Janakpur Agriculture Development Project
JICA	-	Japan International Co-operation Agency
KTP	-	Kapilbastu Tubewell Project
KVA	-	Kilovolt-Ampere
LPS	-	Liter Per Second
MD	-	Man days
M	-	Meter
MTW	-	Medium Tubewell
NA	-	Not Available/Not Applicable
NCA	-	Net Command Area
NGO	-	Non Governmental Organization
NPC	-	National Planning Commission
NTP	-	Narayani Tubewell Project
O & M	-	Operation and Maintenance
R & M	-	Repair and Maintenance
SIRDP	-	Sagarmatha Integrated Rural Development Project
STW	-	Shallow Tubewell
UK	-	United Kingdom
UNDP	-	United Nations Development Program
WUA	-	Water User's Association
WUG	-	Water Users Groups

List of Tables

EXECUTIVE SUMMARY

Background

1. Agriculture is, traditionally, the dominant sector of Nepalese economy. It provides livelihood to about 90% of the population, and accounts for 42% of the GDP.

2. Irrigation and agriculture are inseparable in the sense that development of the latter cannot be anticipated without development in irrigation. In Nepal, irrigation development continues to be one of the priority sectors of public investment in almost all development plans and the Department of Irrigation (DOI) is the responsible public agency for the execution of irrigation projects.

3. The Agricultural Perspective Plan (APP) of Nepal, which was formulated as a blueprint for economic transformation of the nation, envisages rapid growth in agriculture through irrigation development. Therefore, to establish a defined policy guideline for future course of action, the NPC has decided to execute a study on the *Effectiveness of Investment in Groundwater Development.*

4. The main goal of the study was to assess the effectiveness of GW irrigation systems with respect to area coverage economic benefits, operation and maintenance and recommend future measures for implementation.

5. Altogether ten (out of twenty) sample districts were selected purposively with a view of geographical (terai & inner terai) and administrative (all five development regions) representations, by type of GW systems (shallow, medium, deep) and by agencies (DOI, ADBN, DOA).

6. The area under irrigation was verified basically by measuring the discharge of at least two selected pumps and observation of the irrigated area in the above mentioned districts.

7. The sample size was taken as one percent of the total GW schemes and the number of households for enumeration were determined on the basis of one household per 15 ha area covered by each sampled GW system. The particular tubewell(that has been installed and operated for more than two years) to be studied was selected in consultation with district level DOI/ADBN offices. Attention was paid to represent samples from different geographical area within the district.

8. The study relies mainly on primary information through field survey (Household, Key informant survey and measurement & observation). Besides, secondary information was collected from various relevant agencies.

9. DOI, ADBN and DOA are the major players in GW development in Nepal. Groundwater Resources Development Board (GWRBD) under DOI was established for exploring the potentials of GW. GWRBD is being supported by the World Bank through Irrigation Line of Credit (ILC) Project.

10. ADBN is involved (since 1970) in promoting STWs and has the largest network of field offices. ADBN was involved in installing 41000 STWs, 4500 Dugwells, 9000 rower and treadle pumps and 800 artesian wells providing irrigation facilities in approximately 165,000 ha. area through government supported subsidy programs. The STWs, dugwells, rower pumps, and treadle pumps being propagated by ADBN in the Terai region have already created irrigation means for about 165,000 ha.

11. DOA's role in promoting GW development was confined to JICA supported Janakpur Agricultural Development Project area in Dhanusha district with recent extension of its activities in Chitwan and Banke districts.

12. Beside these main actors, International Development Enterprises(IDE) is supporting Treadle pumps in coordination with ADBN and Grameen Bank and other non-governmental organizations (NGOs).

Findings

1. Some variation between reported and actual number of running GW schemes has been found during the field survey. The variation of individual (ADBN) shallow tubewell was caused due to replacement of tubewell after 10-12 years of installation. The total actual number of STWs were deviated from reported number by 7% due to installation failure and the number of actually running STW were deviated from reported number by 14%. Likewise the failure cases of DTW has found about 5%. So the actually running numbers of DTW was less by 27% from reported numbers. It was found that about 30% DTWs installed by JADP were non-functional. The optimum failure cases of DTW has been encountered in Dhanusha district.

2. Nepal's Terai is rich in ground water potentiality. Out of the total potentiality of STWs only 7% is used thus far. Similarly 23% potentiality of DTW was used. Taking into consideration the above facts, it is clear that the huge ground water potentiality remains still unused and future prospect of ground water development in Terai appears promising.

3. Technical aspect of the study has covered the installation details comprising of well specification of GW schemes, physical condition of existing GW schemes, water distribution system and drilling technologies adopted in various GW schemes, utilization of water, operation and maintenance situation and sustainability of GW project in comparison to surface irrigation schemes.

4. Various factors govern the life of a tubewell. The effective life of both manual and machine drilled tubewell depends, besides other things, on type of material used, well design, operation and timely maintenance and on the skill of installer and drilling technology. About 67%

DTWs and 22% STWs were found in operation for more than 10 years. Likewise 50% MTWs and 56% STWs were found in operation below 5 years. Time required to install a tubewell varied from 5 days for STWs to 40 days for DTWs. And, the manpower needed for installing STWs and DTWs varied from 6 and 13 md, respectively

5. Tubewell of various sizes ranging from 1.5"- 4" (STW) to 6"-12" (MTW/DTW) in diameter have been installed depending upon the transmitting capacity of aquifer and purpose of the scheme.

6. Similarly, average depth of the GW systems range from 18m (STW) to 68.5m (MTW) and 124m(DTW). Static water level (SWL) of shallow aquifer fluctuates heavily in comparison to deep confined aquifer. Average SWL of shallow aquifer was noted to be 3.45m, while that of deep aquifer - 26.2m. There was no considerable differences noted in discharge of STW and MTW, which was 12.7 lps and 15.5 lps respectively.

7. Overall physical condition of different types of structures eg. tubewell, water lifting device, canal and ditches of GW schemes has been observed during field visit. No considerable damages have been encountered, except minor case of breakdown of water lifting devices (pumpsets) and leakage in gate-valve (DTW).

8. Almost 74% of the individual STWs did not have water conveyance structures, because they were installed directly in the farmers own land. The physical condition of open field channel constructed in deep tubewells were very satisfactory. About 36% of field channel were damaged and only 27% of them were in good condition.

9. Mainly two types of water distribution systems were found in practice i.e. open channel and buried piped system. Buried piped distribution system has been introduced recently in MTWs and DTWs by BLGWIP and KTP under ILC program. The system has comparative advantage over open channel in terms of saving agricultural land and reducing conveyance losses due to leakage and evapotranspiration, despite of cost increment by 25-30%.

10. Most of the MTWs (67%) and DTWs(64%) have lined field channels and their average length was found to be 1000m and 600m, respectively. And, maximum conveyance losses (45%) was noted in DTW due to damage of field channel. It was almost negligible in case of STWs.

11. Various types of indigenous drilling technologies eg. sludge, bogi, thokuwa and manual rotary were used in STW installation. Construction of MTW and DTW was confined in machine drilling technology. Selection of drilling technology basically depends on type of well, depth of well and subsurface formation. Each drilling technology has its own advantages before other technologies.

12. The operation and maintenance of individual tubewell was satisfactory in comparison to community owned well. The O&M situation of agency managed systems which were recently handed over to water user's group (WUGs) was found not satisfactory due to ineffectiveness of WUGs.

13. Availability of repair and maintenance facility and spare parts was found relatively good in STW scheme because those were equipped with Indian diesel engine driven pumpset. The repair and maintenance and spare parts of diesel pumpset is not a problem to the farmer because this facility is available in the local market.

14. About 40% DTW and 97% STW had diesel driven primeover, and 60% DTW and all MTW had electric submersible pumpsets

15. Most artesian tubewells had a decreasing discharge over time. The variation of discharge in winter to summer occurred due to water table fluctuation. The area coverage by an individual STW was found relatively low with respect to tubewell capacity due to small and fragmented land holding of tubewell owner, low cropping intensity and marketing problem. The low area coverage of community tubewells were due to poor motivation, inadequate support services, lack of coordination between line agencies, relatively high cost of operation and maintenance and ineffectiveness of water user's group.

16. A positive deviation of actual discharge (upto 112%) from reported discharge was found in case of STW while a negative deviation in discharge was found in case of MTW and DTW (upto 35%).

17. On an average, the discharge of a well was 3-10% higher in winter in comparison to summer.

18. The actual area coverage was 37% lower than reported with maximum deviation (57%) in manually drilled ATW and 47% in case of DTW schemes. The negative deviation of area coverage of MTW and STW which came to be -12% and -10% respectively was not so remarkable.

19. The area coverage by a tubewell in winter and summer season depends mainly on the cropping intensity adopted by the farmers.

20. The average investment cost of a DTW and STW was found to be Rs.19,65,000 and Rs.36,000 respectively. Similarly, the cost of Operation and Maintenance of DTW and STW was found to be Rs.17000 and Rs.3000, respectively. The average replacement cost of DTW and STW was found to be Rs.1200 and Rs.2300, respectively.

21. Although the life of the GW project depends on materials used, well design and workmanship of installing personnel, the sample DTWs and STWs were found to be operating since last 20 years and 10 years respectively.

22. From O&M point of view, STWs were comparatively more efficient than DTWs. The user's committees formed for the overall operation and management of Community projects (usually DTWs) were not functioning successfully.

23. Repair and Maintenance facilities for large scale DTW's and their accessories were not locally available. On the contrary, the same was easily available in case of STWs.

24. A socio-economic impact assessment of GW schemes reveals that the average annual working days of the sampled households was 186 indicating only half of the annual working days utilized in agricultural activities. Moreover, small size of land holding is not sufficient enough to generate full employment for the family.

25. The introduction of irrigation system brought positive changes in terms of cropping patterns, cropping intensity and yields. Installation of GW systems helped to change the traditional (rain-fed) cropping patterns. Farmers are able to prepare seed-beds on time so as to carry out transplantation as soon as the rain starts. Wheat and vegetables, which were hardly visible in rain-fed systems before, have become important crops after GW scheme installation. An average cropping index in the sampled areas increased from 154% to 178% after GW installation.

26. The average yields of all the crops increased from 2.28 mt, 1.16 mt, and 1.36 mt before to 3.48 mt, 2.14 mt and 1.73 mt per ha after in case of Paddy , Wheat and Maize respectively.

27. As a result of increase in farm production, total per capita income increased from Rs 5070 (US$ 89) to Rs 7456 (US$ 131) before and after the project.

28. The increase in income had positively contributed to the consumption level. On an average, 67% of the sampled respondents begun to consume more vegetables. Similarly 65% of the respondents begun to eat more nutritious foods like meat, fish and milk.

29. There was hardly any direct impact of the project on women to reduce their work burden except easing laundry work in areas having artesian tubewells.

30. Most of the farmers who had good harvest reported to have problems in getting fair price for their product.

31. The services provided by the line agencies was found to be less than satisfactory.

32. No dispute among beneficiaries was found for using the GW schemes for fish ponds.

33. None of the GW schemes had significant environmental hazards.

Conclusion and Recommendation

There is a huge potential of exploiting GW for the benefit of the country. Of the GW schemes available in the country, STWs seems to be financially viable, technically feasible and operationally sustainable. An integrated GW development program incorporating key areas and collaborating partners indicating their defined roles & responsibilities has to be developed, implemented and monitored strictly. Furthermore, a masterplan comprising of inventory assessment of the resource and a time frame use and a human resource development plan also has to be developed.

CHAPTER - I

INTRODUCTION

1.1 Background

Agriculture is, traditionally, the dominant sector of Nepalese economy. It provides livelihood to about 90% of the population, and accounts for 42% of the GDP. Despite agriculture being the hub of the national economy, its growth during last two decades is limited to an average of 3% per year, only slightly above the population growth rate of about 2.5% for the same period.

Irrigation and agriculture are inseparable in the sense that development of the latter cannot be anticipated without development in irrigation. In Nepal, irrigation development continues to be one of the priority sectors of public investment in almost all development plans and the Department of Irrigation (DOI) is the responsible public agency for the execution of irrigation projects. As of 1993, DOI constructed a total of 220 new irrigation schemes and provided assistance in the rehabilitation of more than 500 farmer developed and managed irrigation schemes. The declared command area under its intervention is reported to be 451,300 ha.

Nepal's agricultural productivity has remained relatively stagnant over the past 20 years or more, with a modest average annual increases of 1.8 per cent in total cereal grain production. The potential for expanding areas being minimal, the only option left for improvement is the introduction of modern farming practices with the provision of irrigation facilities and their effective management.

At present, under rainfed conditions, average cropping intensity is about 111 per cent. Whereas it could be easily increased to 175 and 250 per cent with the provision of year round irrigation. The performance of the irrigation sub-sector needs substantial improvement. Statistics shows that the average annual expansion of irrigated area is 3.3 per cent only.

A major policy shift however has occurred after the restoration of democracy in 1990. The Agriculture Perspective Plan (APP) introduced by the government has a different outlook for the irrigation sub-sector. It accords high priorities to irrigation development and places increased emphasis on agriculture as a system requiring a broad range of complementary activities to increase production.

The Agricultural Perspective Plan (APP) of Nepal, which was formulated as a blueprint for economic transformation of the nation, envisages rapid growth in agriculture through irrigation development. The plan forms the basis of the upcoming ninth five year plan and aims to increase the cropping intensity by increasing the irrigated area. The plan emphasizes that if Nepal has to transform its subsistence agriculture into diversified/commercial form, the vast potential of groundwater (GW) must be exploited by installing STW and increasing the productivity per unit area by increasing the rate of fertilizer use. Therefore, to establish a defined policy line for future course of action, the NPC has decided to execute a study on the Effectiveness of Investment in Groundwater Development

1.2 Goals and Objectives of the Study

The main goal of the study is to assess the effectiveness of GW irrigation systems with respect to area coverage, economic benefits, operation and maintenance and recommend future measures for implementation. Other objectives set to achieve the goals are as follows.

a. to confirm actual area irrigated in the country by GW schemes;

b. to examine the issues concerning the efficiency, effectiveness and impact of groundwater irrigation development to improve future performance;

c. to assess the appropriateness of design, inputs and implementation arrangements as well as the sustainability of benefits generated by various modes of implementation of groundwater development processes;

d. to establish the linkages between the groundwater and surface water development and recommend the course of action to be adopted in order to achieve the balanced development in both the sectors keeping in view the factors such as sustainability, operation and maintenance cost, long term and short term national needs.

1.3 Study Approach and Methodology

1.3.1 Conceptualization of the Study

The study approach and methodology was designed for the in-depth field investigation of GW schemes in Nepal . A conceptual framework was developed to understand the problem, project goal, study concern etc (fig. 1). The framework formed basis for conceptual clarity about the study and in designing the study methodology.

Fig: 1 Conceptual Linkage of the Study

PROBLEM/ISSUES	PROGRAM	STUDY CONCERN	GOAL
Low Production Casusing: • Food Deficiency • Poverty	Increase Productivity by: • Expanding Irrigation Facilities • Adequage Supply of other Inputs	Varification of irrigated Area • Study of Effectivenes of GW Irrigation with respect to Sustainability Operation and Maintenance etc; • Socio-economic Benefits • Lessons Learned and Future NPC Interventions	Effective Use of GW for: • Food Security • Eradication of Poverty

1.3.2 Development of Assessment Indicators

The evaluation indicators were developed as per the study concern, objectives and conceptualization (fig.2).

Fig. 2 Study Concerns, Indicators and Tools

Study Concerns	Indicators for Verification	Tools to be used
Command Area Development under Tubewells (recorded and actual)	• Assessment of recorded command area by various agencies at central and district level • Assessment of actual area covered under various agency supported GW systems at field level • Output of a tubewell • Command area	• Review of data bases at ADBN /DOI/ DOA/NGO's. • Review of databases at ADBN, DOI and DOA's field level offices • Measurement of tubewell discharge. • Interview with WUGs and Key Informants
<u>Effectiveness of:</u> System Design Inputs TW Installation	• Appropriateness • Relevance and • Effectiveness of the design • Availability of water at various seasons and year • Tubewell utilization rate • Cropping intensity • Productivity before and after • Drilling technology used • Time taken for installation • Workmanship of driller and number of manpower used • Quality of installation • Problems	• Technical Field Survey of GW schemes

Financial Aspects	• Total Cost of installation • Operation and Maintenance cost	• Household survey • Key Informants Survey
System Inputs/ Operation and Maintenance of Tubewells	• Operation hours & energy requirement • M services, Spare parts • O & M procedures • Problems	• Household survey • Key Informants Survey
Implementation Arrangement	• Actors, their roles and responsibilities. Strengths and weaknesses of present implementation procedures and actors.	• Consultation with concerned authorities • Review of secondary documents • Household survey • Key Informants Survey
Sustainability	• Durability of Tubewell Availability of spare parts and O&M services	• Household survey • Key Informants Survey
Socio-economic Impact	Before and after situation analysis of: • Cropping pattern/Index • Crop productivity per unit area • Employment generation • Changes in on and off-farm income • Food availability/Health • Family expenditure pattern • Changes in social participation and Women's work burden	• Household survey • Key Informants Survey
Institutional Impact	• Institutional development process in farmer level • Irrigation Institutions. • Conflict management • Problems	• Key Informants Survey • Household survey
Environmental Impact	Changes in environment: positive/negitive.	Household survey/Observation Key Informants Survey

1.3.3 Selection of the Districts for Area Verification

The project districts for the study were selected purposively using the following criteria.

- Geographical Representation (terai, inner terai)
- Administrative Representation (eastern to far-western region)
- Type of GW systems (shallow, medium, deep)
- Agency Involvement (DOI, ADBN, DOA)

Based on the above criteria, ten districts out of twenty were selected for the verification of the irrigated area as shown in the table below.

Table: 1.1
Districts selected for GW Irrigated Area Verification

Administrative Zone	Agency Type						Tubewell Type		
	DOI				ADBN	DOA	STW	MTW	DTW
	GWRDB	SIRDP	ILC	IFAD		JADP			
I **Eastern Region**									
Jhapa	X				X	X	X		X
Siraha		X		X	X	X	X		X
II Central Region									
Dhanusha					X	X	X		X
Bara	X				X	X	X		X
Chitwan					X	X	X		
III Western Region									
Rupendehi	X				X	X	X		X
Nawalparsi	X		X		X		X	X	X
IV M-Western Region									
Dang	X		X		X		X		X
Banke			X		X	X	X		X
V F-Western Region									
Kailali	X		X		X		X		X

The area under irrigation was verified basically by measuring the discharge of at least two selected pumps and observation of the irrigated area in the above mentioned districts.

1.3.4 Selection of Districts for In-depth Socio-economic Study

The sample districts were selected for in-depth study adopting the criteria mentioned under chapter 1. Initially it was agreed upon to carry out study only on 5 districts namely Jhapa, Dhanusa, Rupandehi, Nawalparasi, Dang and Kailali. In the field, however, ten districts were surveyed. The size of the sample number of tubewells studied under technical and scoio-economic aspects are presented in table below:

Table: 1.2

Sample size and Number of Surveyed Tubewells

Districts	Technical Study					Socio-Economic Study									
						No.of Tubewells Studied					No.of Respondents				
	STW	ATW	MTW	DTW	Total	STW	ATW	MTW	DTW	Total	STW	ATW	MTW	DTW	Total
Kailali	5	-	-	2	7	9			2	11	9			5	14
Banke	2	-	-	1	3	1			1	2	1			1	2
Dang-Deukhuri	1	-	-	1	2	1			1	2	1			3	4
Rupandehi	4	1	-	2	7	8	1		2	11	8	1		5	14
Nawalparasi	3	-	2	1	6	3	-	2	1	6	5		2	-	7
Chitwan	3	-	-	1	4	1			-	1	1			-	1
Bara	3	-	-	1	4	2			-	2	2			-	2
Dhanusa	1	1	-	1	3	1	1		2	4	1	1		2	4
Siraha	3	-	-	1	4	1			1	2	1			1	2
Jahpa	6	-	-	1	7	9			-	9	9			-	9
Total	31	2	2	12	47	36	2	2	10	50	36	2	2	17	59

The sample size and study area were determined as the following basis.

- One percent of the total GW schemes were taken as a sample in the above mentioned districts.
- The number of Households for enumeration were determined on the basis of one Household per 15 ha area covered by each sampled GW system.
- The particular tubewell to be studied was selected in consultation with district level DOI/ADBN offices.
- Those GW systems installed and operated at least for two years or more were selected for the study.
- Attention was paid to representative samples from different geographical area.

1.3.6 Information Collection and Analysis

The study relies mainly on the primary information collected through field survey. Secondary information were also collected from available reports and documents. The survey was conducted using various survey tools and methods. Among others, the following survey techniques were used to different sources for collecting primary information.

- Key Informant Survey
- Household Survey
- Measurement and Observation

The data and information collected from various primary and secondary sources have been analyzed and presented in simple tabular form. The tables are self explainatory in many cases and are discussed in brief. Supporting information of the main tables are presented in the annexes.

CHAPTER - II

IRRIGATION DEVELOPMENT IN NEPAL

2.1 History of Irrigation Development

Irrigation has been practiced in Nepal for ages. For centuries farmers in Nepal have developed numerous irrigation systems with local resources and technical capabilities. Most farmer managed irrigation systems (FMIS) exhibit technical limitations but have demonstrated impressive managerial skills that have kept them functioning.

Until mid-sixties, emphasis was given to the construction of government-financed medium and large irrigation projects. The Minor Irrigation Program, a precursor to irrigation sector project (ISP)/irrigation line of credit (ILC) launched in 1966, was the first effort that formally recognized the need for people's participation in irrigation development. It has provided assistance to some 37,000 ha of existing FMIS, most of which are located in the Terai. Further programs to assist FMIS have been initiated by DOI (e.g., the Food for Work Program), Department of Agriculture Development (DOAD) the Ministry of Local Development (MLD), and the Agriculture Development Bank of Nepal (ADBN). The DOAD and MLD programs were consolidated into DOI in 1988, but ADBN continues its programs in two important areas: shallow tubewell (STW) development and small farmers development.

In the Sixties, Indian involvement in irrigation began to dwindle and the involvement of the FAO/UNDP and, subsequently, in the early seventies, the Asian Development Bank (ADB) and the World Bank began to assume greater importance. Presently, almost three-fourths of Nepal's irrigation activities are financed by external donors.

Although great emphasis has been placed (in successive Five Year plans) on the rapid expansion of the irrigated area, hectare target still remains the main guiding principle for irrigation development until the eighth plan. The government still heavily depends on large irrigation schemes rather than individual and farmer managed irrigation systems. The status of area covered under irrigation is presented in the table below.

Table 2.1:
Irrigation Development by Government Agencies

Plan Period	Target (ha)	Achievement (ha)		Remarks
		Total	Per Year	
Before First Plan	-	6,228	NA	Chandra Canal
First Plan (1956-61)	20,785	5,200	1,040	Five years
Second Plan (1962-65)	32,544	1,035	345	Three years
Third Plan (66-70)	50,654	52,860	10,572	Five years
Fourth Plan (1971-75)	253,711	37,733	7,547	Five years
Fifth Plan (1976-80)	230,220	95,425	19,085	Five years
Sixth Plan (1981-85)	233,482	172,649	34,530	Five years
Seventh Plan (1986-90)	235,000	179,337	35,867	Five years
Fiscal Year (1990-91)	41,158	20,810	20,810	No plan
Fiscal Year (1991-92)	38,000	27,527	27,527	No plan
Eighth Plan (1992-1997)	293,895	273,348 (Estimated)	54,670	Five years
Total	1,429,413	872,152	-	-

Source: The Eighth Plan (1992-97), NPC, 1992

2.2 Groundwater Resource Development Potential

Nepal is believed to have surplus water resources both surface (200 billion cubic metres) and groundwater (12 billion cubic metres) development of the 1.8 million ha of land available for irrigation. At present, Nepal is making use of less than 8% of its water resource potential (APP 1995).

The groundwater resource potential of Nepal is being studied at various levels. Two comprehensive investigaions of the shallow aquifier have been conducted in recent years. The first investigation supported by World Bank and carried out in 1986/87 by Groundwater Development Consultants (Cambridge, UK), investigated the most suitable strategy for groundwater irrigation development including both deep and shallow aquifiers. The second one, supported by UNDP, involved collection of large amount of technical information on the properties, occurence and potential of shallow groundwater resources in the terai since 1987 for all terai districts. It has established a computerized Groundwater Information System (GWIS).

Different agencies have developed irrigation infrastructures covering about 62% (1.1 million ha) of Nepal's potential irrigable area. But the actual irrigated area is about 71% of the developed potential, and only 38% of the development potential is for year round irrigation. More than two thirds of the area actually commanded by irrigation is in the terai, a little over a quarter in the hills, and less than 5% in the mountains.

Nepal's Terai holds large potential of groundwater development. The Terai lies in the Indo-gangetic basin and contains large sediments and alluviums deposited by rivers from centuries. The old alluvial deposits lies at a depth of 500 m and more, where as recent alluvium is found to be above 500 m. In the process of deposition by river, a complex system of aquifers developed in it and became aquitard and aquiclude at distances, i.e., sandstone horizon changed to silt and finally clay. Geometrically, the aquifers are inter fingering.

The ground water resources of the Terai are dependent on two parameters, i.e., rainfall and geology. The Terai has, on average, 1,500 mm rainfall per annum, and according to space-wise distribution the foot hill zone has more precipitation as compared to the southern part. ✓

As the Terai region is flat, 8 to 10 percent of rainfall is retained as ground water. Furthermore, most of the big and small rivers cut across the Terai. These rivers act as a source of recharge in the upper part of Terai, whereas in winter and summer months when rainfall is not available, the surface aquifer and bank storage help to augment the low flow of the stream.

Extensive investigations were carried out by Ground Water Resources Development Board(GWRDB) and ADBN for deep as well as shallow tubewells in the Terai. For water table higher than seven meters, either it will require deep tubewells or injection pumps. Most of the shallow aquifers in

Terai is confined within 40 m. The deep tubewells can be used to tap shallow as well as deep confined aquifers. As the Terai plain rises near the foot hills, it is necessary to install deep tubewells in the northern part of the East-West Highway. The STW and DTW potential of Terai region is presented in table 2.

Table 2.2:
Shallow and Deep Tubewell Potential in the Terai (District-wise) on the Basis of Recharge

District	Land area (sq. km)	Estimated Area of Bhabar (sq. km)	Surface area (sq. km)	Recharge to Bhabar (mil.cu.m)	Recharge of STW (mil.cu.m)	Total recharge (mil.cu.m)	No. of DTW	No.of STW	Spacing of STW	Total command area by STW (ha)	Spacing of DTW (m)
Jhapa	1,568	258	1,310	260	939	1,199	325y3256X65.208150			163,020	890
Morang	1,846	203	1,643	174	609	783	217	42.291	200	105,727	960
Sunsari	1,270	141	1,129	122	419	541	152	29.097	200	72,742	960
Saptari	1,359	249	1,110	159	361	520	198	25.069	210	62,672	1.121
Siraha	1.227	226	1,001	145	360	505	181	25,000	200	62,500	1.117
Dhanusa	1,217	138	1,070	106	232	338	132	16.111	250	40,277	1.045
Mahottari	987	113	874	87	188	275	108	13.055	250	32,637	1,052
Sarlahi	1,263	143	1,120	111	113	223	138	7.777	400	19,442	1,017
Rautahat	1,037	130	907	76	258	334	95	17,916	200	44,790	1.169
Bara	1,295	162	1,133	94	322	416	117	22.361	225	55.902	1,176
Parsa	1,389	171	1,218	99	347	446	123	24.097	225	60.242	1.179
Chitwan	2,194	280	1.914	164	295	459	205	20.486	300	51,215	1.168
Nawalparasi	2,016	243	1,773	264	775	1,039	330	53.819	175	134.547	866
Rupandehi	1,413	170	1,243	185	543	728	231	37.708	175	94,270	857
Kapibastu	1.756	212	1,544	232	676	908	290	46.944	175	117,360	855
Dang & Deukhuri	2.973	437	2,535	144	842	986	180	58.472	200	146,150	1.588
Banke	2,359	198	2.161	88	264	352	110	1.833	350	45.832	1.341
Bardiya	2.035	171	1.864	77	228	305	96	15.833	350	39.582	1.334
Kailali	3,247	244	3.003	157	646	803	196	44.861	250	112,152	1.115
Kanchanpur	1,636	125	1,511	80	421	501	100	29.236	225	73.090	1.118

Source: APP Estimate (C.K. Sharma), 1994

Note: 1. No. of STW has been calculated for 10 l/s of average discharge and 1000 operating hr/year for 4 ha of NCA
2. No. of DTW has been calculated for average discharge of 400 cu.m/hr and 2000 operating hours per year for 100 ha of NCA

Recent studies (GDC, 1994) have indicated large ground water potential in the Terai. The specific areas which are suitable for large-scale ground water exploitation have also been identified (GDC, 1994).

Table 2.3:
Priority Area for GW Development

District	TOP priority	Medium priority	Low priority
Jhapa	Butta bari, Ghera bari, Ghailaduba, Goldhap	Panchganchi, Lakhanpur, Mahespur	Sangam Basti, Satighatta
Sunsari	Kushaha, Devanganj, Lauki	Satya Jhora, Inaruwa, Ramnagar	Chandsela
Morang	Biratnagar, Sikiyahi, Surat, Gobindapur, Hasandada	Kanepokhari, Salakpur, Pottiyahi	Kurelis, Chunemari
Saptari	Boriyagohan, Kochabakhori, Batnaha, Kanchanpur, Baghuwa, Liljatole	Piprahi, Kalyanpur	Portaha
Siraha	Basbitta, Karjaha, Bhediya, Sundarpur (south)	Barcharuia, Kasaha, Choharwa, Luxmipur, Sundarpur (north)	Kanchibazar, Madar Barhari
Dhanusha	Bateswar, Hariharpur, Mahendranagar, Raghunathpur, Sabaila	Nagrain, Etharba (Badah) Khajura, Balahagoth, Tulsiyah	Pidari, Raduali, Kharibani, Rampur, Parwala, Bafai, Dhabauli, Kishanpur
Mahottari	Matihani, Ratauli. - MadhepurÿX		Dhirpur
Sarlahi	Sitapur, Hazaria, Bhawanipur, Sisaut, Bairiya, Balara, Madhuban, Baibas, Sirsirya	Harion	Jhirgarhwa, Malangwa, Pokhariya
Rautahat	Sarautha, Santpur, Gahur, Mattiyahi, Basanpathi	Sitalpur, Shivnagar, Banjarha	Rajpur, Tulsi, Tahan, Kankpur, Sarbhujwa
Bara	Chotapipara, Pheta, Hatirawa, Kabhigoth, Kaesraul, Bardua, Bodhabnan, Bishanpurwa, Umjan, Mabhriya, Motisar, Behri	Simara, Narabasti, Jitpur, Likmi, Rehriya	Nautan, Bishrampur
Parsa	Madhaval, Chorni, Malebasti, Sedwa, Paterwa	Nichuta, Inarwa, Raniganj	Ashurai, Sukhachina
Chitwan	Parsa, Meghauli, Bhimnagar, Tikauli, Ratnagar	Prembasti, Dibyanagar	Bhandara
Nawalparasi	Kuniya, Kharhani, Surajpur, Guthi, Parsauni	Paldanda	Jamuniya, Gobarhiya, Banjaria, Bishanpur, Sunwal

Rupandehi	Manoharpur, Baksad, Saljhandi, Ranibagiya, Baluhi, Bhalwari, Makrahar	Siktahan, Panani, Ramnagar	Gajedi, Bochwapur, Padriya, Sisosemra
Kapilbastu	Bijgawari, Lohraula, Karmahiwa, Gorusinge	Dhamauliya	Simrasat, Sultanpur, Amuwa, Mahuwa, Babudihwa
Dang (For deep tubewells)	Kataha, Tarigaun, Jaspur	Bargadwa, Baisa, Lalpur	Pakadi
Deokhuri	Hanspur, Gahiragaun, Manpur	Balapur, Gobardiya, Masuriya	-
Banke	Jabodahwa, Khairancha, Phatepur, Materhia, Halbaldoli	Kanchanpur, Gaughat	Shikarpurwa
Bardia	Rampur, Padnaha	Jainpurwa	Mainapur
Kailali	Bishnu, Kantipur, Dhusi, Joshipur, Simri, Dhangadi Village, Lalpur, Tikapur, Durgauli	Kota, Prithivipur (south), Phulbari, Baliya	Rampur, Prithivipur (north)
Kanchanpur	Kankar, Mahuwa, Phanta, Matiapachvi, Amiliya, Dekhatbhuli	Patia, Jaun	Bansa, Bani, Bichuwa, Amariya, Pachui

Source: Reassement of GW Development Strategy for Irrigation in Terai, GDC, 1994.

Ground water holds about 6 to 8 percent of Nepal's total water in the rocks of hills and beneath the aquifers of the Terai in the form of confined and unconfined aquifers. The extent to which ground water can be intensively developed in the longer term is still largely unknown and difficult to ascertain. Broad assessment indicates the availability of about 12 billion cubic meters, of ground water, out of which about 50 percent can be safely extracted annually for irrigation and other purposes and is rechargeable. Almost all of Terai area could be irrigated by STW and DTW developments.

2.3 Status of Groundwater Development

Investigation of GW potential in terai was initiated in 1969 with the assistance of USAID. The first attempt to develop the groundwater resources in the terai region for irrigation on a large scale was the Bhairahawa-Lumbini Ground Water Irrigation Project (BLGWP). Presently, it successfully provides year-round irrigation in more than 10000 ha land.

The total irrigated area recorded as being developed using GW in the terai is 201941 ha (161825 ha through STWs and the rest DTWs). The DTWs which account for about 13.6% of the total number of tubewell in the country are managed by the government, whereas all shallow tubewells are farmer managed. The utilization of GW irrigation systems is below potential. About 400 DTWs and 48000 STWs are reported being managed by farmers of terai with agency assistance until mid 1996. In addition, STWs have also been installed in many areas without agency assistance. Preliminary estimates show that their number may be around 6000. About 14% of agency reported STWs are not functioning or out of order. The district wise status of GW development is given in the table below.

Table 2.4:
Number and Area Covered Under Different GW Systems by District

DISTRICT	STW		DUGWELL		ARTESIAN		MTW		DTW		TOTAL	
	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Jhapa	3254	12980	426	1704	0	0	0	0	10	188	3690	14872
Morang	3702	14692	49	186	0	0	0	0	4	200	3755	15078
Sunsari	4242	16988	8	32	0	0	0	0	1	50	4251	17070
Saptari	972	2406	52	206	1	2	0	0	3	82	1028	2696
Siraha	1455	5238	86	337	0	0	0	0	30	889	1571	6464
Dhanusha	2377	3510	155	579	269	364	0	0	108	2950	2909	7403
Mahottari	1218	4683	76	286	347	672	26	793	21	840	1688	7274
Sarlahi	2627	10261	528	2074	2	4	0	0	32	1200	3189	13539
Rautahat	2652	6807	55	213	0	0	0	0	0	0	2707	7020
Bara ✓	4517	19088	73	276	7	4	0	0	26	181	4623	19549
Parsa	673	2145	0	0	0	0	0	0	5	75	678	2220
Chitwan	450	1226	1470	5097	0	0	0	0	24	1400	1944	7723
Nawalparasi	1248	4445	329	1071	17	34	14	209	10	334	1618	6093
Rupendehi	3777	13686	115	418	72	114	0	0	176	12285	4140	26503
Kapilvastu	599	2402	32	125	4	5	26	380	20	518	681	3429
Dang	484	2010	660	1029	0	0	0	0	19	240	1163	3279
Banke	2387	7301	52	205	23	46	0	0	14	280	2476	7832
Bardia	1953	6577	10	40	1	2	0	0	12	400	1976	7019
Kailali	4850	17252	3	12	25	22	0	0	55	1400	4933	18686
Kanchanpur	2461	8128	1	4	0	0	0	0	3	60	2465	8192
Total	45898	161825	4180	13894	768	12689	66	1382	573	23572	51485	201941

Source: Calculated from unpublished information from ADBN, DOI (GWRDB) and DOA (JADP).

Beside this, DOI has been investigating deep aquifers with the objective of exploring the potential ground water. The status of these tubewell is given below. These investigating tubewells are also providing irrigation facilities, which is not mentioned in the table.

Table: 2.5
Status of Investigating Deep Tubewells Installed as of 1997

District	Number of Deep Tubewells Installed
Parsa	6
Bara	2
Rautahat	10
Sunsari	7
Siraha	7
Total	32

Source: DOI, 1996. Project Status Report (unpublished report)

2.4 Major Players in GW Development and Performance

DOI, ADBN and DOA are the major players in GW development in Nepal. Groundwater Resources Development Board (GWRDB) under DOI was established for exploring the potentials of GW. GWRBD mainly concentrated in the installation of DTWs in its early days. GW development efforts of DOI is also supported by the World Bank through Irrigation Line of Credit (ILC) Project to install deep, medium and shallow tubewells in Nawalparasi, Kapilbastu, Dang, Banke, Bardia, Kailali and Kanchanpur. Similarly, International Fund For Agricultural Development (IFAD), since 1995, has been supporting GW activities in Sunsari, Saptari, Siraha, Sarlahi and Rautahat districts through providing technical and financial assistance for the installation of community STWs.

ADBN is the only institution in the country having many years involvement (since 1970) in promoting STWs in Nepal and has the largest network of field offices. ADBN was involved in installing 41000 STWs, 4500 Dugwells, 9000 rower and treadle pumps and 800 artesian wells providing irrigation facilities in approximately 165,000 ha. area through government supported subsidy programs. Since 1980, ADBN has emerged as a prominent institution working in the creation of irrigation facilities. The STWs, dugwells, rower pumps, and treadle pumps being propagated by ADBN in the Terai region have already created irrigation means for about 165,000 ha. ADBN has also provided credit for the development of more than 41,000 STWs.

ADBN has played a pioneering role in the promotion and development of STWs in Nepal since 1970, financing (together with the subsidy provided by HMGN) more than 30 000 STWs (including hand pumps and rower pumps), of which around 20% are community wells.

DOA's role in promoting GW development was confined to JICA supported Janakpur Agricultural Development Project area in Dhanusha district. It has recently extended its activities in Chitwan and Banke districts.

Most wells financed by ADBN were drilled manually using indigenous methods by local Nepali or Indian drilling contractors hired by ADBN. Typical well diametres range from 38 to 150 mm and utilize bamboo or mild steel casing and screen pipes. All wells exceeding 100 mm diameter are operated by diesel driven centrigugal pumps whereas smaller size STWs are operated by hand pumps or rower pumps. Water distribution systems comprise temporary earthen canals constructed by the farmers. With the use of such low cost technology, STWs under the ADBN programme have been constructed for around Rs 30000. Whilst ADBN has been active in arranging the drilling and the supply of materials and pumps, it has lacked the necessary technically qualified manpower for quality assurance. This has contributed to the considerable underutilization of the wells which have been constructed under the programme.

Beside these main actors, there are other agencies; both local and international, supporting GW development in the minor scale. International Development Enterprises (IDE) is supporting Treadle pumps in coordination with ADBN and Grameen Bank and other non-governmental organizations (NGOs). The involvement of different agencies in GW development is summarized in table below.

Table: 2.6
Major Players in GW Development

Agencies	Area of Specialization	Total Number of Projects	Total Area Covered (ha)	Average Area/project	Duration of Involvement since
DOI					
GWRDB	DTW	278	9789	35.2	1970's
	MTW	26	793	30.5	
	STW				
SIRDP	DTW	15	473	31.7	1981
ILC	STW	117	930.5	7.9	1966
	MTW	36	588	16.3	
	DTW	65	2392	36.8	
IFAD	STW	111	932	8.4	1995
ADBN	STW	41085	145095	3.5	1970
	DW	4511	14726	3.2	
	ARTESIAN	763	1246	1.6	
	ROWER/ TREADLE	8637	4179	0.5	
DOA					
JADP	DTW	220	7700	35.0	1970's
	STW	3743	22558	6.0	

Source: Compiled from ADBN, DOI (GWRDB), DOA (JADP) reports.

Several surveys of operational wells have indicated that although expected to serve a command area of at least 4 ha, the average command area is reportedly around 2.5 ha whilst pumping hours are low at only around 100-200 hours per year in case of ADBN tubewells. This underutilizaion of the ADBN wells derives partly from technical factors with a lack of technical guidance during construction resulting at times in poorly performing wells.

It has been reported that the existing tubewells have not been effectively utilized. Operation hours of both DTWs and STWs developed by the government agencies as well as by the farmers are discussed below.

Hours of operation of tubewell and pumps is important to find out their effective utilization.

A study of STW installed by JADP found that farmers have not utilized pump and tubewell sets more than 300 hours in a year. Likewise, pumps of JADP are operating on an average of 300 hours per year (JADP, progress Report, 1993).

The trend of STWs installed by the farmers themselves is also not encouraging. Most shallow tubewells were utilized only for the irrigation of wheat and partial irrigation of early paddy and main paddy. It is noted that farmers utilize a maximum of 250 hours/per year/per pump, which is very low in comparison to the average of 2000 hours of pump use per year in adjoining areas in India. It might be possible that most of pumps lent by ADBN have not been effectively utilized to date.

The installation of STW or DTW alone donot contribute much to increase production unless it is tied with an integrated package that includes crucial aspects like extension, credit and marketing .

2.5 Eighth Plan Policies of Groundwater Development

The basic objectives of irrigation development set out in the Eighth Plan are to: i) increase agricultrual production through the application of irrigation technologies to diverse climate and soil conditions and with the minimum detremental effects to the environment; ii) enhance the credibility of irrigation systems through improvement in the management of existing irrigation systems and iii) provide irrigation facilities in the maximum area of land by implementing economically, technically and environmentlly sustainable projects with the participation of farmers.

To achieve the above objectives, a new Irrigation Policy was promulgated by the Ministry of Water Resources in 1992. This declares that the role of the government shall focus on areas of wider national importance such as review and development of sectoral policy on irrgiation, resource mobilization, economic analysis and technological development whilst maximising the participation of the private and non-government sector in the implementation and operation of programmes for irrigation development. The policy emphaiszes sustainable and environmentally friendly utilization of irrigation water and a demand driven approach to irrigation development whereby farmers would: i) individually or collectively submit a request for tubewell facilities ii) form a Water Users Groups and Farmers Irrigation Association (representing a number of WUGs) iii) involved in all stages of irrigtion development iv) contribute a minimum of 15% of STW construction costs and v) accept responsibility for tubewell O&M upon completion of construction works. The users would also hav to provide all land required for the construction free of cost. Present government policy supports investment in irrigation infrastructure through capital subsidies which for groundwater development range from 40% fro an individual private shallow tubewell to 85% for community shallow tubewell (BLGWP, 1994).

Other significant provisions of the new Irrigation Policy are i) a 20% representation of women on all executive orans of farmer organizations; and ii) responsibility for delivering agri-inputs as per the damand of farmers with DOA and other relevant agencies.

The Eighth Plan envisaged to provide irrigation facility in 293895 ha land both from the new and ongoing irrigation projects. The total physical target of the under construction projects included in the plan was 135250 ha of which 120690 ha is to receive irrigation by fiscal year 1996/97. The proposed new projects with a total physical target of 81400 ha to be initiated during the plan period were to be implemented with a view to provide irrigation facility to 39292 ha within the plan period. The irrigation development program to be implemented through ADBN has been estimated to provide irrigation facility to 119700 ha during the plan period.

The Plan also states to provide irrigation facility in 132763 ha through irrigation projects of short gestation period. Similarly, 52650 ha land has been planned to be under irrigation through ILC and ISP. Of the total irrigation target set in the Eighth Plan, the large and small irrigation projects were to cover 108482 ha and 185413 ha respectively.

The area to be irrigated by underground irrigation projects in the Eighth Plan period is put at 87790 ha. To achive this target, the plan emphasizes the development of different groundwater irrigation projects. The BLGWP is estimated to provide irrigation facility in 12200 ha during the Eighth Plan. The ILC Project has also target of irrigating 8750 ha land from groundwater systems. Other undergound irrigation projects intended for implementation during Eighth Plan are: i) Mahottari Deep Tubewell Irrigation Project (8000 ha), Sunsari-Morang-Jhapa Tubewell Irrigation Project (11000 ha), Birjung Groundwater Irrigation Project (8000 ha), Community Tubewell Development Project (1000 ha), Eastern Terai (Morang) Irrigation Project (7000 ha). The Plan also lays emphasis ÿn groundwater development through groundwater schemes to be implemented by ADBN.

2.6 Ground Water Development in Ninth Five Year Plan

Importance of Ground Water Irrigation has been realized from the very beginning of periodic plans in Nepal. The Ninth Five Year Plan which is going to commeće from mid July 1997 has also given high priority to this component. Even in the Agriculture Prospective Plan (APP), irrigation has been identified as one of major inputs for agriculture development. Irrigation palys a vital role in crop diversification and crop intesification which ultimately will help increase productivity.

It is learnt from DOI that the Plan has invisaged to place high priority to those projects which could be managed and maintained by the farmers themselves. As a result, special focus has been put forward to private and community shallow tubewell development in the Terai region.

2.6.1 Major objectives of the Plan

- to remove the dependency on nature and bring about the certainety on year round irrigaion facility;
- to implement cost effective irrigation schemes;
- to make maximum people's participation in the progammes;
- to implement environment friendly irrigation schemes;

2.6.2 The Policy guide lines for GW system development

- Deep and Shallow tubewells programmes to be launched to avail the irrigation facilities in Terai;
- GW systems that are being managed by HMG to be handed over to the farmers;
- Identification of feasible projects with the participation of the user's groups and carry out detailesd studies;
- Appropriate technology on STW schemes to be developed;
- As envisaged by the Irrigation Policy 2049 (first amendment 2053), the programme to be launched by providing necessary subsidy and loans from banks and NGOs;

The Plan has put target of achieving area coverage of 100,000 ha under GW systems and 191000 ha under surface irrigation systems within its plan period.

CHAPTER - III

PERFORMANCE OF GROUND WATER (GW) PROJECT

3.1 Status and Potentiality varification of GW Schemes

The variation between reported and actually running numbers of GW schemes has been found. The variation of individual (ADBN) shallow tubewell was caused due to replacement of tubewell after 10-12 years of installation. The total actual no.of STWs were deviated from reported number by 7% due to installation failure and the number of actually running STW were deviated from reported number by 14%. Likewise the failure cases of DTW has found about 5%. So the actually running numbers of DTW was less by 17% from reported numbers. It was found that about 30% DTWS installed by JADP were nonfunctional. The optimum failure cases of DTW has been encountered in Dhanusha district. Agencywise status of different types of GW schemes is given in table 3.1 below.

Table 3.1:
Summary of Status by Agency and Tubewells of Surveyd Duistricts

Type of GW Scheme	Agency	Number of GW Schemes				Ground Water Potentiality		
		Reported	Replaced/ Failure	Actual	Actually Running	Total	Used	Unused
STW	ADBN	22735.0	1368.0	21366.0	20938.0	345859.0	24795.0	321064.0
	DOI							
	ILC	338.0	4.0	239.0	214.0	0.0	0.0	0.0
	IFAD	29.0	5.0	24.0	20.0	0.0	0.0	0.0
	DOA							
	JADP	1763.0	236.0	1527.0	247.0	0.0	0.0	0.0
TOTAL		**24865.0**	**1613.0**	**23156.0**	**21419.0**	**345859.0**	**24795.0**	**321064.0**
DTW	DOA							
	JADP	160.0	10.0	150.0	68.0	1070.0	212.0	858.0
	DOI							
	ILC	83.0	2.0	81.0	72.0	706.0	71.0	635.0
	GWRDB	30.0	0.0	30.0	19.0	0.0	0.0	0.0
	BLGWP	174.0	11.0	163.0	163.0	231.0	176.0	55.0
	SIRDP	12.0		12.0	11.0			
	SETI	25.0		25.0	22.0			
TOTAL		**484.0**	**23.0**	**461.0**	**355.0**	**2007.0**	**459.0**	**1548.0**
	DOI							
MTW	ILC	14	0	14	12			

Source: Progress Report of DOI, ADBN, DOA (JADP).

Nepal's terai is rich in ground water potentiality. Out out total potentiality of STW only 7% was used. Similarly 23% potentiality of DTW was used. Taking in to consideration the above facts, it is clear that the huge ground water potentiality remains still unused and future prospect of ground water development in terai is bright.

3.2 Technical Aspect

Technical aspect of the study has covered the installation details comprising of well specification of GW schemes, physical condition of existing GW schemes, water distribution system and drilling technologies adopted in various GW schemes, utilization of water. operation and maintenance situation and sustainability of GW project in comparision to surface irrigation schemes.

3.2.1 Installation details of GW Schemes

The rich potentiality of Ground Water of Nepal's Terai has been exploited by various type of GW schemes depending upon depth of well installed, type of aquifer tapped, static water level and size of well installed. Flowing artesian wells were installed in confined aquifer where piezometric water level is higher than the ground level. The size of such artesian well has been noted 1.5"-2" dia. in case of manually drilled well and 6"-12" in case of deep machine drilled wells. Deep tubewells were installed at the depth of more than 100m and the tubewell installed at the depth upto 100m in confined aquifer with machine drilling technology was categorized as medium tubewell. A shallow tubewell was obviously a tubewell installed at the depth upto 60m tapping shallow quifer.

3.2.1.1 Installation

Various factors govern the life of a tubwell. The effective life of a tubewell either manually drilled or machine drilled depends on type of material used, well design, and its installation, operation and timely maintenance, and definitely on the skill of installer and drilling technology. About 67% deep tubewells (DTW) and 22% shallow tubewells (STW) were found in operation for more than 10 years. Likewise 50% medium tubewells (MTW) and 56% STWs were found in operation for less than 5 yrs. Manually drilled artesian wells (ATW) were found operating 50% of below 5 yrs. and 50% morethan 10 yrs. (refer table 3.2.1.1).

Table 3.2.1.1
Installation of GW Schemes

Type of GW Scheme	No.of Sample (no)	Duration of Operation			Time taken to install a well (days)	No.of man-power used (MD)
		>5 yrs. (%)	6-10 yrs (%)	>10 yrs (%)		
ATW	2	50	0	50	7	10
DTW	12	25	8	67	40	13
MTW	2	50	50	0	28	NA
STW	31	56	22	22	5	6

Source: Field Survey.

Working days required to install a tubewell varied from 5 days/tubewell for STW to 40 days/tubewell for DTW. Likewise the manpower needed per day in installation period was varied from 6 to 13 MD for STW and DTW respectively (refer table 3.2.1.1).

3.2.1.2 Well Specification

Technical parameters of different types of tubewell installed in Terai has been studied. Size of well, depth of well, static water level (SWL) tubewell's discharge capacity, use of casing and screens and thickness of aquifer were the main parameters which were taken under study.

Tubewell of various sizes ranging from 1.5"dia. to 12" have been installed depending upon the transmitting capacity of aquifer and purpose of installation. Productive DTW's were installed with the size of 8"-12" and whereas investigating once with 16"-8" dia. meter. The diameter of medium tubewells were found to be 8". A standard 4" diameter shallow tubewell was commonly used in terai. Besides that, smaller sized manually drilled STWs of 1.5", 2" and 3"dia were also introduced in Chitwan and Bara districts. Manually drilled artesian wells with 1.5" diameter were common in Dhanusa and Rupandehi districts (refer annex IV).

Table 3.2.1.2
Well Specification

Type of GW Scheme	Size of well (inch)	Depth of well (m)	Static water level (m)	Discharge (lps)	casing length (m)	Screen length (m)	Aquifer thickness (m)
ATW	1.5-2	78.5	0	0.5	17.25	2.25	4
DTW	6-12	124	26.2	26.6	92.5	31.5	32
MTW	8	68.5	NA	15.5	60.5	8.0	9.5
STW	1.5-5	17.8	3.45	12.73	12.25	5.55	5.68

Source: Field Survey.

Average depth of STW has been found to be about 18m where as the depth of DTW and MTW has come to be 124m and 68.5m, respectively. Depth of different types of tubewell varied from district to district. Minimum depth of STW (7.5m) was noted in Nawalparasi district when maximum depth of 38m noted in Jhapa district. Likewise deeper tubewell of 205m was noted in Banke district (refer annex IV).

Static water level (SWL) of shallow aquifer fluctuates heavily in comparision to deep confined aquifer. Average SWL of shallow aquifer was noted 3.45 m when SWL of deep aquifer was at the depth of 26.2m. (refer table 3.2.1.2). Wide range of aquifer thickness of different types of wells were found. The shallow aquifer to 12m thick of Siraha district was thicker and richer than the average thickness of aquifer (6m) of medium tubewell of Nawalparasi district.

There were no considerable differences noted in discharge rate of STW and MTW. The discharge rate of former was 12.7 lps and latter 15.5 lps, respectively. Average discharge of 26.6 lps of DTW was not found fairyly good in comparison to the discharge of STW due to its vast difference in initial investment.

Length of casing and screen used was depended on aquifer thickness and depth of well. Average length of casing and screen was found 12m and 6m respectively for STW and 94m and 31m for DTW.

3.2.2 Physical Condition of GW-Schemes

Overall physical condition of different types of structures eg. tubewell, water lifting device, canal and ditches of GW schemes has been observed during field visit. No considerable damages have been encountered and the structures were found satisfactory in general.

The overall physical condition of tubewell has been found good enough except minor case of breakdown of water lifting devices (pumpsets) and leakage in gate value in case of DTW (See table 3.2.2). Breakdown of pumpsets and leakage in gate valve were caused due to lack of proper and timely maintenance. Such cases were found mainly in community schemes.

Table 3.2.2
Physical Condition of Irrigation Structures

Type of GW Schemes	Tubewell			Canal			
	Good (%)	Satisfactory (%)	Bad (%)	No.applicable (%)	Good (%)	Satisfactory (%)	Damaged heavily (%)
ATW	100	0	0	50	50	0	0
DTW	82	18	0	0	27	27	36
MTW	100	0	0	0	50	50	0
STW	100	0	0	75	25	0	0

Source: Field Survey.

There was no water conveyance structures constructed in most of the individual STW schemes (75%) because the tubewells were installed directly in the farmers farm land and there is no need of conveying water. The physical condition of open field channel constructed in deep tubewells were found not satisfactory. About 36% of field channel of DTW were damaged heavily and only 27% of them were in good condition. The heavy damage of field channel and lack of timely maintenance has caused low area coverage by DTW.

A piped water conveyance system was introduced to reduce the water losses during conveyance to farmer's field.

3.2.3 Water Distribution System

Mainly two types of water distribution systems were found in practice i.e. open channel and burried piped system. Burried piped distribution system has been introduced recently in deep and medium tubwells by Bhairahawa Lumbini Ground Water Irrigation Project, (BLGWP) and Kapilvastu Tubewell Project, Butwal (KTP) under its Irrigation Line of Credit (ILC) project, showing its comparative advantage of saving agricultural land to be used in field channel construction and reducing conveyance losses due to leakage and evapotranspiration in comparision to open field channel system irrespective of cost increment by 25-30%. This system also did not seem free of defects. The repair and maintenance of burried piped system may be difficult to the farmers in case of pipe blockage with silt deposited inside it and in case of pipe replacement without technical knowledge of farmers after the system handed over to the farmer's management.

Table 3.2.3
Water Conveyance System

Type of GW Scheme	Type of Conveyance System				Length of System			Water Losses	
	NO (%)	Lined (%)	Earthen (%)	Piped (%)	Lined (%)	Earthen (%)	Piped (%)	High (%)	Negligible (%)
ATW	50	0	50	0	0	10	0	0	100
DTW	6	63	19	12	1000	40	1373	45	55
MTW	0	67	33	0	600	20	0	0	100
STW	75	6	19	0	28	13	0	10	90

Source: Field Survey.

Most of the medium and deep tubewell have lined field channel which has come to be 67% and 63% respectively. 50% artesian wells have no distribution system and remaining 50% have earthen field channel of about 10m long per tubewel in an average. The average length of lined field channel of DTW and MTW came to be 1000m and 600m respectively. Only 19% of STW have earthen field channel. 12% of DTW has introduced piped distribution system (refer table 3.1.3). Average length of piped system has come to be 1373m per tubewell.

While talking about the water losses, maximum conveyance losses (45%) was noted in DTW due to damage of field channel. Remaining 55% of DTW has negligible losses through conveyance system. Most of the STWs (90%) have negligible water losses found because they did not require conveyance system at all.

3.2.4 Utilization Situation of GW Scheme

The practice of water sharing with neighboring farmers existed only in individually owned STW because the discharge of STW is more than enough to irrigate owners land and to sell the water to others. But the water sharing possibility is very limited. Most of the individual STWs were under utilized because of small and fragmented land holding of tubewell owner and land holding was very low with respect to tubewell capacity. There was no practice of water sharing in community MTW and DTW because the tubewells were designed in such a way that the capacity of tubewell is just enough to irrigate the project's command area. About 42% of irrigated area was covered by rent out in STW scheme (see table 3.2.4)

Table 3.2.4
Tubewell Utilization Situation

Type of GW Scheme	Irrigated Area			Operating Hours			Efficiency Tubewell (Hrs./ha)
	Own (Ha)	Rentout (Ha)	Total (Ha)	Own (Ha)	Rentout (Ha)	Total (Ha)	
ATW	0.7	0.15	0.85	-	-	-	240
DTW	21.4	0	21.4	345	0	345	9.7
MTW	11.65	0	11.65	288	0	288	11.6
STW	2.1	1.5	3.6	165	35	200	14.8

Source: Field Survey.

Very low operating hours of tubewell has been noted irrespective of type of scheme. The annual operating hours of deep and medium tubewell has found considerably low because of high cost of operation, unavailability of spareparts, in effectiveness of water users' group and lack of intime repair and maintenance of water distribution system. Low annual operating hours (345 hrs) of deep tubewell was also caused due to damage of field channel and frequent break down of water lifting devices. The annual 200 hrs of operation of STW scheme was also not satisfactory. It is because the farmers used to operate the tubewell just to meet the emergency need for supplementary irrigation. Low cropping intensity was also the cause of low operation of tubewell. Lowest operating hours (only 105) of tubewell has been found in Dang-Deukhuri district. (see annex VI).

Manually drilled 1.5'dia artesian well has lower utilization rate of 240 hrs to irrigate a hectare of land because of its low discharge of 0.5 lps. The utilization rate (9.7 hrs/ha) of DTW did not seem attractive in comparision to utilization rate of STW which was 14.8 hrs/ha.

3.2.5 Drilling Technology and Material Used

Various types of indgeneous drilling technologies eg. sludge, bogi, thokuwa and manual rotary were used in STW installation. Construction of MTW and DTW was confined in machine drilling technology. Selection of drilling technology basically depends on type of well, depth of well and subsurface formation. Each drilling technology has its own advantages before other technologies.

Sludge boring method was very common in STW installation with its comperative advantage of easiness, simplicity and cost effectiveness. This method is capable to drill a hole with a diameter of 200mm suitable to install a 4"dia tubewell at the depth up to 60m. Difficulty in penetrating gravel and hard formtion are the main distadvantages limiting the use of this technology. A multilayered sandy formation is also not comfortable to this method.

Another most common manual drilling technology used in Terai STW installation is Thokuwa method. The driling capacity of this method is limited to 20m depth. It is a only one manual drilling method capable to penetrate hard formation. Low drilling depth and limited size of well ie upto 4" dia are the main constrants to its wide use. Besides these limitation this method is widely used in northern part of Nepal's terai.

Bogi is not a common drilling technology used in Terai.. This technology is in practice in western districts and in some extent in Nawalparasi and Rupandehi districts. This method is similar to percussion drilling and capable to lift gravel from the depth of 60m. The advantage of this method is its capability to drill safely in multilayered sandy formation.

Manual rotary drilling technology is similar to Rotary Rig operated manually. It has advantage of achieving greater depth upto 80m. This method is capable to drill upto 150m depth to install 1.5"dia tubewell. Difficult to penetrate hard formation is the only disadvantage of this method.

Rotary Rig has technical advantages in comparison to manual drilling technologies of achiving greater depth, larger hole size, and capability to penetrate hard formation. High cost, requirement of skilled manpower and difficulty in penetrating pebbles, cobles and boulder are the defficiencies of this technology. Percussion rigs which are suitable to pentrate coarse gravel formation, were not found in practice. Furthermore a drilling through driving DTH technology suitable to drill in boulder formation was also not introduced in terai except manual thokuwa method.

Table 3.2.5.1
Drilling Technology and Type of Aquifer

Type of GW Schme	Drilling Technology					Tyupe of Aquifer			
	Sludge (%)	Thokuwa (%)	Bogi (%)	Manual Rotary (%)	Rotary Rig (%)	Sand (%)	Gravel (%)	Boulder (%)	Information not avai. (%)
ATW	50	0	0	50	0	0	100	0	0
DTW	0	0	0	0	100	50	0	0	50
MTW	0	0	0	0	100	8	0	0	92
STW	50	22	16	6	6	41	31	9	19

Source: Field Survey

Almost 50% and 22% of STW were installed by sludge and thokuwa boring methods respectively while the use of Rig machine for installation of STW was only 6%. DTW and MTW were installed only by Rotary Rig machine due to limitation of manual drilling technology to achieve greater depth. Most of the STW (41%) were installed in sandy aquifer. Likewise, about 50% DTW were found being installed in sandy aquifer with gravel packing. Only 31% STW had used gravel aquifer. The information regarding aquifer type of MTW could not be available (refer table 3.2.5.1)

One of the factor affecting life of tubewell is the type of material used to install a well. Most of the machine drilled tubewells have mild steeel casing. Mild steel (MS) casing was also common in STW installation. The percentage of use of MS casing was 75 (see table 3.2.5.2). The use of HDP pipe as casing in STW was introduced in various districts mainly in Bara. Use of bamboo casing is rare now (see table 3.1.5.2).

Table 3.2.5.2
Material Used in GW Scheme

Type of GW Scheme	Casing Pipe				Screen					Gravel Packing	
	MS (%)	BB (%)	HDP (%)	GI (%)	BS (%)	SL (%)	PF (%)	NL (%)	CR (%)	Yes (%)	No (%)
ATW	0	0	50	50	0	0	100	0	0	0	100
DTW	100	0	0	0	0	80	20	0	0	100	0
MTW	100	0	0	0	0	50	0	0	50	100	0
STW	75	3	16	6	7	32	36	16	7	6	92

Source: Field Survey.

Note: MS = Mild Steel, BB = Bamboo, HDP = High Density Polyethelene Pipe,
GI = Galvanized Iron, BS = Bamboo Strainer, SL = Slotted Pipe,
PF = Perforeted Pipe, NL = Nylon Net Strainar, CR = Coir Strainer.

Selection of screen should depend on type of aquifer where the screen is placed. Use of slotted pipe strainer with gravel packing was very common in machine drilled wells even in sandy aquifer. The slotted pipe and perforated pipe strainer was found equally used in STW installation. The use of Nylon net strainer and coir strainer was very common at the very strarting of GW development. The technological development has limited the use of such nylon and coir strainer now a days.

Most of the STWs were found not packed by gravel showing the reason that the screen was selected to suit the available aquifer which did not require gravel packing. Gravel packing was the pre requisite for machine drilled wells.

3.2.6 Operation and Maintenance Situation

The operation and maintenance of individual tubewell was satisfactory in comparision to community owned well. The O&M situation of agency managed systems which were recently handed over to water user's group (WUGs) was found not satisfactory due to ineffectiveness of WUGs.

3.2.6.1 Ownership and Operation of GW Scheme

Most of the individual STW schemes were operated by owner himself except few cases. 87% STWs were owned by individuals where DTW and MTW were totaly community owned. 60% of STW were operated by owner and 40% by operater. DTWs and MTWs were totally operated by operator in most cases appointed by the project itself (refer table 3.2.6.1)

Table 3.2.6.1
Owner and Operation of GW Scheme

Type of GW Schme	Ownership of Scheme		Operation of Scheme		Technical Knowhow	
	Individual (%)	Community (%)	Owner (%)	OPerator (%)	Selficient (%)	Insufficint (%)
ATW	100	0	NA	NA	NA	NA
DTW	0	100	0	100	18	82
MTW	0	100	0	100	0	100
STW	87	13	60	40	16	86

Source: Field Survey.

Technical knowhow of operator evenif it was owner himself was not enough for minor maintenance also. They were only able to operate the machine. Proper training to the operator appeared lacking.

3.2.6.2 Repair and Maintenance Facility

Availability of repair and maintenance facility and spare parts was found relatively good in STW scheme because those were equiped with Indian diesel engine driven pumpset. The repair and maintenance and spare parts of diesel pumpset is not a problem to the farmer because this facility is available in the local market (see table 3.2.6.2).

Table 3.2.6.2
Repair and Maintenance Facility and Availability of Spareparts

Type of GW Scheme	R&V Facility		Requency of R&M (Times)	Spareparts	
	Available (%)	Not Avialable (%)		Available (%)	Not Avialable (%)
ATW	NA	NA	NA	NA	NA
DTW	91	9	0.6	36	64
MTW	100	0	0	100	0
STW	97	3	0.6	70	30

Source: Field Survey.

The repair & maintenance and spareparts of DTWs were being arranged by the project. The repair and maintenance and arrangements of spareparts for the huge foreign made diesel engines was major probem.

3.2.6.3 Energy Needs

Most of the tubewells were equipped with diesel engine driven pumpsets. 40% DTW and 97% STW have diesel engine used as primeover. 60% DTW and total MTW were equiped with electric submersible pumpsets. So the energy needed to operate the GW scheme was primarily the diesel fuel and secondarily electricity. Gasoline pumpset operated with kerosene was also being introudced in smaller size (1.5"-3") STW (see table 3.2.6.3).

Table 3.2.6.3
Water Lifting Devices Used

Type of GW Scheme	Type			Capacity						
	Diesel (%)	Gasoline (%)	Electric (%)	Diesel			Gasoline	Electricity		
				<5 hp	5-8 hp	<8 hp	<3 hp	<25 hp	26-5- hp	>50 hp
DTW	40	0	60	0	0	100	0	25	50	25
MTW	0	0	100	0	0	0	0	100	0	0
STW	97	3	3	22	72	6	100	0	0	0

Source: Field Survey

Diesel pumpsets used in DTW were found in more than 8 HP capacity upto 102 HP while 72% of diesel pumpsets used in STW were at the range of 5-8 HP. 50% electric pumpset used in DTW had fallen on 26-50 HP range while 100% electric submersible pump used in MTW was of below 25 HP.

3.2.6.4 Operation and Maitenance Cost

The O&M cost accumulates the operating cost of GW scheme, remuneration to operator, and repair & maintenance cost. Actual O&M cost was calculated considering the all cost incurred in operation and maintenance and deducting the revenue collected from rent out of water and charges collected from the farmers (see table 3.2.6.4).

Table 3.2.6.4
Operation and Maintenance Cost

Type of GW Schme	R&M Cost (Rs)	Operating Cost (Rs)	Remuneration to Operator (Rs)	Total O&M Cost (Rs)	Revenue from rentout/ farmers (Rs)	Actual Cost of O&M (Rs)
ATW	NA	NA	NA	NA	NA	NA
DTW	1675	21877	5713	27590	9972	17618
MTW	0	8006	2219	10225	0	10225
STW	691	2977	668	4335	1618	2217

Source: Field Survey.

Above table shows that the actual O&M cost Rs 17618 per annum for DTW is not alarming in comparision to command area but the low operating cost caused by low operating hours of tubewell (only 345 hrs annually) appears unsatisfactory.

3.3 Discharge and Area Coverage

The decreasing trend of tubewell discharge mainly in artesian well has been encountered. As a result, either water lifting device was being used to pump water or a shallow tubewell was installed near the deep artesian well to cover the command area. The variation of discharge in winter to summer occured due to water table fluctuation. Decreasing in discharge of deep and medium tubewell lead to low area coverage. The area coverage by an individual STW was found relatively low with respect to tubewell capacity due to small and fragmented land holding of tubewell owner, low cropping intensity and marketing problem. Lack of motivation, inadequate support services, lack of coordination between line agencies, relatively high cost of operation and maintenance and ineffectiveness of water user's group in case of community wells were the reasons of low area coverage per tubewell.

3.3.1 Designed/reported Vs Actual Discharge

Deviation in actual discharge from designed or reported figures has been encountered. Positive deviation of actual discharge upto 112% from reported discharge of STW was encouraging in comparision to the negative deviation of discharge of MTW and DTW upto 35% (seee table 3.3.1).

Table 3.3.1
Discharge Situation

Type of GW Scheme	Designed/Reported discharge (lps)	Actual Discharge		Deviation (Suimmer) discharge (%)	Sufficiency of Discharge	
		Winter (lps)	Summer (lps)		Sufficient (%)	Not Sufficient (%)
ATW	1.0	0.6	0.5	-50	50	50
DTW	41.2	28.1	26.6	-35	55	45
MTW	24.0	17.0	15.5	-35	0	100
STW	6.0	13.1	12.73	+112	100	0

Source: Field Survey.

The discharge of a well was high in winter in comparision to summer due to rise in water table in winter. The increase in tubewell discharge during winter season was noted at the range of 3-10%.

3.3.2 Designed/Reported Vs Actual Command Area

The actual situation of area coverage was found different than reported. The actual area coverage was 37% lower on an average. Maximum deviation (57%) of area coverage was found in manually drilled ATW because of reduction in discharge. Another considerable deviaiton (47%) of area coverage was found in DTW schemes. That was because of inadeauate discharge of tubewell to cover designed command area and ineffectiveness of WUGs in operation and maintenance of the system. The negative deviation of area coverage of MTW and STW which came to be -12% and -16% respectively was not so remarkable. So there is no need to be worried about it.

Table 3.3.2
Area Coverage Situation

Type of GW Scheme	Designed/Reported (Ha)	Actual (Ha)	Deviation (%)
ATW	2.0	0.85	-57.5
DTW	40.4	21.4	-47
MTW	13.25	11.65	-12
STW	4.3	3.6	-16

Source: Field Survey.

Variation of area coverage in winter and summer depends on the cropping pattern and cropping intensity adopted by the farmers. The experience shows that the cropped area in winter is always less than cropped area in summer. It is not because of inadequate discharge in winter but because of cropping system and unawarness of farmers.

3.4 Sustainability of Ground Water Systems

Followings are the major bases on which the sustainability of any Ground Water Irrigation project depends :

- Investment cost
- Operation and Maintenance Cost
- Project Life
- Operation and Management
- Efficiency of the supportive services
- Repair and Maintenance facilities

3.4.1 *Investment Cost*

Based on the field survey, the average investment cost of a DTW was found to be Rs.19,65,300 and Rs.35600 for a STW.

3.4.2 *Operation & Maintenance Cost*

The cost of Operation and Maintenance of DTW and STW was found to be Rs.17273 and Rs.2718, respectively. The O. & M. cost of Agency managed DTW was not included in the maintenance costs.

The average Replacement Cost of DTW and STW was found to be Rs.1166 and Rs.2323, respectively. The Replacement Cost of DTW includes replacement cost of pumpset, whereas in case of STW it includes replacement cost of strainer and its installation cost. The details are presented in the Table below.

However, the rehabilitation cost of the GW schemes was found to be negligible.

Table: 3.4.
Cost of GW Schemes

Type Of GW Schemes	Total Project Cost	Annual O & M Cost	Replacement Cost
1. ATW	9100	-	-
2. DTW	1965300	17273	1166
3. MTW	480000	10225	-
4. STW	35600	2718	2323

3.4.3 *Project Life*

The life of the GW project depends on materials used, well design and workmanship of installing personnel. In the course of field survey it was found that some of the sample DTWs have been functioning successully for over 20 years and STWs - over 10 years.

3.4.4 *Operation & Management*

It was found that the status of operation and management of STWs have been comparatively more efficient than that of DTWs. The user's committees formed for the overall operation and management of Community projects (usually DTWs) were not functioning successfully.

3.4.5 Repair and Maintenance Facilities

Repair and Maintenance facilities for large scale deep tube-well systems and their accessaries such as imported pumpsets are difficult to find in the country. Hence, there are a number of sample tube-wells that were found lying idle due to non availability of spare parts. On the contrary, the shallow tube-wells and their accessaries are easily available in the country. Thus, in terms of repair & maintenance and availability of spare parts, the STWs are comparatively more substainable than DTWs.

3.4.6 Comparative Advantage

The GW irrigation systems have comparative advantage over surface irrigation usually the water from the GW systems are available year round and can be used in growing all types of crops. The surface irrigation systems generally are seasonal in nature and vulnerable to flood damage.

3.5 Socio-economic Impacts

One of the major objectives of the study was to assess the socio-economic changes brought after the installation of Ground Water (GW) irrigation systems and compare them with that of without-project situations (ie. before project). The major socio-economic characteristics that have been scrutinized during the study consisted up of Ethnic composition, Landholding size, Income and Expenditure situation. Similarly, a basic agricultural scenario in terms of Cropping patterns and Cropping intensity and Crop yields, etc. has also been dealt upon. The data and information derived from the field survey have been duly compiled and analyzed as the following.

3.5.1 Beneficiary Households

Altogether 59 households from ten districts (Table 2) were selected for administering the questionnaire (Annex I). These samples represented all developing regions, of both Terai and Inner terai and tube-wells by type.

3.5.1.1 Ethnic Composition

The sample population of the surveyed area is broadly divided into four major ethnic groups, namely Brahmins, Chhetries, Baisyas and Sudras. Ethnically, the Baisya (58%) topped the list of people installing GW systems, followed by Chhetries (51%), Brahmins (49%) and Sudras (30%). The details are presented in the table-3.1 below.

Table-3.5.1
Ethnic composition of the sample population

Sn	Districts	No. of Samples	Composition				
			Brahmin	Chhetri	Baisya	Sudra	Total
1	Kailali	14	43%		57%		100%
2	Banke	2		100%			100%
3	Dang	4		50%	50%		100%
4	Rupandehi	14	8%	7%	85%		100%
5	Nawalparasi	7	71%		14%	14%	100%
6	Chitwan	1	100%				100%
7	Bara	2			50%	50%	100%
8	Dhanusha	4			75%	25%	100%
9	Siraha	2			100%		
10	Jhapa	9	22%	45%	33%		100%
	Total	59					
	Avg		49%	51%	58%	30%	100%

3.5.1.2 Land holding

An average size of landholding in the surveyed area is computed in hectare and presented in Table-3.2. The irrigated landholding among sampled households increased from 0.49 ha to 1.31 ha after the installation of the tube-wells. Consequently, the average un-irrigated landholding per sampled household decreased from 1.76 ha to 0.89 ha at the same period.

Table-3..5..2
Average Land holding of the sample population

S. No	District	No.of Samples	Irrigated (Ha.)		Unirrigated (Ha.)		Working Days Per Yr.
			Before	After	Before	After	
1	Kailali	14	0.33	2.00	3.07	1	240
2	Banke	2		1.00	2.00	2.00	150
3	Dang	4		0.28	0.27	0.36	150
4	Rupandehi	14	0.15	2.05	3.53	1.73	227
5	Nawalparasi	7	0.48	1.30	1.05	0.23	150
6	Chitwan	1		1.33	1.33	0.50	140
7	Bara	2		1.83	2.20	0.50	210
8	Dhanusha	4		0.38	1.00	0.50	225
9	Siraha	2		1.07	0.87	0.73	180
10	Jhapa	9	1.00	1.87	2.33	1.00	185
	Total	59					
	Avg		0.49	1.31	1.76	0.89	185.70

3.5.1.3 Working days

It was found that the average annual working days of the sampled households was 186. This indicates that only half of the annual working days has been utilized in agricultural activities.

Moreover, small size of land holding is not sufficient enough to generate full employment for the family. Since the production is not sufficient to support households for the whole year, some of the sample population were found engaged in activities other than agriculture (paid labour, small business and trading, etc.).

3.5.2 Land Ownership

Almost all of the sampled respondents had their own land. In case of shallow tube-well, the nature of the project itself does not allow the landless or tenants to be included in the scheme, ie. the tube-wells can be installed only on own land. The community deep tube-wells might have some tenant users as well, but they could not be entertained due to the lack of the adequate information.

3.5.3 Agricultural Performance

Agriculture is the main occupation of the sample population and is the major source of livelihood.

Irrigation is so important for agriculture that its performance is largely dependent on it. Irrigation is one of the most important component for the successful agriculture. Use of all other inputs such as improved seeds and fertilizers depends on continuous and assured source of irrigation water.

The introduction of irrigation system have brought positive changes in terms of cropping patterns, yields. Since improved crop varieties respond well and give higher yields under irrigated conditions, farmers ÿave started using more fertilizers and plant protection materials after the installation of the tube-well.

Irrigation alone cannot bring remarkable changes in gross farm production. It has to be closely tied with other packages such as extension and credit support and linkages to the market.

3.5.3.1 Cropping Patterns

Installation of GW systems has helped in changing the traditional (rain-fed) cropping patterns in the surveyed area. The farmers got easy access to the irrigation water, and are able to carry out agricultural activities on time and adopt modern agriculture technology. Which in turn. gave rise to higher crop yields and cropping intensity.

Table-3.5.3
Cropping patterns in the sample districts

Sn	District	No. Of Samples	Cropping Pattern		Cropping Index	
			Before	After	Before	After
1	Kailali	14	Pdy-Len-Mus Pdy-Wht	Pdy-Wht-Mus/Veg Pdy-Grm-Mze Sugarcane	133%	200%
2	Banke	2	Pdy-Wht/Mus Mze-Mus	Pdy-Wht/Mus Mze-Mus	130%	145%
3	Dang	4	Pdy-Wht/Mus	Pdy-Wht/Veg Cotton	215%	248%
4	Rupandehi	14	Pdy-Wht/Mus Mze-Pulses	Pdy-Wht/Veg Banana	142%	164%
5	Nawalparasi	7	Pdy-Wht/Mus Pdy-Len	Pdy-Wht/Mus Pdy-Wht/Veg Sugarcane	140%	168%
6	Chitwan	1	Pdy-Wht Mze-Pdy	Pdy-Wht Mze-Pdy	227%	227%
7	Bara	2	Mze-Pdy-Wht Mze-Pdy-Wht/Len	Mze-Pdy-Wht/Veg Mze-Pdy-Wht/Len	150%	156%
8	Dhanusha	4	Pdy-Wht/Len	Pdy-Wht/Len/Veg	158%	170%
9	Siraha	2	Pdy-Mil Tobacco	Pdy-Wht/Mil Tobacco/Oilseed(Niger)	106%	141%
10	Jhapa	9	Pdy-Wht/Mus Jut-Pdy-Wht Tea(Perm.)	Pdy-Wht/Mus/Veg Jut-Pdy-Wht Tea(Perm.)	144%	161%
	Total	59				
	Avg				154%	178%

NOTE :

PDY	: PADDY	MUS	:	MUSTARD	
WHT	: WHEAT	MIL	:	MILLET	
MZE	: MAIZE	VEG	:	VEGETABLES	
LEN	: LENTIL	JUT	:	JUTE	

In Kailali district for instance, farmers used to cultivate paddy by broadcasting due to scarcity of reliable source of water for irrigation. With the availability of water from GW systems, farmers nowadays prepare seed-beds on time so as to carry out transplantation without any hitch. Furthermore, kitchen gardening is increasingly becoming popular among Tharu community.

Besides, some of the enterprising farmers in the sample districts are found engaged themselves into growing high value crops, such as vegetables in Kailali, Dang, Rupandehi, Bara, Dhanusha and Jhapa; banana in Rupandehi and Siraha; oil seeds (niger) in Siraha; sugarcane in Kailali and NawaÿXlparasi.

Moreover, due to availability of water, area coverage under winter crops like wheat and vegetables increased significantly. The availability of irrigation led to practicing Paddy-Paddy-Wheat Cropping pattern. Wheat which was hardly visible in rain-fed systems before become an important crop after GW scheme installation.

3.5.3.2 Cropping Intensities

The changes in the cropping pattern after the installment of tube-wells led to the increase in cropping intensity. An average index calculated for the whole surveyed districts is 154% in before project scenario and 178% after project scenario. The highest increase was noted in Kailali district followed by Siraha, Dang, Nawalparasi and so on. Please refer to above table for details.

3.5.3.3 Yields

The comparative (before and after) yields of major crops such as paddy, wheat and maize are calculated and presented in the Table-3.5.4 below. The average yields of all the crops have increased after the installation of GW systems. But the increase is not very significant compared to the national average. The average yield of paddy, wheat and maize before the project was 2.28 mt per ha, 1.16 mt per ha, and 1.36 mt per ha, respectively. It increased to 3.48 mt per ha, 2.14 mt per ha and 1.73 mt per ha, respectively after the project.

Table-3.5.4
Average Yield of Major crops

Sn	Districts	No. Of	Yield, Ton/Ha						Varieties Used	
		Samples	Before			After				
			Paddy	Wheat	Maize	Paddy	Wheat	Maize	Local	Improved
1	Kailali	14	1.8	0.6		3.8	2.3	0.4	8%	92%
2	Banke	2	3.0	1.1	1.5	3.8	2.0	2.3	33%	67%
3	Dang	4	4.7	1.2	2.6	4.5	1.8	2.9	10%	90%
4	Rupandehi	14	2.0	1.2	1.2	3.5	1.8	1.7	30%	70%
5	Nawalparasi	7	2.7	1.0	1.3	3.9	1.8	1.5	35%	65%
6	Chitwan	1	1.2	2.4	1.5	3.0	3.0	2.4	20%	80%
7	Bara	2	1.5	0.7	0.9	3.9	2.7	1.8	25%	75%
8	Dhanusha	4	1.4	0.9		2.1	1.7		20%	80%
9	Siraha	2	1.8		0.6	3.0	2.4	1.2	30%	70%
10	Jhapa	9	2.6	1.3	1.2	3.3	1.9	1.5	27%	73%
	Total	59								
	Avg Yield		2.28	1.16	1.36	3.48	2.14	1.73	24%	76%

The highest yield of paddy was noticed in Dang and lowest in Chitwan. Whereas, in the case of wheat, highest yield is recorded in Chitwan and lowest in Kailali.

The study also revealed that 76% of the sample population used the improved seeds and rest -local.

3.5.3.4 Output marketing

An average distance of the nearest markets has been calculated in the Table-3.5.5 and it is found to be 6.7 km. The products like vegetables and grains are the major items that are marketed.

Table 3.5.5:
Distance of nearest markets

Sn	Districts	No. of Samples	Avg Mrkt. Distance (Km)
1	Kailali	14	4.5
2	Banke	2	12.0
3	Dang	4	5.8
4	Rupandehi	14	5.0
5	Nawalparasi	7	8.5
6	Chitwan	1	3.0
7	Bara	2	15.0
8	Dhanusha	4	6.5
9	Siraha	2	5.0
10	Jhapa	9	2.5
	Total	59	
	Avg		6.8

3.5.4 Family Income and Expenditure

The average on-farm and off-farm family income and expenditure computed before and after the installation of GW systems for each surveyed districts have been presented in the table-3.5.6

It showed that the average annual on-farm and off-farm incomes per household before the project were Rs.16 thousand and Rs.13 thousand, respectively. They increased to Rs.29 thousand and Rsỹ.15 thousand, respectively after the project. The total per capita income increased from Rs 5070 (US$ 89) to Rs 7456 (US$ 131) before and after the project (assuming average family size 5.7 and exchange rate Rs 57 per unit of US$).

On-farm income is generated usually by sales of vegetables, fruits and surplus grains, whereas the off-farm income is the contribution of labour works, trading and services.

Table: 3.5.6
Average family income and expenditure

(Rs '000)

Sn	Districts	No. Of Samples	Before				After				Chnages		
			On-Farm Income	Off-Farm Income	Total Income	Total Expend're	On-Farm Income	Off-Farm Income	Total Income	Total Expend're	Income	Expend.	Saving
1	Kailali	14	25.5	24.3	49.8	15.8	34.2	33.5	67.7	30.1	17.8	14.3	3.6
2	Banke	2	10.0	10.0	20.0	8.5	20.0	15.0	35.0	15.0	15.0	6.5	8.5
3	Dang	4	8.0		8.0	4.5	17.0	0.9	17.9	8.3	9.9	3.8	6.2
4	Rupandehi	14	27.0	16.0	43.0	17.0	53.0	21.0	74.0	27.0	31.0	10.0	21.0
5	Nawalparasi	7	14.0	12.0	26.0	20.0	25.0	17.0	42.0	35.0	16.0	15.0	1.0
6	Chitwan	1	6.0		6.0	12.0	20.0		20.0	22.0	14.0	10.0	4.0
7	Bara	2	15.0	7.0	22.0	22.0	35.0	12.0	47.0	25.0	25.0	3.0	22.0
8	Dhanusha	4	15.0	6.0	21.0	12.0	25.0	9.0	34.0	16.0	13.0	4.0	9.0
9	Siraha	2	5.5	3.0	8.5	4.0	12.0	5.0	17.0	7.0	8.5	3.0	5.5
10	Jhapa	9	33.0	24.0	57.0	26.0	48.0	22.0	70.0	36.0	13.0	10.0	3.0
	Total	59											
	Avg Income/Expense		15.9	12.8	26.1	14.2	28.9	15.0	42.5	22.1	16.3	8.0	8.4

The expenditure also changed as a result of increase in income. The average total expenditure has increased from Rs.14 thousand (before the project) to Rs.22 thousand (after the project). The major expenditure includes purchase of clothing, expenses on feast and festivals, schooling the children and miscellaneous household expenses.

3.5.5. Financial/Economic Indicators

The detailed financial and economic analyses of whole sampled GW Schemes could not be carried out due to lack of sufficient data and information available. As an example, the financial and economic indicators such as Benefit Cost Ratio (BCR), Financial Rate of Return(FIRR) and Economic Rate of Return (EIRR) are calculated both for STW and DTW schemes, seperately.

For the above purpose, cost of production and returns are derived on the basis of average area coverage of 3.6 ha under STW and 21.4 ha under DTW. And the average initial investment cost for STW installation is taken as Rs.32,040 and that for DTW - Rs.17,68,770. Similarly, the average O. & M. cost of STW and DTW is found to be Rs.2718 and Rs.17273, respectively.

Table 3.5.7:
Cash-Flow Projection of STW

Sn	Particulars	Without Project	With Project										
			0	1	2	3	4	5	6	7	8	9	10
A	Cash-Inflow	51620	0	87624	87624	87624	87624	87624	87624	87624	87624	87624	89226
	- Sales Revenue	51620		87624	87624	87624	87624	87624	87624	87624	87624	87624	87624
	- Salvage Value												1602
B	Cash-Outflow	43924	32040	53319	53319	53319	53319	53319	53319	53319	53319	53319	53319
	- Initial Investment	-	32040										
	- O. & M. Cost			2718	2718	2718	2718	2718	2718	2718	2718	2718	2718
	- Production Cost	43924	-	50601	50601	50601	50601	50601	50601	50601	50601	50601	50601
C	Net Cash-Flow	7696	-32040	34305	34305	34305	34305	34305	34305	34305	34305	34305	35907
D	Incremental Cash-Flow		-32040	26609	26609	26609	26609	26609	26609	26609	26609	26609	28211

Financial/Economic Indicators

1	Bcr (Discounted, @16.5%)	1.52
2	Firr	74%
3	Eirr	83%

Note : Economic Cost Is Taken As 90% Of Initial Investment

Table-3.5.8
Cash-flow Projection of a DTW Scheme

SN	PARTICULARS	WITHOUT PROJECT	WITH PROJECT														
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	CASH-INFLOW	308160		520876	520876	520876	520876	520876	520876	520876	520876	520876	520876	520876	520876	520876	520876
	- SALES REVENUE	308160		520876	520876	520876	520876	520876	520876	520876	520876	520876	520876	520876	520876	520876	520876
	- SALVAGE VALUE																
B	CASH-OUTFLOW	262960	1768770	318067	318067	318067	318067	318067	318067	318067	318067	318067	318067	318067	318067	318067	318067
	- INITIAL INVESTMENT	-	1768770														
	- O & M COST	-	-	17273	17273	17273	17273	17273	17273	17273	17273	17273	17273	17273	17273	17273	17273
	- PRODUCTION COST	262960	-	300794	300794	300794	300794	300794	300794	300794	300794	300794	300794	300794	300794	300794	300794
C	NET CASH-FLOW	45200	-1768770	202809	202809	202809	202809	202809	202809	202809	202809	202809	202809	202809	202809	202809	202809
D	INCREMENTAL CASH-FLOW		-1768770	157609	157609	157609	157609	157609	157609	157609	157609	157609	157609	157609	157609	157609	157609

Contd

SN	PARTICULARS	With Project															
		15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
A	CASH-INFLOW	520876	520876	520876	520876	520876	5818075	520876	520876	520876	520876	520876	520876	520876	520876	520876	609315
	- SALES REVENUE	520876	520876	520876	520876	520876	520876	520876	520876	520876	520876	520876	520876	520876	520876	520876	520876
	- SALVAGE VALUE							0	0	0	0	0	0	0	0	0	88439
B	CASH-OUTFLOW	318067	318067	318067	318067	318067	318067	318067	318067	318067	318067	318067	318067	318067	318067	318067	318067
	- INITIAL INVESTMENT																
	- O & M COST	17273	17273	17273	17273	17273	17273	17273	17273	17273	17273	17273	17273	17273	17273	17273	17273
	- PRODUCTION COST	300794	300794	300794	300794	300794	300794	300794	300794	300794	300794	300794	300794	300794	300794	300794	300794
C	NET CASH-FLOW	202809	202809	202809	202809	202809	5500008	202809	202809	202809	202809	202809	202809	202809	202809	202809	291248
D	INCREMENTAL CASH-FLOW	157609	157609	157609	157609	157609	5454808	157609	157609	157609	157609	157609	157609	157609	157609	157609	246048

Financial/Economic Indicators

1 BCR (discounted, @ 12%) 1.09
2 FIRR 11%
3 EIRR 12%

Note : Economic cost is taken as 90% of initial investment

The BCR is calculated from the incremental cash-flow at the discount rate of 16.5% for STW and 12% for DTW.

For calculating EIRR, the economic cost is taken at 90% of initial investment. The results, which are presented in the table below, shows that STW scheme is comparatively more beneficial than DTW.

3.5.6 Changes in the Consumption Pattern

With the availability of water for irrigation, people has started to grow different types of seasonal vegetables for sales. Besides sales, it is noted that the rate of vegetable consumption has also increased among the sample population.

On an average, 67% of the sampled respondents reported that they begun to consume more vegetables as a result of increase in availability of water. Similarly 65% of the respondents mentioned that they are eating more nutritious foods like meat, fish and milk as a result of increase in production and income.

All respondents in Bara and Dang (100%) mentioned that they consume more vegetable and eat nutritious food than before. In Rupendehi however, the response was poor (45% and 35% respectively). It may be because the GW schemes (DTWs) were installed long ago and respondents had little memory of what was the consumption pattern before the project.

Table 3.5.9:
Consumption Pattern

Sn	Districts	No. Of Samples	Eating More Veg.	Eating Nutr. Food
1	Kailali	14	45%	30%
2	Banke	2	50%	100%
3	Dang	4	100%	100%
4	Rupandehi	14	45%	35%
5	Nawalparasi	7	50%	70%
6	Chitwan	1		
7	Bara	2	100%	100%
8	Dhanusha	4	75%	25%
	Siraha	2	50%	50% 9
10	Jhapa	9	90%	75%
	Total	59		
	Avg		67%	65%

3.5.7 Crop Diversification

Water is the critical component for initiating any market oriented agriculture. The installation of GW schemes paved ways for crop diversification as per the market situation. Crop diversification is more visible around market centers. Wheat and vegetable, Banana and Papaya were the major crops that came up in the picture after the GW installation. In areas near the sugar mills, sugarcane replaced conventional Paddy-Wheat-Maize cropping pattern (Kailali. Dhanusa, Bara and Siraha districts).

Crop diversification led to crop intensification. Farmers started producing more than two crops per year from the small holding they have. Thus the same unit of land has started to give higher returns. Some of the respondents who used to buy additional grains for livelihood are now self sufficient in foods.

3.5.8 Impact on Women

After the installation of GW systems, be it private or community tube-wells, women are indirectly benefitted from them. In the course of field study, it was observed that women and children were using water from the systems for drinking, washing and bathing purposes as well.

Fetching of water for household use including watering to animal and kitchen gardening is the responsibility of women. In the area where drinking water is scarce, water from the systems has been the main source of water.

3.5.9 Marketing

The issues of agricultural products marketing have always been the topic of discussion. be it in the national level or in the local levels. The producers are always, found in the losing grounds. The field survey duly confirmed these facts. Except the crops like sugarcane and banana, all other crop products are facing the problems of marketing.

It is observed that the farmers face big marketing problems especial during the harvest seasons. Farmers are hard-pressed to sell their major product ie, Paddy immediately after harvest. The price of Paddy at this time used to be so low that it hardly cover the cost of production.

3.5.10 Level Of Perception

Besides entertaining questions on the socio-economic aspects, the sample respondents were also entertained questions to understand their perceptions towards the following issues. This was also done to verify the previous answers of the respondents.

3.5.10.1 Level of family Income

On average 81% of the respondent mentioned that their family income increased as rent of GW scheme installation. About 25% respondents of Dang, 14% from Nepalgunj and 10% from Jhapa reported that their family income remained the same.

3.5.10.2 Level of living Condition

No clear cut correlation was found in between increase in family income and increase in living condition. Of the respondents, 45 percent of them mentioned that their living condition increased while 55% of said that their level of living remained the same even after GW scheme installation.

While entertaining the questionnaire, it was realized that the respondents cannot really realize the improvement in living condition happening due to the GW scheme. This may be due to increase in the number of children after the project.

3.5.10.3 Quality of GW System

The quality of GW system was mainly related to the output of water from the GW schemes. Of the total Rs 64% mentioned it to be good, 23% excellent and 18% bad (Annex-).

3.5.10.4 Services of line agencies

Of the total respondents, 53% reported to be good, 40% excellent and 41% poor 50% Rs each from Dhanusa, Siraha, Dang and Banke reported that the F services from were poor while 60th of the Rs from Bara districts reported it to be excellent.

About 64% of the respondents mentioned that the extension support was very poor. Similarly 62% of the respondents reported the services of DOI to be poor.

Some of the respondents encountered during the field survey are found virtually illiterate on the new technology and methods of farming. Training and extension activities for initiating market oriented agriculture are found very poor in some of the surveyed area.

Table: 3.5.10
Perception about Line Agency's Services

Sn	Districts	No. of Samples	Services Of Fin. Inst.			Support Of Doi			Agri. Extn. Service		
			Excell.	Good	Poor	Excell.	Good	Poor	Excell.	Good	Poor
1	Kailali	14		57%	43%		21%	79%		43%	57%
2	Banke	2		50%	50%		50%	50%		lÿ*p-1X00%	
3	Dang	4		50%	50%		25%	75%		50%	50%
4	Rupandehi	14	22%	50%	28%	10%	20%	70%	7%	50%	43%
5	Nawalparasi	7	14%	58%	28%	14%	86%			57%	43%
6	Chitwan	1									
7	Bara	2	100%							50%	50%
8	Dhanusha	4	25%	35%	50%		50%	50%		25%	75%
9	Siraha	2		50%	50%		50%	50%			100%
10	Jhapa	9		70%	30%					10%	90%
	Total	59									
	Avg		40%	53%	41%	12%	43%	62%	7%	48%	64%

3.5.10.5 Repair and Maintenance

The R&M services were perceived as good by most of the Rs (85% respondents), R & M facility was very good in Banke, Dang and Siraha.

Table 3.5.11
Perception about Repair and Maintenace Facility

Sn	Districts	No. of	Repair & Maintenance			Level Of Water Disch.			Fuel Shortages		
		Samples	Excell.	Good	Bad	Increase	Decrease	Same	Frequent	Sometime	Rare
1	Kailali	14	7%	57%	36%		64%	36%	21%	57%	21%
2	Banke	2		100%				100%			100%
3	Dang	4		100%		25%	50%	25%			100%
4	Rupandehi	14		71%	29%		50%	50%	7%	8%	85%
5	Nawalparasi	7		71%	29%	28%	14%	58%	28%	42%	30%
6	Chitwan	1									
7	Bara	2		50%	50%			100%			100%
8	Dhanusha	4		75%	25%		50%	50%			100%
9	Siraha	2		100%			50%	50%			100%
10	Jhapa	9		80%	20%		20%	80%		10%	90%
	Avg	59	7%	78%	31%	27%	43%	61%	19%	29%	81%

5.10.6 Water Discharge from the System

Of the total respondents, 88% mentioned that the water discharge over the year remained same or increased (61% and 27%). However, in 43% cases, the discharge over the years decreased as a result of the following reasons.

- Destruction of vegetable cover affecting re-charge of groundwater and thereby reducing the water table
- There were many pump-sets around
- Faulty boring procedures.
- Mechanical trouble in the pump-sets.

The decrease in water table was more evident in Kailali (64% respondents) followed by Dang, Rupendehi, Dhanusa and Siraha (50% respondents each)

3.5.10.7 Fuel Shortages

Most of the respondents (81%) mentioned that fuel shortages were rare. Similarly, 29% of them had opined that it happens sometimes.

3.5.11 GW Water Use in Fish Pond

Only in few isolated cases, (12% of the total respondents) GW was used in fish ponds. Approximately, 14% each in Rupendehi and Nawalparasi followed by 7% in Kailali were using GW for fish pond.

Conflicts occur when there is shortage of water. Since in most of the cases (except in those old DTWs installed many years ago) GW schemes were far behind their optimal use level. there was no question of dispute.

Farmers were charged additional money for using GW in fish ponds in Rupendehi. Therefore, demands, not disputes were made by fish pond owners to lower the tariff of electricity.

3.5.12 Basis of Payment for Using Community GW

The basis for payment against using DTW varied over the sampled districts. The rate per hour for areas where the pump had to be run by diesel was costlier than those which were operated by the electricity.

There was also variation among districts where the pumps run by using electricity for example, the rate per hour using a Deep tube-wells or Medium tube-wells ranged from rs 36.75 to 104 Rs per hour depending upon the capacity (KVA) of the pump.

3.6. Environmental Concerns

The surveyed tube-wells appeared largely to have positive impacts. To a great extent. the tube-well irrigation schemes have contributed to check up soil erosion and maintain greenery. Since GW scheme does not require large distribution systems (canals) like surface systems, it contributed in saving agricultural land.

CHAPTER - IV

WATER USER ASSOCIATIONS

4.1 Background

Most of the irigation development programs in recent times have begun to place emphasis on local institution building at different levels of project handling and management. Specificially, the community tubewells (shallow, medium and deep ones) envisaged to strengthen the planning, implementation and management capacity at the community levels. For this purpose, Water Users' Associations (WUAs) were formed in almost all sites where community tubewells were to be installed.

4.2 Users Committees and Organization

Under most of the donor supported GW schemes, it was mandatory to form user committees from among the beneficiary members. Accordingly, the users requesting for installing GW schemes were instructed to form users committees at the users level. The rationale behind forming user committees at grassroots was partly to comply with the decentralization policy that stresses involvement of village level committees in planning, construction, supervision, and operation and maintenance of local level projects. The policy aimed for capability building of local level committees in planning and management of local level projects, thereby ensuring peoples' participation and involvement for sustained operation and management of projects at local levels.

Organizational growth and evolution calls for certain requirements that should keep on going. The more formal the organizational features, the fast it could evolve as an active system and vice versa. The following sections deal on the organizational qualities of the committees surveyed in the project districts.

4.2.1 Committees' Legal Status

The users committees were formed in all the community tubewells studied but none of them were registered at the CDO Offices. However, they seemed to have certain formal status provided by the very agencies which supported these projects. These committees in most case lack the legal basis and authority to be a non- governmental organization. The committees have no charter or constitution which is also essential for a fully legal and formal organization to evolve and operate.

The agencies supporting the projects had provided instructions to the users to form users' committees before starting the installation. The committees were reportedly formed in short duration just to complete the formalities required by the supporting agencies.

These committees at large were found poorly organized and structured reflecting fundamental weaknesses right from the formation stage. Formal organizational qualities were hardly noticed in the committees formed. However, despite the lack of formalness that is essential for a local organization to evolve, the committee's success in accomplishing the installation activity cannot be ignored either. The committees, in general, were found working actively during the installation period. However, after the completion of installation, the committees hardly were functional.

4.2.2 *Composition and Selection of Committee Members*

The WUAs varied in terms of composition of officials and members. The number of committee members generally varied from 7 to 11 and only in very few cases that women representatives were included in the committees. There seems little efforts made while forming the committees and selecting the members for a fair composition.
The formation of WUAs in relatively short time as mentioned above reflects both the strength and weakness. The strength is reflected from the ability of people in forming the committees in short time that is generally necessary to undertake and manage the projects. The formation of committees also reflects the weakness that concerns to little communication and less transparency that characterized the formation process in most of the community tubewells.

4.2.3 *Role and Functions*

There was virtually no documented evidence with the WUAs about the roles and functions performed by them. In general, their roles were limited to collecting farmers monetary contribution, availing labor, transporting machines and collecting water cess during operation.

4.2.4 *Meetings and Decisions*

The WUAs held hardly held any formal meetings except in occasions that were essential for getting support from the supporting agencies. Most of the committee members reported that they held very few formal meetings and held more meetings informally. In most of the cases, the Chairman and the Secretary jointly maintained the accounts and records of the WUA.

4.3 Institutional Sustainability

WUAs were, in principal, envisaged to evolve gradually and sustain their activities in planning, implementing as well as operating and maintaining their systems effectively in future. The key elements of institutional sustainability are, among others, the followings.

- legal status of the organization having been registered in District Administration with its own charter or constitution
- clearly defined rules and regulations to regulate the activities
- provision of democratic election of committee members

- internal capacity building for planning, implementation, supervision and monitoring of works including leadership development and

- capacity development for adequate resource generation and utilization.

The very elements as mentioned above are missing and many WUAs do not consider themselves as permanent bodies.

4.4 Capacity Building of Trainees

The WUA members and beneficiaries were provided trainings on O& M aspects. Some of the sampled respondents also received training to improve their skills and knowhow as shown below.

Table 4.1:
Training provided

	% of Respondent Receiving Training				
	Number of Sample	O&M	Cultivation	Other	Total
Kailali	14	7%	29%	-	36%
Banke	2	-	-	-	
Dang	4	-	-	-	30
Rupendehi	14	-15%	15%	-	42
Nawalparasi	7	14%	28%	-	
Chitwan	1	-	-	-	50
Bara	2	50%	-	-	50
Dhanusha	4	25%	25%	-	-
Siraha	2	-	-	-	-
Jhapa	9	-	11%	-	11
Average	9	-	11%	-	33

On an average 22% of the sampled respondents had received formal training in O&M and agriculture production. Most of the trainees who got the opportunities to take part in the training reported that the training was useful in many ways, specially for repair and maintenance of their GW systems. However, users in most of the community tubewells run by electricity complained that they were not able to repair even minor problems.

CHAPTER - V

ISSUES, STRENGTHS AND WEAKNESSES

The study team observed numerous issues that have obstructed the beneficiary farmers to realize the potential of GW schemes installed . The issues varied largely across the system and the regions. In general, the common issues are related to marketing of farm produces, farm inputs, training & extension, repair & maintenance, spareparts and coordination etc. Project specific issues by key players, strengths and weaknesses are presented in the following matrix.

5.1 Key Players Of Gw Development, Their Strengths And Weaknesses

Key Players	Strengths	Weaknesses
I. DOI/GWRDP (IFAD)	• Equipped with machinery • Enough technical manpower • Adequate logistic support	• Improper system for construction management, arrangements of irrigation material and repair and maintenance. • Inadequate motivation to farmers for community development to make them participate • Relatively high cost of GW system development
DOI/GWRDB (ILC)	• Relatively good system of GW development • Adequate infrastructure • Good experience	• Inadequate machines for drilling • Lack of manpower of electrical background • Inadequate budgetary provision • Weak people's participation • Ineffective monitoring and supervision system • Inadequate coordination between line agencies • Inadequate motivation to the farmers
DOI/BLGWP	• Well established infrastructure for GW development • Equipped withmachinery and technical manpower • Integrated approach of GW development with agricultural system	• Project is being terminated • Agency managed system has been developed which created problem to transfer them to the people • Low peoples participation • Lack of coordination between line agencies • Maintenance of large system causing problem due to unavailability of spare parts • High cost of system development

DOI/GWRDB (NTP)	• Equipped with machinery and manpower • Good infrastructure	• Agency managed system has been developed • Problem has been created in O&M of the project • Difficulty in management transfer to people • Inadequate water charge collection
II ADBN	• Well established network and system of GW development with appropriate drilling technologies • Relatively low cost of system development • Farmer managed system development • Farmers have choices on irrigation material • Effective peoples participation in system development	• Inadequate technical manpower to develop the qualitative system • Inadequate subsidy and overhead expenses for expansion • Ineffective monitoring, supervision and reporting system • Inadequate motivations to the farmer • Lack of coordination between line agencies • Inadequate efforts to develop skills of its technical personnel • Lack of machinery for drilling in hard formation
DOA (ADPJ)	• Well managed, integrated approach of GW development • Equipped with machinery • Good experience	• Inadequate efforts has been done to utilize the developed system • Improper allocation of budget for system development • Lack of skilled manpower • High cost of system development • Lack of concrete plan of action

5.2 Implementation problems of Key Players of GW Systems

PLAYERS	IMPLEMENTATION PROBLEMS
1. DOI	• Farmers participation is low • Hiring of incompetent contractors • Unavailability of spare-parts for repair and maintenance of large scale pump-sets • Inadequate and untimely budget allocation • Procedural problems for irrigation material arrangement (tender process) • Poor response of WUA
2. ADBN	• Manpower constraints • Inadequacy of skilled boring mechanics • Overhead constraints Lack of research and development.
3. DOA (ADPJ)	• Budget allocation for well construction and distribution system does not match • Lack of spare parts for Japanese pump-sets • Inadequate skilled technical manpower • Inadequate logistics support.

CHAPTER - VI

CONCLUSION AND RECOMMENDATIONS

Of the GW schemes available in the country, STWs seems to be financially viable. technically feasible and operationally sustainable. They can be managed by the user farmers. spareparts are easily available in the local markets and the owners can approach and afford them. Large scale deep tubewells in contrary are managerially difficult, financially costier and operationally complicated in farmer managed situations. In this context it is recommended that the following measures be taken to utilize the GW resources.

- An inventry of the existing status of use and potential be prepared;
- A definite master plan indicating the areas of installing STWs, MTWs and DTWs be prepared so that DTWs would not be installed in an area feasible for STW installation;
- While identifying areas for GW schemes, proper assessments be made so that the extraction rate of GW would not exceed the recharge rate;
- The existing cost effective manual drilling technolgy be modified in such a way that it would be technologically sound;
- The areas of high recharge for GW be identified and preserved/conserved so that there would be a sustainable harvest of the GW in the long run;
- An integrated approach of GW use be developed, followed and monitored strictly to increase gross agriculture production. Integrated program packages and coordination mechanism be developed;
- A long term strategy for subsidy administration and financing be made;
- Local level manpower be trained in such a way that would help the massive expansion program of the GW use.

ANNEXES

ANNEX-I (A)

QUESTIONNAIRE FOR TECHNICAL ASPECTS OF GW SCHEMES

1. Respondent

Name:
Address of Project site District VDC Ward

2 Installation

Year of Installation

Drilling Technology: Rig Machine/Manual Rotary/ Bogi/Thokuwa/Sludge

Time taken for Installation -------- Days

Number of Manpower used Persons per day

Total Cost of Installation: RS:

3. Design

Casing Pipe Type: Length (m)

Screen Type: Length (m)

Gravel Packing Yes/No

Water Lifting Device Used: Type: Diesel/Electric/Gasoline
HP/kW:

Conveyance System Canal: Lined/Earthen
Piped:

4 Well Specification

Depth (m)

Static water level (m)

Aquifer Type: Thickness (m)

Discharge (LPS)
Winter
Summer

Have you ever noticed shortage of water in your system ? Yes/No
If Yes,

Which Season? Summer/Winter

How many months?

For how many hours, the pump can work in full capacity ?

5 Operation and Maintenance

Ownership	Individual/Community
Who operates the tubewell ?	Owner himself/Operator
Technical Know-how of Operator:	Enough/Insufficient
Operating Hours (Hours/year)	Own Rent out
Repair & Maintenance facilities	Available/Not available
Repair and Maintenance Cost (RS/annum)	
Servicing	Once a year/Twice a year/None

Total Cost of Operation

Fuel Consumption (LPH)

Cost per Liter or per unit (RS)

Remuneration of Operator if hired (RS/year)

Problems of Repair and Maintenance

6 Tubewell Utilization

Area Covered (bigha) Own area: Service (rent) area Total area

Income per hour from rent out (RS)

Utilization Rate: (hour required to irrigate one Bigha)

7 Replacement/ Rehabilitation

Have you replaced the Tube well and pump?Tubewell Pumpset Both None

If yes, Year of replacement

Cost of Replacement (RS)

Have you rehabilitated the tubewell ? Yes/No

If yes, type of rehabilitation Flushing/Chemical treatment/Surging/Others

Frequency of rehabilitation (times)

Cost of rehabilitation (RS)

8. Efficiency of Irrigation Structures (by observation/discussion)

Condition of Structure:

Tubewell

Canal

Ditches

Water Loss during delivery

Very high/high/Negligiable

9 Designed and Actual Discharge and Command Area

	Designed	Actual
Discharge		
Command Area		

10 Reasons of Low Utilization of this GW scheme ?

11 General Comment and Remarks of the Enumerator about the GW Scheme.

ANNEX- I(B)

QUESTIONNAIRE FOR SOCIO-ECONOMIC SURVEY

(to be administered at the Household level)

I Family Information

1. Name of the Respondent
2. Address: District VDC Ward No
3. Family Size
4. Ethnicity
5. Land Holding (bigha)

	Before	After
Irrigated		
Unirrigated		

6. Employment Status

   Number working in own farm

   Number working Off-farm

   Average Working days/months a year

II GW System Information

7 Type of GW System Installed STW/MTW/DTW

8. Ownership Private/Community

9. Tubewell Capacity (LPS)

10 Primemover capacity (HP)

11 Year of Installation

12 Source of Finance

13 Total Cost of the Project

14. Existing Condition of the GW system Operational Semi-operational Non-operational

15. Give Average Pumping Hours a year

Month	Crops						
	Paddy	-	-	-	-	-	Total
Ashad							
Srawan							
Bhadra							
Asoj							
Kartik							
Mangsir							
Push							
Magh							
Falgun							
Chaitra							
Baisakh							
Jestha							
Total							

16 Out of this Hour, how many hour do you rent out ?

17 What are the reason for being this Utilization rate ?

18 Please give the Cost of Operation and Repair and Maintenance.

Fuel Requirement per hour (liter)

Cost of fuel/Liter (KW)

Repair and Maintenance cost per year (RS)

Salary of the Operator if hired (RS per year)

III Agricultural Information

19 Cropping Pattern

Area in Bigha

Crops Grown	Before	After
1		
2		
3		
4		
5		
6		
Total Land Area		
Total Cropped Area		
Cropping Index		

20 Yield and Varieties Used (Local or improved variety)

Crops	Before			After		
	Area	Yield	Variety	Area	Yield	Variety
1						
2						
3						
4						
5						
6						

IV **Benefits Perceived by the Respondent**

21 Changes in Food Availability

Food Sufficiency	Before	After
Surplus (mention amount/year) Just Sufficient Available for 9 months Available for 6 months Available for 3 months		

22 Do you grow more vegetables than before ? Yes/No

23 Do you eat more vegetables than before Yes/No

24 Do you eat more nutritious food (meat, egg, fruit and milk) than before ? Yes/No

25 Changes in Employment Pattern

Did the project generate any additional on-farm job ? Yes/No
If yes, How mandays a year ?

26 Changes in Income

Source	Before	After
On-Farm Income		
Off-Farm Income		
Total		

27 Changes in Family Expenditure Pattern

Purposes	Before	After
Clothes Feasts/Festivals Schooling Others		
Total		

V Institutional Aspects

(to be filled by Community GW System Users only)

28 Are you a member of Water User Association (WUA)?

29 If not do you know such an association exists ?

30 List out the function of this association

-

-

31 Is there any conflict in using water ? Yes/No

32 What is the basis of using this community GW system ?

33 Are you satisfied with the performances of the WUA ? Yes/No

34 Do you use the water of this system for other Household purposes ? Yes/No
If yes, what are the direct effects to women in work allocation and time saving?

-

-

35 What are the Environmental effects of this GW Scheme ?
Positive

Negitive

36 Have you received any training in the following aspects?

O&M	Yes/No
Agriculture Production	Yes/No
Others (specify)	

37 In what way are the trainings useful to you ?

VI Overall Perception of the Respondent

38	Level of family Income	Increased/Decreased/Same
39	Level of Living Condition	Increased/Decreased/Same
40	Quality of the GW System	Excellent/Good/Bad
41	Services of the Financial Institution	Excellent/Good/Poor
42	Support from the DOI	Excellent/Good/Poor
43	Quality of Agriculture Extension services	Excellent/Good/Poor
44	Repair and Maintenance facility	Excellent/Good/Bad
45	Level of water discharge over year	Increased/Decreased/Same

ANNEX- I (C)

CHECKLISTS FOR KEY INFORMANT SURVEY

(to be administered with DOI/ADBN and other related agencies)

I General Information

1 Name and Designation of the Respondent

2 Organization

3 Years of Involvement in the program in the study area

II GW System Related Information

4 Total Agricultural Area of the district

5 Total Area covered by different Irrigation systems in the district

Irrigation Systems	Agencies Involved										
							Total			[illegible]	
	No. of Schemes	Area Covered (bigha)	Beneficiary HHs	No. of Schemes	Area Covered (bigha)	Beneficiary HHs	No. of Schemes	Area Covered (bigha)	Beneficiary HHs	No. of Schemes	[illegible]
STW											
MTW											
DTW											
DUGWELL											
ARTESIAN											
ROWER											
TREADLE											
OTHERS											
TOTAL											

5 Total GW potential in the district

Total potential
Used
Unused

6 GW Recharge areas and amount of recharge per year/unit area

7 Average depth of well (m)

8 Popular pump brands

9 Type and capacity of pumps commonly used:

Type: Kerosene/Petrol/Diesel/Electrical
Capacity: 7 HP/5HP/3HP/2 HP/Rower/Treadle

10 Common Drilling Technology Used in the area

11 Common Aquifer Type and thickness

12 Availability of spare parts and quality of Repair and Maintenance Facilities in the area

13 Effectiveness of WUA in water sharing and management

14 List problems of institutionalizing WUA

15 List the strengths and weaknesses of various modes of implementation of various GW schemes by various agencies

Agencies	Strengths	Weaknesses
ADBN		
GWRDB		
SIRDP		
ILC		
IFAD		
JADP		
INGO/NGO		
OTHERS		

16 How do you implement irrigation programs in your area ?

17 Who are the players and their role?

18 What are the reasons of Low Utilization rate of the GW Schemes ?

18 Are You satisfied with the existing Coordination situation ? Yes/No

19 What should be done to improve it ?

20 List Major problems in program implementation

21 What should be done to exploit the GW potential in your district ?

List of Key Informants

District	Name of Respondents	Designation	Organisation	Year of Involvement	Effectiveness of WUA	Coordinatio Situation Satistied	Use of Water in Fish Pound
Jhapa	1.Shambu Rajbansi	Loan officer Main Branch Bhadrapur	ADBN	6	NA	Yes	No
Siraha	2.Dr.Remash Man Tuladher	Project Chief, CSTP	CSTP	1	Yes	No	No
	3.Bhagawan Das Ulak	Branch Managar Lahan	ADBN	1.25	NA	No	Negligable
Dhanusa	4. Ram Sheh Pandey	Asst. Agri Engineer, ADPJ	ADPJ	4	Yes	Yes	Yes
	5. Nitya Nanda Dev	Branch Managar Janakpur	ADBN	1.5	NA	No	Yes
Bara	6.Shiv Narayan Mandal	Superviser, NTP	NTP	1.5	NA	Yes	Negligable
	7.Padam Raj Silwal	Overseer Main Branch Kalaiya	ADBN	1	NA	No	Negligable
Chitwan	8.Mahesh Kumar Shrestha	Managar Main Branch, Bhratpur	ADBN	2	NA	No	Yes
Nawalparasi	9.Tikaram Neupane	Leader Farmer	Farmer	7	Yes	No	Yes
	10.Basanta Rayamajhi	Chief	KTP		Yes	No	No
Rupendehi	11.Ichha Kumar Shrestha	Hydrogeologist	BLGWP	1.5	Yes	No	Yes
	12.Uma Kanta Sharma	Loan Officer Branch,Bhirawa	ADBN	2	NA	No	Yes
Dang	13.Dhruba Raj Thapa	Geologist Field Office Lamahi	GWRDP	5	No	No	No
	14.Rajendra Samant	Manager Branch Lamahi	ADBN	1	Average	No	No
Bankey	15.Ramesh Gautem	Chief, Field Office Nepalgung	GWRDP	3	No	Yes	No
	16.Ramchandra Acharya	Section Officer Branch,Nepalgung	ADBN	1	Yes	Yes	Yes
Kailali	17.Netra Baahadur Karki	Chief ,Field Office Dhangadhi	GWRDP	23	Average	No	Yes
	18.Damodar Bhatta	Manager, Branch Dhangadi	ADBN	1.5	NA	Yes	Yes

STATUS OF GW SYSTEMS IN SURVEYED DISTRICTS

ANNEX- III

District	Type of GW Scheme	Status of GW Systems: # of GW Schemes: Reported #	Reported failure	Actual #	Actually functionin	Area Coverage: Reported ha.	Actual ha.	GW Potentiality: Total #	Used #	Unused #	Average Depth of Tubewell (m)	Aquifer: Type	Thickness (m)	Drilling Technology	Popular Brand of pumpset: Brand	Type	Capacity (HP)	Availability of Spare parts
JHAPA	STW (A)	3243	260	2983	2919	12980	11682	65208	3254	61954	20	SG	4	SL,TH	K,BS	D	8	Y
	STW (J)	11		11										RR	K,BS	D		Y
	DTW (J)	5		5				325	10	315	130	G	17	RR	FI,IS	D	72,47	N
	DTW (G)	5		5	5	185	188											
SIRAHA	STW (A)	1116	23	1143	1085	4939	4692	25000	1455	23545	20			SL,TH	K,B	D	7	Y
	STW (J)	260	52	208		105								RR				
	STW (IF)	29	5	24	20	194	175				26	SG	11.5	RR	K	D	7	Y
	DTW (J)	18	2	16		498	400	181	30	151	135	G	10	RR	FI,IS	D	72,47	N
	DTW (S)	12		12	11	391												
DHANUSA	STW (A)	990	30	960	940	3510	3335	16111	2377	13734	33	MS	10	SL	B,K	D	8,1.5	Y
	STW (J)	1387	181	1206	247									RR				
	ATW (A)	269	8	261	255	364	346				110	S	6	SL				
	DTW (J)	108	6	102	68	2950	2000	132	108	24	170	G		RR	FI,IS	D	72,47	N
BARA	STW (A)	4501	900	3600	3600	19088	15267	22361	4517	17844	15	SG	6	SL	B,K	D	7,5	Y
	STW (J)	16	2	14														
	DTW (J)	1		1		50	30	117	26	91	122		18	RR	FI,IS	D	72,47	N
	DTW (N)	25		25	14	131					120			RR	SUB	E	50,40	Y/P
CHITWAN	STW (A)	361		361	361	1226	1226	20486	450	20036	10	B	3	TH	K	D	7	Y
	STW (J)	89	1	88										RR	K	D	7	Y
	DTW (J)	24		24		1400	895	205	24	181	80	B	6	RR	FI,IS	D	72,47	N
NAWALPARASI	STW (A)	1223	2	1198	1138	4227	3804	53819	1248	52571	20	SG	10	TH	BS,K	D	7,5	Y
	STW (IL)	25	5	25	20	218	175				30	SG	3	RR	K	D	7	Y
	MTW (IL)	14		14	12	209	179				70	SG	10	RR	SUB	E		Y/P
	DTW (IL)	10		10	9	334	325	330	10	320	150	SG	17	RR	SUB	E		Y/P
RUPENDEHI	STW (A)	3777	37	3740	3703	13686	13418	37708	3777	33931	15	SG	4.5	SL,TH	K	D	7,5	Y
	ATW (A)	72	2	70	70	114	110				175	G	3	SL				
	DTW (B)	174	11	163	163	12250		231	176	55	140	FG		RR	SIM.	E		Y/P
	DTW (J)	2		2		35					130	FG		RR				
DANG	STW (A)	462		462	462	1785	1785	58472	480	57992	20	B	3	TH	FM	D	7	Y
	STW (IL)	18	4	14	14	225					30	B	7	RR	K	D	7	Y
	DTW (IL)	6		6	6	240		180	6	174	80	B	44	RR	JJ	E	40	Y/P
BANKE	STW (A)	2362	47	2315	2126	7301	6571	1833	2387	-554	25	SB	10	SL,TH	K	D	7,5	Y
	STW (IL)	25																
	DTW (J)	2	2					110	14	96		S						
	DTW (IL)	17	2	10	7	480	260				150	SG	45	RR	SUB	E	30	N
KAILALI	STW (A)	4650	46	4604	4604	13752	12377	44861	4850	40011	20	SG	8	TH,BG	FM	D	7,8	Y
	STW (IL)	200		200	180	3500	3150				33		10	RR			7,5	Y
	DTW (IL)	55		55	50	1400	1260	196	55	141	50			RR				
	ATW (SE)	25		25	22	500	450											

Source: Progress Report of DOI, ADBN, DOA and Key Informants

ABBREVIATIONS USED IN THE TABLE

(A)= ADBN
(J) = JADP
(G)= GWRDP
(S)= SIRDP
(IL)= ILC
(IF)= IFAD
(B)= BLGWP
(SE)= SELFPROJECT

S= Sand
G=Gravel
B=Bolder
SG= Sand-gravel
MS= Medium sand
FG= Fine gravel
SB= Sand boulder

SL=Sludge
TH=Thokuwa
BG=Bogi
RR= Rotary Rig

BS= Bharat Shakti
K=Kirloskar
FI=Fiat
IS= Issuzu
B= Bharat
FM= Field Marshal
SUB= Submersible
SIM= Simm
JJ= Jaya Jyoti

D=Diesel
E=Electric

Y=Available
N=Not available
Y/P= Arranged by project

Annex - IV

Well Specification by Surveyed Districts

District	Type of well	Size of well	Depth of well	SLW	Discharge	Casing Length	Screen Length	Aquifer Thickness
		Inch	M.	M.	LPS	M.	M.	M.
Jhapa	STW	4	20.6	3	15.2	12.2	8.3	9.1
	DTW	12	168	0	0	0	0	
Siraha	STW	4	20.8	4	14.5	4.8	8.2	12
	DTW	12	97	33	67	30		
Dhanusha	ATW	1.5	96	0	0.5	91.5	5.5	6
	DTW	12	130	15	0	0	0	0
	STW	4	27	9	10	21	6	0
Bara	STW	1.5-4	16.2	0	8.7	9.3	6.7	7.8
	DTW	12	122	0	20	0	0	
Chitwan	STW	2-4	15.2	4	12	13.2	1.8	1.7
	DTW	8	86	0	15	0	0	
Nawalparasi	STW	4	18.2	4.2	10.2	9.2	9	9
	MTW	8	68.5	0	15.5	46	6	6
	DTW	10	152	10.6	11	120	32	32
Rupandehi	STW	4	16.8	2.5	11.7	13.2	3.6	3
	ATW	1.5	61	0	0.5	61	0	2
	DTW	12	194	0	59	0	0	0
Dang-Deukhuri	STW	4	10.5	3.5	18	8	2.5	3
	DTW	6	85	33	17	75	10	0
Banke	STW	4	15.7	0	15	12.3	3.5	4.5
	DTW	10	30.5	13	11		52	
Kailali	STW	4	17.8	4.3	12	11.4	5.8	6.7
	DTW			0	12.5		0	0

Annex - V

Physical Condition of Irrigation Structures by Surveyed Districts

	Tubewell			Canal			
	Good %	Satisfactory %	Bad %	Good %	NA %	Satisfactory	Damaged heavy %
1.Jhapa	100	0	0	43	57	0	0
2. Siraha	100	0	0	25	50	25	0
3. Dhanusha	100	0	0	33	33	0	33
4. Bara	100	0	0	0	75	0	25
5. Chitwan	100	0	0	25	75	0	0
6. Nawalparasi	100	0	0	17	50	33	0
7. Rupandehi	100	0	0	43	43	14	0
8. Dang-Deukhuri	100	0	0	100	0	0	0
9. Bankey	100	0	0	34	33	0	33
10. Kailali	17	29	0	0	71	1	14
Average	97.1	2.9	0	32	48.8	8.7	10.5

Source: Field Survey.

Tubewell Utilization by Surved Districts

District	Irrigated Area			Utililzation	Replacement				Rehabilitation	
	Own	Rentout	Total	Rate	Tube-well	Pump-set	Pump only	Cost of replace	Rehabi	Cost
	Ha.	Ha.	Ha.	Hr./Ha	%	%	%	Rs	%	Rs
1. Jhapa	3.77	0.35	4.3	19.2	17	0	0	16	0	0
2. Siraha	12.4	0	12.4	8.25	0	0	0	0	0	0
3. Dhanusha	7.7	0	7.7	70	0	0	0	0	0	0
4. Bara	7.9	1.4	9.3	34.5	0	0	0	0	25	NA
5. Chitwan	4.6	1.1	5.7	10.9	0	0	0	0	0	0
6. Nawalparasi	7.4	0.1	7.5	8.1	17	33	0	3166.7	0	0
7. Rupandehi	8.2	2.7	10.9	48.8	0	14	0	1400	14	NA
8. Dang-Deukhuri	8.7	0.1	8.8	9.75	0	0	0	0	0	0
9. Bankey	4.3	2	6.3	10	0	0	0	0	0	0
10. Kailali	7.8	0.1	7.8	11.8	14	29	14	5428.5	14	NA
Average	7.3	0.8	8.1	23.1	4.8	7.6	1.4	1276.2	5.3	NA

Source: Field Survey.

Annex - VII

Drilling Technology and Material Used by Surveyed Districts

District	Driling Technology					Casing Pipe				Type of Screen					Aquifer Type			
	Sluge (%)	Thokuwa (%)	Bogi (%)	Manual Rotary (%)	Rig (%)	MS (%)	BB (%)	HDP (%)	GI (%)	BS (%)	SL (%)	PF (%)	NI (%)	CR (%)	Sand (%)	Gravel (%)	Bouder (%)	% (%)
1.Jhapa	57	14	0	0	29	86	14	0	0	39	33	17	17	0	07	33	0	
2. Siraha	0	25	0	25	50	100	0	0	0	0	100	0	0	0	0	25	0	75
3. Dhanusha	0	0	0	67	33	33	0	66	0	0	50	50	0	0	0	33	0	7
4. Bara	75	0	0	0	25	50	0	50	0	0	0	33	67	0	75	0	0	25
5. Chitwan	75	0	0	0	25	50	0	25	25	0	100	0	0	0	0	50	0	50
6. Nawalparasi	33	17	0	0	50	100	0	0	0	0	0	40	0	50	50	17	17	16
7.Rupandehi	71	0	0	0	29	71	0	14	15	0	25	75	0	0	0	71	0	29
8. Dang	0	50	0	0	50	100	0	0	0	0	50	50	0	0	0	0	50	10
9. Bankey	0	33	34	0	33	67	0	0	33	0	0	50	0	50	34	33	0	33
10. Kailali	0	29	42	0	28	100	0	0	0	0	17	33	50	0	38	12	13	7
Average	31	17	8	9	35	76	1	16	7	3	38	35	13	11	27	27	8	88

Source: Field Survey.

Ownership & Operation of GW Scheme by Survey Districts

District	Ownership of Scheme		Operation of Scheme		Technical Knowl how	
	Individual %	Community %	Owner %	Operator %	Sufficient %	Insufficient %
Jhapa	43	57	83	17	0	100
Siraha	50	50	50	50	0	100
Dhanusha	67	33	50	50	50	50
Bara	75	25	75	25	25	75
Chitwan	75	25	75	25	0	100
Nawalparasi	50	50	50	50	17	83
Rupandehi	71	29	50	50	17	83
Dang-Deukhuri	50	50	0	100	0	100
Banke	67	33	67	33	0	100
Kailali	71	29	71	29	14	86
AVERAGE	61.9	38.1	57.1	42.9	12.3	87.7

Source: Field Survey.

Annex - IX

Operation and Maintenance Situation by Surved Districts

District	R&M Cost	Operating Hours			Operating Cost	Remunaration of Operator	Total O&M Cost	Revenue from Rent out	Actual Cost of O&M
		Own	Rentout	Total					
Jhapa	666.7	227.3	3.3	230.7	3288	3200	7154.7	166.7	6988
Siraha	2781.3	198	81.3	279.3	8034.5	625	11440.8	8637.5	2803.3
Dhanusha	0	875	0	875	22387.5	8100	30487.5	2100	9487.5
Bara	250	177.5	5	227.5	2793.2	6900	9943.2	0	9943.2
Chitwan	6.7	245	20	265	20350	500	20856.7	14740	6116.7
Nawalparasi	383.3	165	0	165	4293.5	1007.8	5684.7	0	5684.7
Rupandehi	1000	154	50	204	10395	740	12135	3000	9135
Dang-Deukhuri	0	100	5	105	6045	562.5	6607.5	1050	5557.5
Banke	1900	90	50	140	7503.3	533.3	9936.7	2833.3	7103.3
Kailali	1528.6	170.9	10.7	181.6	3426.4	400	5354.9	357.1	4997.8
AVERAGE	**851.66**	**240.27**	**22.53**	**267.3**	**8851.64**	**2256.86**	**11960.17**	**3288.46**	**6781.7**

Source: Field Survey.

Annex - X

Repair and Maintenance Facilities by Survey Districts

District	Availability		Frequency	Cost of R&M Rs
	Available %	Not Available %	Times	
Jhapa	100	0	0.7	666.7
Siraha	100	0	0.5	2781.3
Dhanusha	100	0	0.5	0
Bara	75	25	0.8	250
Chitwan	75	25	0.7	6.7
Nawalparasi	100	0	0.5	383.3
Rupandehi	100	0	0.6	1000
Dang-Deukhuri	100	0	0	0
Banke	100	0	0.7	1900
Kailali	86	14	0.7	1528.6
AVERAGE	93.6	6.4	0.57	851.66

Source: Field Survey.

Annex - XI

Situation of Tubewell Dischrage and Command Area by Surveyed Districts

Districts	Discharge Situation				Area Coverage Situation			Sufficiency		Remarks
	Disigned/ Reported (lps)	Actual Winter	Actual Summer (lps)	Deviation (%)	Designed/ Reported (ha)	Actual (ha)	Deviation (%)	Sufficient (%)	Not Sufficient (%)	
1.Jhapa	6	15.2	15.2	150	4.0	4.3	+7.5	100	0	
2. Siraha	18.5	20.5	19.25	4	17.75	12.4	-30	100	0	
3. Dhanusha	17	9.9	8.5	-50	13.7	7.7	-44	67	33	
4. Bara	17	13	11.5	-32	15.5	9.3	-40	75	25	
5. Chitwan	11.25	12.75	12.75	13	10.5	5.7	-52	100	0	
6. Nawalparasi	17.5	10.8	12.2	-30	12.9	7.5	-45	50	50	
7. Rupandehi	18.3	24.5	24.5	34	17.3	10.9	37	57	43	
8. Dang	111.5	19.5	17.5	52	10.5	8.8	-16	100	0	
9. Bankey	17.3	13.7	13.7	-21	10.0	6.3	-16	100	0	
10. Kailali	15.7	14.1	13.8	-12	14.3	7.9	-45	100	0	
Average	15.0	15.4	`14.9	-6.6	12.75	8.1	-36.5	85	15	

Source: Field Survey.

Annex - XII

Technical Information of GW Schemes by Sampling

Respondent			Installation					Well Specification					Casing		Screen		Aquifer			Water lifting divice		Conveyancy System		
Code No	Name of Responent	Address of Projects Site	Year of Installation	Drilling Technology Used	Time Taken for Inst.	# of Manpower Used	Total Cost of Project	Type of GW Schme	Size of Tubewell	dept. of Tubewell	Stati Water Level	Actual Discharge	Type	Length	Type	Length	Type	Thickness	Gravel Packing	Type	Capacity	Command Area	Type	Length
District : Jhapa																								
J1	Surendra Yadav (Operator)	Garamuni-3	2050	Sludge	7	4	31500	STW	4	38	NA	18	MS	14	BS	24	S and	26	No	D	7	2.7	No.	0
J2	Jogeswar Chandra Singh Rajbansi (C	Maheshpur-1	2042	Rig	30	NA	460000	DTW	12	168	NA		MS							E	30		No.	
J3	Sahat Lal Singh Rajbansi (Owner)	Maheshpur-6	2036	Sludge	2	4	8000	STW	4	12	NA	12	MS	6	SL	6	S and	6	NO	D	5	3.3	No.	
J4	Man Bdr. Khadka (Owner)	Jyamirgadhi-9	2046	Thokuwa	2	4	NA	STW	4	12	3	20	MS	9	PF	3	Gravel	3	NO	D	8	3.3	No.	
J5	Naran Bdr. Thapa (Owner)	Prithvinagar-5	2049	Sludge	3	4	48000	STW	4	32	Na	12	ms+bb	27	NL	5	CS	6	NO	D	8	4	Earthen	50
J6	Krishna Raj Shrestha (Owner)	Damak-3	2052	Rig	30		60000	STW	4	18	Na	19	MS	12	SL	6	G	6	YES	D	5	5.3	Earthen	50
J7	Yam Kumar Basnet (Owner)	Dharmpur-9	2049	Sludge	3	4	32000	STW	4	12	3.3	10	MS	6	BS	6	S	7.5	NO	D	8	7.3	Earthen	150
	Average				**11**	**4**	**106583.3333**		**5.14**	**41.714**	**3.15**	**15.167**		**12.333**		**8.33**		**9.0833**	**0**	**0**	**10.1429**	**4.3167**	**0**	**83.3333333**
District: Siraha																								
S1	Lakhan Lal Shah (Owner)	Hanumannagar-3	2051	Thokuwa	10	3	39750	STW	4	12	NA	15	MS	6	SL	6	NA	NA	NO	D	6.5	3	no	
S2	Satya Narayan Mahato (Owner)	Sonmati Majhura-7	2049	Manual Rotary	4	6	9100	STW	4	15.5	NA	17	MS	6	SL	9.5	NA	NA	NO	D	7	1.1	no	
S3	Santosh Chaudhary (Operator)	Bastipur-5	2053	Rig	4	8	340000	STW	4	35	4	12	MS	26	SL	9	S+G	12	YES	D	8	12	Line	285
S4	Nathuni Yadav (Operator)	Gobindapur-9	2041	Rig	120	15	NA	DTW	12	97	NA	33	MS	67	SL	30	NA	NA	YES	D	40	33.3	Lined	NA
	Average				**34.5**	**8**	**129616.6667**	**0**	**6**	**39.875**	**4**	**19.25**	**0**	**26.25**	**0**	**13.6**	**0**	**12**	**0**	**0**	**15.375**	**12.35**	**0**	**285**
District: Dhanusha																								
D1	Bikram Pd. Yadav (owner)	Benga Sivpur-9	2049	Manual Rotary	8	12	15200	ATW	1.5	96	FA	0.5	HDP	91.5	SL	4.5	G	6	NO	NN	NN	0.7	Earthen	20
D2	Bulan Shah (Operator	Ramdaiya Vavadi-3	2033	Rig	NA	NA	460000	DTW	12	130	NA	15	NA	NA	NA	NA	NA	NA	YES	D	16	20	Lined	600
D3	Bikru Mahara Chamar (owner)	Tera Kachuri-6	2050	Manual Rotary	12	12	NA	STW	4	27	9	10	HDP	21	HDP (PF	6	NA	NA	NO	D	8	2.3	No	
	Average				**10**	**12**	**237600**	**0**	**5.83**	**84.333**	**9**	**8.5**	**0**	**56.25**	**0**	**5.25**	**0**	**6**	**0**	**0**	**12**	**7.6667**	**0**	**310**
District: Bara																								
B1	Sukhad Shah (Owner)	Kotwali-9	2048	Sludge	2	4	39550	STW	4	15	NA	15	HDP	9	HDP (PF	6	Sand	6	NO	D	7	2.7	No	
B2	Jaldhari Mukhiya (Owner)	Amritganj-4	2052	Sludge	1	4	17936	STW	1.5	15	NA	3	HDP	10	HDP (NL	5	FS	6	NO	G	1.5	0.5	No	
B3	Hira Man Mahato (Owner)	Amritganj-6	241	Sludge	2	9	10500	STW	4	18	NA	8	MS	9	NL	9	CS	11.5	NO	D	8	4	No	
B4	Bijaya Kumar Yadav (Operator)	Kalaiya-2	2036	Rig	NA	NA	683000	DTW	12	122	NA	20	NA	NA	NA	NA	NA	NA	YES	E	40	30	Lined	3000
	Average				**1.67**	**5.67**	**187746.5**	**0**	**5.38**	**42.5**	**0**	**11.5**	**0**	**9.3333**	**0**	**6.67**	**0**	**7.8333**	**0**	**0**	**14.125**	**9.3**	**0**	**750**
District: Chitwan																								
C1	Dadhi Raj Ghimire (owner)	Ratnanagar-2	2051	Sludge	Na	Na	19800	STW	2	16	Na	3	GI	14	SL	2	Na	Na	No	D	5	1.3	No	
C2	Dhan Bdr. Ghimire (Operator	Ratnanagar-12	2050	Rig	30	Na	460000	DTW	8	86	Na	15	MS	Na	SL	Na	Na	Na	Yes	D	72	15	Lined	1000
C3	Ram Chandra Ghimire (Owner)	Gitanagar-6	2052	Sludge	5	5	40000	STW	4	14	4	19	MS	12	SL	2	G	2	No	D	8	4	No	
C4	Gokul Bdr. Thapa	Chainpur-1	2053	Sludge	10	5	15000	STW	3	15.5	4	14	MS+HDP	14	SL	1.5	G	1.5	No	D	5	2.4	No	
	Average				**15**	**5**	**133700**	**0**	**4.25**	**32.875**	**4**	**12.75**	**0**	**13.333**	**0**	**1.83**	**0**	**1.75**	**0**	**0**	**22.5**	**5.675**	**0**	**1000**

cont....

Respondent			Installation				Well Specification						Casing		Screen		Aquifer			Water lifting divice			Conveyancy System	
			Installation				Well specification																	
Code No	Name of Respondent	Address of Projects Site	Year of Installation	Drilling Technology Used	Time Taken for Inst.	# of Manpower Used	Total Cost of Project	Type of GW Schme	Size of Tubewell	dept. of Tubewell	Stati Water Level	Actual Discharge	Type	Length	Type	Length	Type	Thickness	Gravel Packing	Type	Capacity	Command Area	Type	Length
District: Nawalparasi																								
N1	Hom Nath Gyawali (Operator)	Jahada-3	2046	Rig	30	Na	600000	MTW	8	52	Na	14	MS	46	Coir	6	Fs	6	Yes	E	15	13.3	Lined+Earth	600+40
N2	Rebat Bdr. Kumhal (Owner)	Tamsariya-8	2049	Thokuwa	7	6	17000	STW	4	7.5	4	12	MS	4.5	PF	3	Boulder	3	No	D	5	1.2	No	
N3	Arjun Gautam (Operator)	Jahada	2049	Rig	25	Na	360000	MTW	8	85	Na	17	MS	Na	Na	Na	Na	Na	Yes	E	16	10	Lined	500
N4	Raj Mangal Pandey (owner)	Davgaun-9	2049	Sludge	3	5	3000	STW	4	24	4.5	8	MS	9	Coir	15	MS	15	No	D	8	2.7	No	
N5	Narayan Pd. Ghimire (operator)	Jahada-9	2048	Rig	45	11	520000	DTW	10	152	10.6	11	MS	120	PF	32	G	32	Yes	E(Sub)	30	15	Lined+Er+P	600+300+50
N6	Babu Ram Gupata	Dabgaon-9	2041	Sludge	3	5	Na	STW	4	23	Na	11	MS	14	Coir	9	FS	9	No	D	8	2.7	NU	
	Average				**18.8**	**6.75**	**300000**	**0**	**6.33**	**57.25**	**6.3667**	**12.167**	**0**	**38.7**	**0**	**13**	**0**	**13**	**0**	**0**	**13.6667**	**7.4833**	**0**	**200**
District: Rupandehi																								
R1	Rohini Mallah (Owner)	Dhakdhai-3	2044	Sludge	1	6	17000	STW	4	12	1.5	6	MS	10.5	PF	1.5	G	1.5	No	D	5	0.2	No	
R2	Mahamod Siddik (Owner)	Pokharvindi-5	2049	Sludge	15	5	37000	STW	4	26	3	15	MS	21.5	PF	4.5	G	4.5	No	D	7	15	No	
R3	Udaya Bdr. Baiddawar (Owner)	Siddartha-4	2041	sludge	5	8	3000	ATW	1.5	61	FA	0.5	GI	61	No	Na	G	2	No	NN	NN	1	No	
R4	Ram Narayan Tharu (Operator)	Madhubaliya-7	2034	rig	45	15	2682000	DTW	12	152	FA	98	MS	Na	Na	Na	Na	Na	Yes	E	102	30	Lined	2000
R5	Gorakh Chaudhary (Owner)	Hamaiya-9	2040	Sludge	12	8	10000	STW	4	16	3	12	MS	13.5	PF	2.5	G	3	No	D	7	8	Earthen	100
R6	Danai Yadav (Owner)	Mainahiya-6	2050	Sludge	4	5	30000	STW	4	13.5	Na	14	HDP	7.5	SL	6	G	Na	No	D	7	2	Earthen	50
R7	Suman Kumar Sharma (Chairman)	Dhakdhai-1	2050	Rig	25	15	10000000	DTW	12	236	FA	20	MS	Na	Na	Na	Na	Na	Yes	NN	NN	20	Piped	14500
	Average				**15.3**	**8.86**	**1825571.429**	**0**	**5.93**	**73.786**	**2.5**	**23.643**	**0**	**22.8**	**0**	**3.63**	**0**	**2.75**	**0**	**0**	**25.6**	**10.886**	**0**	**4162.5**
District: Dang-Deukhuri																								
DG1	Chhabilal Dangi (Operator)	Tarigaun-1	2043	Rig	20	12	823000	DTW	6	85	33	17	MS	75	SL	10	Na	Na	Yes	E(sub)	20	17	Lined+ER	1000+40
DG2	Tikat Ram Chaudhary (Owners)	Satbariya-2	2046	Thokuwa	2	5	18100	STW	4	10.5	3.5	18	MS	8	PF	2.5	Bould	3	No	D	8	0.5	Earthen	15
	Average				**11**	**8.5**	**420550**	**0**	**5**	**47.75**	**18.25**	**17.5**	**0**	**41.5**	**0**	**6.25**	**0**	**3**	**0**	**0**	**14**	**8.75**	**0**	**7.5**
District: Bankey																								
BK1	Pal Bdr. Chanda (Owner)	Mahadevpuri-7	2052	Thokuwa	2	8	42000	STW	4	10.5	Na	21	Ms	7.5	PF	3	G	3	No	D	7	4	No	
BK2	Gagan Singh Rana (Owner))	Bageswari-1	2050	Bogi	7	6	21000	STW	4	21	Na	9	GI	17	Coir	4	CS	6	No	D	7	4	No	
BK3	Kashi Ram Tharu (Operator	Agaun-9	2050	Rig	22	10	1600000	DTW	10	205	13	11	Ms	153		52	Na	Na	Yes	E(Sub)	44	11	Lined+ER	1200+100
	Average				**10.3**	**8**	**554333.3333**	**0**	**6**	**78.833**	**13**	**13.667**	**0**	**88.75**	**0**	**29.5**	**0**	**4.5**	**0**	**0**	**19.3333**	**6.3333**	**0**	**0**
District: Kailali																								
K1	Briz Lal Barai (Owner)	Chuha-4	2046	Thokuwa	3	4	10000	STW	4	18	Na	19	MS	15	PF	3	Bould	3	No	D	10	2	No	-
K2	Jaksan Rana (Operator)	Dhangadhi-8	2025	Rig	30	Na	Na	DTW	Na	Na	FA	2	Na	Na	Na	Na	Na	Na	Yes	NN	NN	17	Lined	500
			2041	Bogi	3	6	Na	STW	4	21	Na	6	MS	Na	Na	Na	Na	Na	Na	D	10			
K3	Bandhu Rana (Owner)	Ghuinyaghat-10	2048	Bogi	2	5	26000	STW	4	14.5	4	11	MS	5.5	NL	9	CS	10	No	D	7	1.5	No	-
K4	Sita Ram Rana (Owner)	Dhangadhi-8	2043	Bogi	2	5	1500	STW	4	21	4.5	11	MS	16	NL	5	CS	7.5	No	D	7	3.3	No	-
K5	Shiv Shanker Rana (Owner)	Ghuinyaghat-10	2042	Bodi	1	8	18000	STW	4	14.5	4	13	MS	5.5	NL	9	CS	10	No	D	7	4	No	-
K6	Rangnath Ojha (Operator	Chaumala-2	2035	Rig	30	12	Na	DTW	Na	Na	FA	23	MS	Na	SL	Na	Na	Na	Yes	D	23	27	Lined	1000
K7	Narayan Dutta Bhatta	Geta-7	2046	Thokuwa	3	6	35000	STW	4	18	4.5	12	MS	15	PF	3	G	3	No	D	7	0.3	No	-
	Average				**9.25**	**6.57**	**18100**	**0**	**4**	**17.833**	**4.25**	**12.125**	**0**	**11.4**	**0**	**5.8**	**0**	**6.7**	**0**	**0**	**10.1429**	**7.8714**	**0**	**800**

NA = Not Availale
SI = Slotted Pipe
FS = Fine Sand
NN = Not Necessary
PF = Perforalted Pipe
FG = Fine Gravel
STW = Shallow Tubewell
NL = Nylon Strainer
D = Diesel
DTW = Deep Tubewell
GI = Galvanized Iron
D = Electric
MTW = Medium Tubewell
BS = Bamboo Straine
(sub) = Submersible
ATW = Artesian Well
S = Sand
FA = Falowing Artesian
G = Gravel
MS = Mild Steel
CS = Coarse Sand
HDP = High Density Polyethene
MS= Medium Sand
B = Boulder

Annex - XIII

Utilization And Condition of GW Schemes by Sampling

District	Cdoeof GW Schems	Type of GW Schems	Tubewell Utilization: Area Coverage: Own	Service Area	Total Area	Utilisst ion Rate	Replacement: Replaced Notreplaced	If yes (year of Replace)	Cost of Replacement	Rehabilitation: Rehablitation or Not	If Yes Type of Rehb.	Frequency of Rehab	Cost of Rehab.	Condition of Structures: Tubewell	Canel	Watersets
			(ha)	(ha)	(ha)	(Hr/ha)			(Rs)			(Time)	Rs.			
Jhapa	J1	STW	2.7	0	2.7	7.5	No	-	0	No				Good	NA	Negligable
	J2	DTW	NA	NA	NA	NA	NA			No				Good	NA	-
	J3	STW	3.3	0	3.3	18	Tubewell	2052	1000	No				Good	NA	Negligable
	J4	STW	3.3	0	3.3	12	No			No				Good	NA	Negligable
	J5	STW	4	0	4	60	No			No				Good	Good	High
	J6	STW	5.3	0	5.3	4.5	No			No				Good	Good	High
	J7	STW	4	3.3	7.3	13.5	No			No				Good	Good	High
Average	7		3.76667	0.55	4.316666667	19.25			166.6666667							
Sirahha	S1	STW	3	0	3	6	No			No				Good	NA	Negligable
	S2	STW	1.1	0	1.1	10.5	No			No				Good	NA	Negligable
	S3	STW	12	0	12	9	No			No				Good	Good	Negligable
	S4	DTW	33.3	0	33.3	7.5	No			No				Good	Minor Damage	Negligable
Average	4		12.35	0	12.35	8.25										
Dhanusa	D1	ATW	0.7	0	0.7	180	No			No				Good	Good	Negligable
	D2	DTW	20	0	20	15	No			No				Good	Damaged Neavily	High
	D3	STW	2.3	0	2.3	15	No			No				Good	NA	Negligable
Average	3		7.66667	0	7.666666667	70										
Bara	B1	STW	0.7	2	2.7	15	No			No				Good	NA	Negligable
	B2	STW	0.2	0.3	0.5	67.5	No			No				Good	NA	Negligable
	B3	STW	0.7	3.3	4	37.5	No			No				Good	NA	Negligable
	B4	DTW	30	0	30	18	No			Yes	Flushing	2	Borne by the NTP	Good	Damaged Neavily	High
Average	4		7.9	1.4	9.3	34.5										
Chitwan	C1	STW	1.3	0	1.3	4.5	No			No				Good	NA	Negligable
	C2	DTW	15	0	15	10.5	No			No				Good	Good	Negligable
	C3	STW	1.3	2.7	4	10.5	No			No				Good	NA	Negligable
	C4	STW	0.77	1.63	2.4	18	No			No				Good	NA	Negligable
Average	4		4.5925	1.0825	5.675	10.875										
Nawalparasi	N1	MTW	13.3	0	13.3	10.5	No			No				Good	Satisfactory	Negligable
	N2	STW	1.2	0	1.2	4.5	No			No				Good	NA	Negligable
	N3	MTW	10	0	10	12	No			No				Good	Good	Negligable
	N4	STW	2.7	0	2.7	15	Pumpset	2052	10,000	No				Good	NA	Negligable
	N5	DTW	15	0	15	3.4	Submersible	2052	donot know	No				Good	Not so good	Negligable
	N6	STW	2	0.7	2.7	3	Tubewell	2051	9000	No				Good	NA	Negligable
Average	6		7.36667	0.1	7.466666667	8.06666667			3166.666667							
Rupandehi	R1	STW	0.2	0	0.2	7.5	No			No				Good	NA	Negligable
	R2	STW	1.3	13.7	15	9	No			No				Good	NA	Negligable
	R3	ATW	0.7	0.3	1	300	No			No				Good	NA	Negligable
	R4	DTW	30	0	30	3	No			Yes	Flushing	1	Borne by BLGP	Good	Satisfactory	High
	R5	STW	4	4	8	10.5	Pumpset	2050	28000	No				Good	Good	Negligable
	R6	STW	1.3	0.7	2	9	No			No				Good	Good	Negligable
	R7	DTW	20	0	20	3	No			No				Good	Good(all Piped)	Negligable
Average	7		8.21429	2.671428571	10.88571429				4000							
Dang	D1	DTW	17	0	17	7.5	No			No				Good	Good	Negligable
	D2	STW	0.3	0.2	0.5	12	No			No				Good	Good	Negligable
Average	2		8.65	0.1	8.75	9.75										
Bankey	Bk1	STW	0.7	3.3	4	12	No			No				Good	NA	Negligable
	Bk2	STW	1.3	2.7	4	15	No			No				Good	Good	Negligable
	Bk3	DTW	11	0	11	3	No			No				Good	Damaged in 2 places	Negligable
Average	3		4.33333	2	6.333333333	10										
Kailali	K1	STW	2	0	2	15	Pumpset	2052	12000	No				Good	NA	Negligable
	K2	DTW	17	0	17	18	Pump		14000	No				Satisfactory	Damag. in some plac	High
	K3	STW	1.5	0	1.5	13.5	No			No				Good	NA	Negligable
	K4	STW	2.6	0.7	3.3	6	Pumpset		6000	No				Good	NA	Negligable
	K5	STW	4	0	4	10.5	Tubewell	2049	6000	No				Good	NA	Negligable
	K6	DTW	27	0	27	13.5	No			Yes	Water Lifting	1		Satiffactory	Damaged	High
	K7	STW	0.3	0	0.3	6	No			No				Good	NA	Negligable
Average	7		7.77143	0.1	7.871428571	11.7857143			5428.571429							

Situation of Tubewell Discharge & Area Average by Sampling

District	Code of Scheme	Type of Scheme	Discharge Situation					Area Coverage	
				Actual Discharge		Sufficiency			
			Designed Reported	Winter	Summar	Sufficient/ Non-sufficien	If no how many Month	Designed/ Reported	Actual
Jhapa	J1	STW	6	18	18	Yes		4	2.7
	J2	DTW	-	-	-	-		-	-
	J3	STW	6	12	12	Yes		4	3.3
	J4	STW	6	20	20	Yes		4	3.3
	J5	STW	6	12	12	Yes		4	4
	J6	STW	6	19	19	Yes		6	5.3
	J7	STW	6	10	10	Yes		4	7.3
Siraha	S1	STW	6	15	15	Yes		4	3
	S2*	STW	6	22	22	Yes		4	1.1
	S3	STW	6	12	12	Yes		12	12
	S4	DTW	50	33	33	Yes		50	33.3
Dhanusha	D1	ATW	1	0.6	0.5	Yes		2	0.7
	D2	DTW	44	19	15	No	3	35	20
	D3	STW	6	10	10	Yes		4	2.3
Bara	B1	STW	6	15	15	Yes		4	2.7
	B2	STW	6	4	3	Yes		4	0.5
	B3	STW	6	8	8	Yes		4	4
	B4	DTW	50	25	20	No	2	50	30
Chitwan	C1	STW	3	3	3	Yes		4	1.3
	C2	DTW	30	15	15	Yes		30	15
	C3	STW	6	19	19	Yes		4	4
	C4	STW	6	14	14	Yes		4	2.4
Nawalparasi	N1	MTW	24	14	7	No	4	17.5	13.3
	N2	STW	6	12	8	Yes		4	1.2
	N3	MTW	24	20	17	No	2	9	10
	N4	STW	6	8	8	Yes		4	2.7
	N5	DTW	39	11	11	No	4	39	15
	N6	STW	6	11	11	Yes		4	2.7
Rupandehi	R1*	STW	6	6	6	Yes		4	0.2
	R2	STW	6	17	15	Yes		4	15
	R3	ATW	1	0.6	0.5	No	3	2	1
	R4	DTW	83	98	98	No	4	83	30
	R5	STW	6	16	12	Yes		4	8
	R6	STW	6	14	14	Yes		4	2
	R7	DTW	20	20	20	No	4	20	20
Dang	DG1	DTW	17	21	17	Yes		17	17
	DG2	STW	6	18	18	Yes		4	0.5
Banke	BK1	STW	6	21	21	Yes		4	4
	BK2	STW	6	9	9	Yes		4	4
	BK3	DTW	40	11	11	Yes		40	11
Kailali	K1	STW	6	19	19	Yes		4	2
	K2	DTW	40	8	8	Yes		40	17
	K3	STW	6	11	11	Yes		4	1.5
	K4	STW	6	11	11	Yes		4	3.3
	K5	STW	6	13	13	Yes		4	4
	K6	DTW	40	23	23	Yes		40	27
	K7	STW	6	14	12	Yes		4	0.3

* = personally installed.

Annex - XV

Operation and Maintenance Situation of GW Schemes by Sampling

District	Code of scheme	Ownership of Scheme	Scheme Operator	Technical Knowledge of Operator	Operation and Maintenance Cost: Repair and Maintenance Facility: Availability	Frequency of Servicing	Cost of repair maintenance	Operating hours: Own	Rent out	Total	Fuel Consumption	Cost of Fuel	Operating Cost	Remuneration of Operator	Total Cost of O&M	Revenue from Rent out/farmers	Actual Cost of O&M
Jhapa	J1	Individual	Opealor	Insufficient	Available	0	0	300	0	300	1	14	4200	19200	23400		23400
	J2*	Community	0	0	0	0	0	0	0	0	0	0	0		0		0
	J3	Individual	Owner	Insufficient	Available	1	2000	150	0	150	1	13	1950		3950		3950
	J4	Individual	Owner	Insufficient	Available	0	0	84	0	84	1.5	13.35	1682.1		1682.1		1682.1
	J5	Community	Owner	Insufficient	Available	1	1000	90	20	110	1	14	1540		2540	1000	1540
	J6	Community	Owner	Insufficient	Available	0	0	40	0	40	1	13.9	556		556		556
	J7	Community	Owner	Insufficient	Available	2	1000	700	0	700	1	14	9800		10800		10800
	Average					**0.7**	**666.7**	**227.3**	**3.3**	**230.7**	**1.1**	**13.7**	**3288.0**	**3200.0**	**7154.7**	**166.7**	**6988.0**
Siraha	S1	Individual	Owner	Insufficient	Available	2	1200	92	175	267	1	14	3738	0	4938	7000	-2062
	S2	Individual	Owner	Insufficient	Available			200	150	350	1	14.2	4970	0	4970	6750	-1780
	S3	Community	Operator	Insufficient	Available			300		300	1.5	14.2	6390	1500	7890		7890
	S4	Community	Operator	Insufficient	Arg.by Proj.	3/3 hrs.	9925	200		200	6	14.2	17040	1000	27965	20800	7165
	Average					**0.5**	**2781.3**	**198.0**	**81.3**	**279.3**	**2.4**	**14.2**	**8034.5**	**625.0**	**11440.8**	**8637.5**	**2803.3**
Dhanusha	D1**	Individual	0	0	0	0	0						0		0		0
	D2	Community	Operator	Sufficient	Arg.by JADP	1	0	1500	0	1500	2	14	42000	16200	58200	42000	15200
	D3	Individual	Owner	Insufficient	Availble			250		250	1	11.1	2775	0	2775		2775
	Average					**0.5**	**0**	**875**	**0**	**875**	**1.5**	**12.55**	**22387.5**	**8100**	**30487.5**	**21000**	**9487.5**
Bara	B1	Individual	Owner	Insufficient	Availble	0	0	175	100	275	1.25	15	5156.25	0	5156.25		5156.25
	B1	Individual	Owner	Insufficient	Availble	2	1000	350	0	350	0.75	10	2625	0	3625		3625
	B3	Indivdual	Owner	Insufficient	Not-available	0	0	185	100	285	1	11.9	3391.5	0	3391.5		3391.5
	B4	Community	Operator	Sufficient	Arg.by NTP	1	0	0	0	0	15	0	0	27600	27600		27600
	Average					**0.8**	**250.0**	**177.5**	**50.0**	**227.5**	**4.5**	**9.2**	**2793.2**	**6900.0**	**9943.2**	**0.0**	**9943.2**
Chitwan	C1	Individual	Owner	Insufficient	Available	1	0	100	20	120	1	15	1800	0	1800	900	900
	C2	Community	Operator	Insufficient	Arrg.byJADP	0	0	355	0	355	10	15	53250	1500	54750	36920	17830
	C3	Individual	Owner	Insufficient	Available	1	20	180	40	220	1.5	15	4950	0	4970	5200	-230
	C4	Individual	Owner	Insufficient	Na	0	0	100	0	100	0.75	14	1050	0	1050	1200	-150
	Average					**0.66666667**	**6.66666667**	**245**	**20**	**265**	**4.41666667**	**19.6666667**	**20350**	**500**	**20856.6667**	**14740**	**6116.66667**
Nawalparasi	N1	Community	Operator	Insufficient	Arg.by ILC	0	0	250		250	8	3.05	6100	2000	8100		8100
	N2	Individual	Owner	Insufficient	Available	1	1500	150		150	0.75	14.5	1631.25		3131.25		3131.25
	N3	Community	Operator	Insufficient	Arg.by ILC	0	0	325		325	10	3.05	9912.5	2437.5	12350		12350
	N4	Individual	Owner	Sufficient	Available	1	800	88		88	1.25	14.1	1551		2351		2351
	N5	Community	Operator	Insufficient	Arg. ILC	1	0	77		77	22	3.05	5166.7	1609	6775.7		6775.7
	N6	Individual	Owner	Insufficient	Available	0	0	100		100	1	14	1400	0	1400		1400
	Average					0.5	383.3	165.0	0.0	165.0	7.2	8.6	4293.6	1007.8	5684.7	0.0	5684.7

Cont...

District	Code of scheme	Ownership of Scheme	Scheme Operator	Technical Knowledge of Operator	Operation and Maintenance Cost												
					Repair and Maintenance Facility			Operating hours									
					Availability	Frequency of Servicing	Cost of repair maintenance	Own	Rent out	Total	Fuel Consumption	Cost of Fuel	Operating Cost	Remuneration of Operator	Total Cost of O&M	Revenue from Rent out/farmers	Actual Cost of O&M
Rupandehi	R1	Individual	Owner	Insufficient	Available	2	2000	140	0	140	1.25	14	2450		4450		4450
	R2	Individual	Owner	Insufficient	Available	1	3000	60	100	160	1.25	14	2800		5800	6000	-200
	R3**	Individual											0		0		0
	R4	Community	Operator	Insufficient	Arg.by BLIP			370		370	75	1.5	41625	3700	45325		45325
	R5	Individual	Operator	Sufficient	Available			100	100	200	1	15	3000		3000	6000	-3000
	R6	Individual	Owner	Insufficient	Available			100	50	150	1	14	2100		2100	3000	-900
	R7	Community	Operator	Insufficient	Prov.BLGIP								0		0		0
	Average					**0.6**	**1000.0**	**154.0**	**50.0**	**204.0**	**0.9**	**11.7**	**10395.0**	**740.0**	**12135.0**	**3000.0**	**9135.0**
Dang-Deukhuri	DG1	Community	Operator	Insufficient	Available			150		150	15	5	11250	1125	12375		12375
	DG2	Individual	Operator	Insufficient	Available			50	10	60	1	14	840		840	2100	-1260
	Average					**0.00**	**0.00**	**100.00**	**5.00**	**105.00**	**0.50**	**7.00**	**6045.00**	**562.50**	**6607.50**	**1050.00**	**5557.50**
Bankey	BK1	Individual	Owner	Insufficient	Available			70	50	120	1.25	14.4	2160		2160	2500	-340
	BK2	Individual	Owner	Insufficient	Available	1	1200	100	100	200	1.5	14.5	4350		5550	6000	-450
	BK3	Community	Operator	Insufficient	Available	1	4500	100		100	32	5	16000	1600	22100		22100
	Average					**0.7**	**1900.0**	**90.0**	**50.0**	**140.0**	**0.9**	**11.3**	**7503.3**	**533.3**	**9936.7**	**2833.3**	**7103.3**
Kailali	K1	Individual	Owner	Insufficient	Available			135		135	1	15	2025		2025		2025
	K2	Community	Operator	Insufficient	Available	2	4000	100		100	1	15	1500		5500		5500
	K3	Individual	Owner	Insufficient	Available	1	2500	120		120	1	14.5	1740		4240		4240
	K4	Individual	Owner	Insufficient	Available	1	1200	326	50	376	1	14.5	5452		6652	2500	4152
	K5	Individual	Owner	Sufficient	Available	1	3000	90	25	115	1	14.5	1667.5		4667.5		4667.5
	K6	Community	Operator	Insufficient	Not Avai.			250		250	2.5	14.5	9062.5	2800	11862.5		11862.5
	K7	Individual	Owner	Insufficient	Available			175		175	1	14.5	2537.5		2537.5		2537.5
	Average					**0.7**	**1528.6**	**170.9**	**10.7**	**181.6**	**1.2**	**14.6**	**3426.4**	**400.0**	**5354.9**	**357.1**	**4997.8**

Cost of Production and Returns of major crops (From a STW Scheme)

Sn	Particulars			Value		After		Value
		Area	Rate/Ha	(Rs.)	Area		Rate/Ha	(Rs.)
I	Costs							
1	Paddy	3.6	8531	30713	3.6		8531	30713
2	Wheat	1.4	7165	10031	2.5		7165	18056
3	Maize	0.5	6361	3180	0.3		6361	1832
	Total Costs	5.5		43924.24	6.4			50600.82
II	Retutns							
1	Paddy	3.6	11500	41400	3.6		17500	63000
2	Wheat	1.4	4800	6720	2.5		8800	22176
3	Maize	0.5	7000	3500	0.3		8500	2448
	Total Returns	5.5		51620	6.4			87624
	Gross Margin			7696				37023

Note :

1. Avg. Area Coverage Of A Stw — 3.6 Ha
2. Avg. Cropping Intensity — 154% (Before)
   178% (After)
3. Cost Of Production Includes Household Labour As Well

Cost of Production and Returns of major crops
(From a DTW scheme)

Annex-XVII

SN	PARTICULARS	BEFORE		VALUE		AFTER	VALUE
		AREA	RATE/HA	(Rs.)	AREA	RATE/HA	(Rs.)
I	COSTS						
1	PADDY	21.4	8531	182570	21.4	8531	182570
2	WHEAT	8.6	7165	61334	15.0	7165	107335
3	MAIZE	3.0	6361	19056	1.7	6361	10889
	TOTAL COSTS	33.0		262960	38.1		300794
II	RETUTNS						
1	PADDY	21.4	11500	246100	21.4	17500	374500
2	WHEAT	8.6	4800	41088	15.0	8800	131824
3	MAIZE	3.0	7000	20972	1.7	8500	14552
	TOTAL RETURNS	33.0		308160	38.1		520876
	GROSS MARGIN			45200			220082

Note :

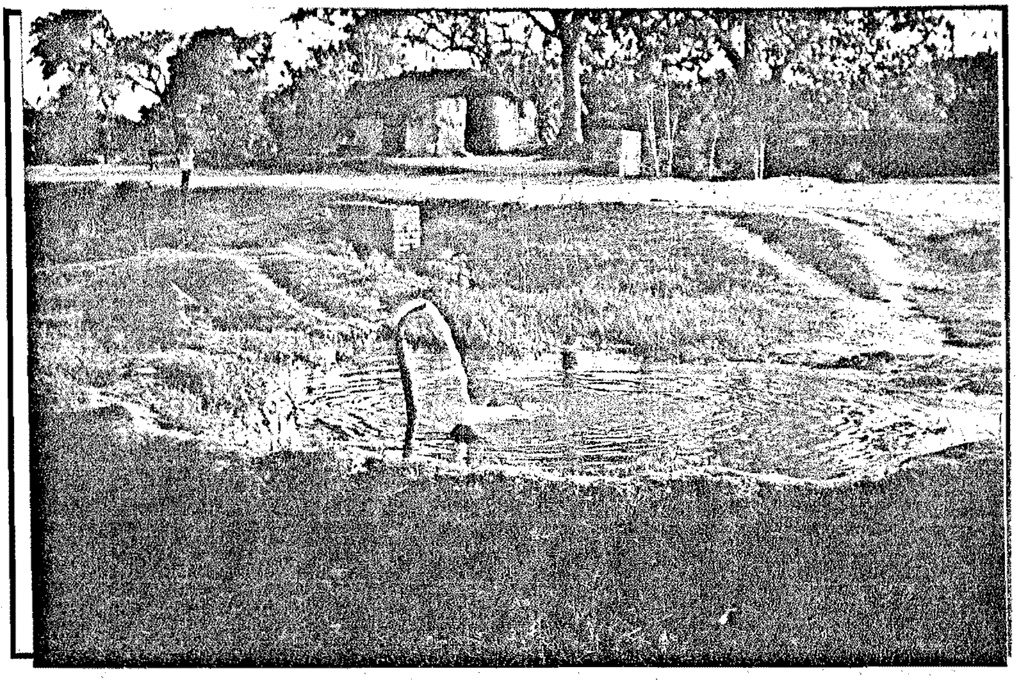
1. Avg. Area coverage of DTW — 21.4 ha
2. Avg. Cropping intensity — 154 (before)
   178 (after)
3. Cost of production includes household labour as well

ANNEX-XVIII

STUDY TEAM COMPOSITION

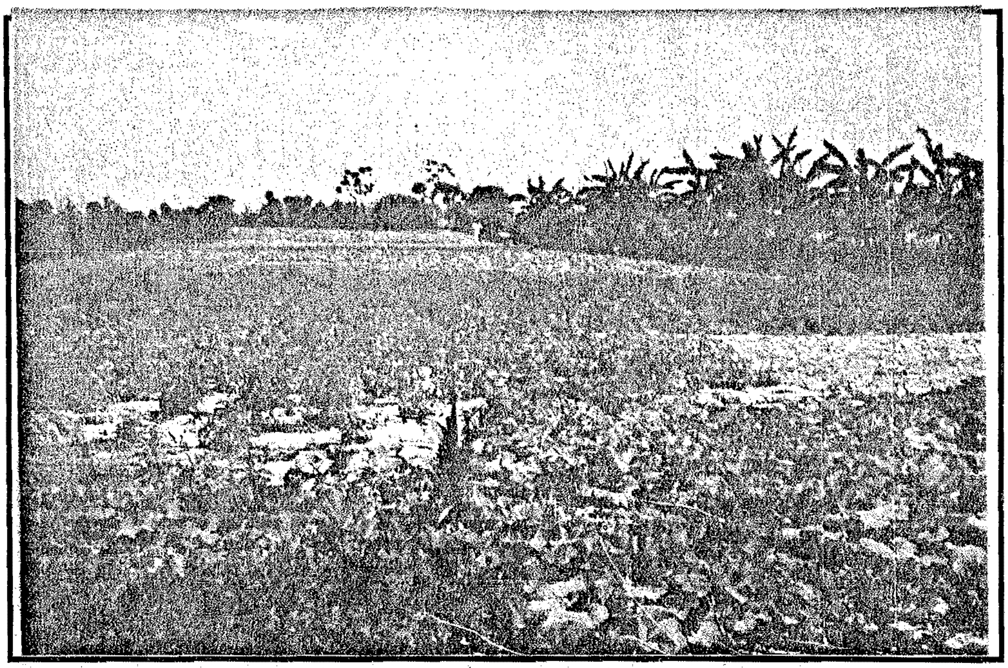
1.	MR. RAM KUMAR SHARMA	TEAM LEADER/ ECONOMIST	MENTOR
2.	MR. ISHOR NEUPANE	SOCIOLOGIST	MENTOR
3.	MR. HEM RAJ POUDYAL	AGRICULTURIST/RURAL DEVMT. SPECIALIST	MENTOR
4.	MR. PREM B. SHRESTHA	IRRIGATION ENGINEER	MENTOR
5.	MR. PRASIDDHA SUWAL	AGRONOMIST	MENTOR
6.	MR. DURGA KHATIWADA	SECTION OFFICER	NPC
7.	MR. BISHNU GAUTAM	RESEARCH ASSISTANT	MENTOR
8.	MR. INDRA B. THAPA	STENO	MENTOR

PHOTOS

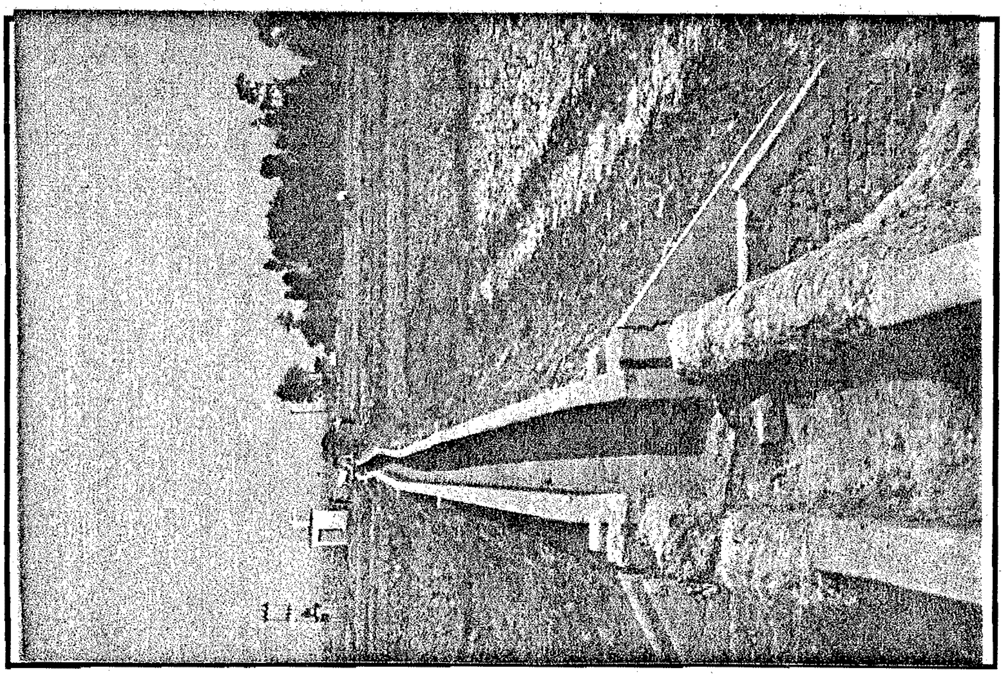


1.5" FLOWING ARTESIAN OF RUPANDEHI

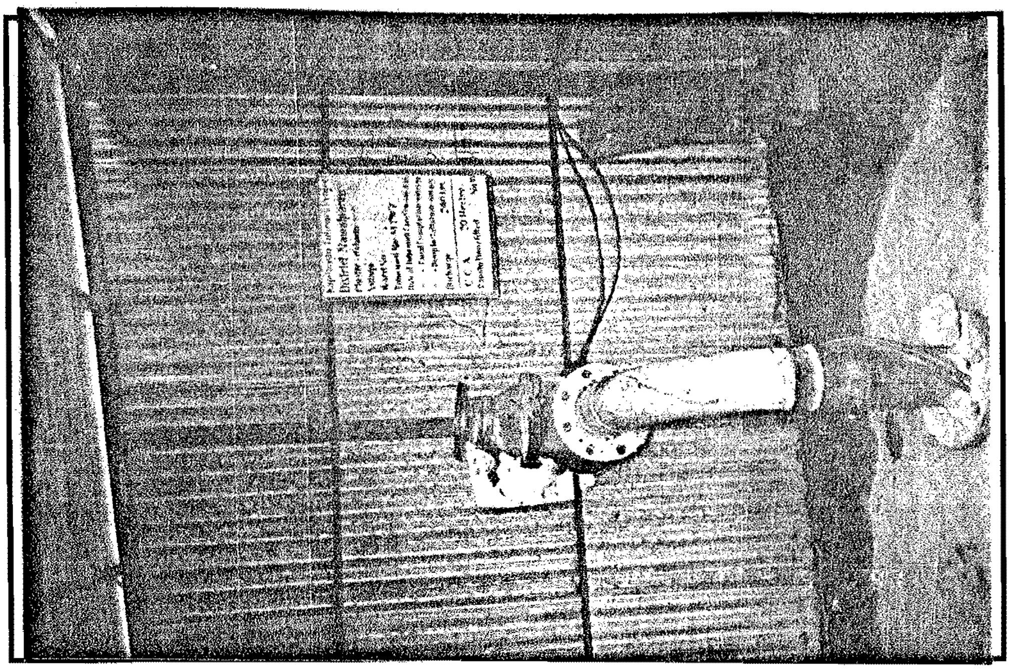
DISCHARGE MEASUREMENT OF STW



VEGETABLE AND BANANA FARMING BY GW SCHEME

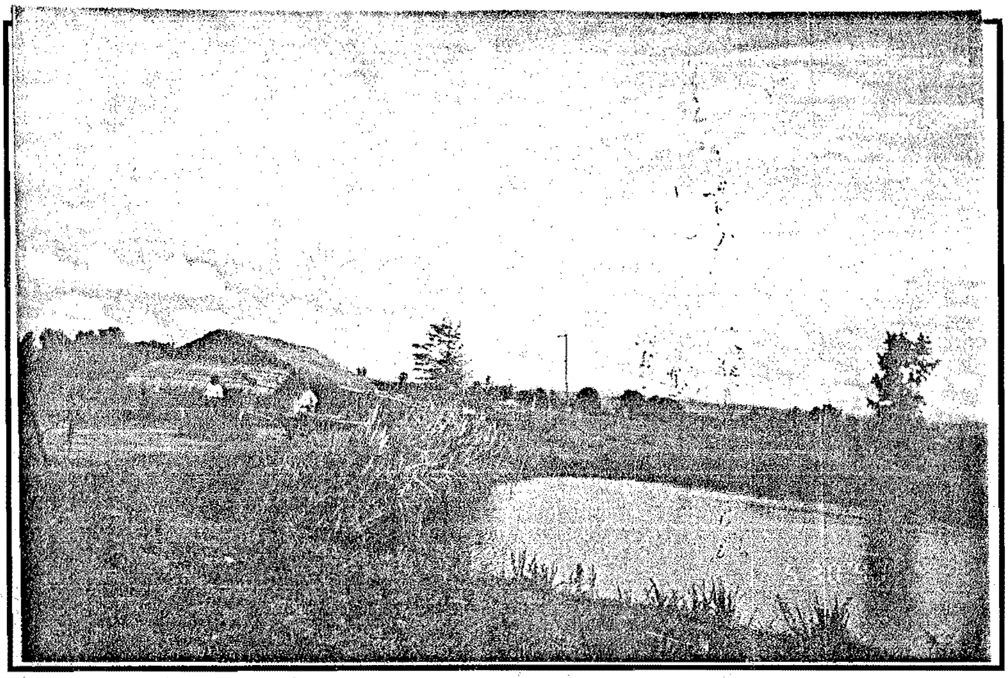


DAMAGE CANAL OF DEEP TUBEWELL, BANKE

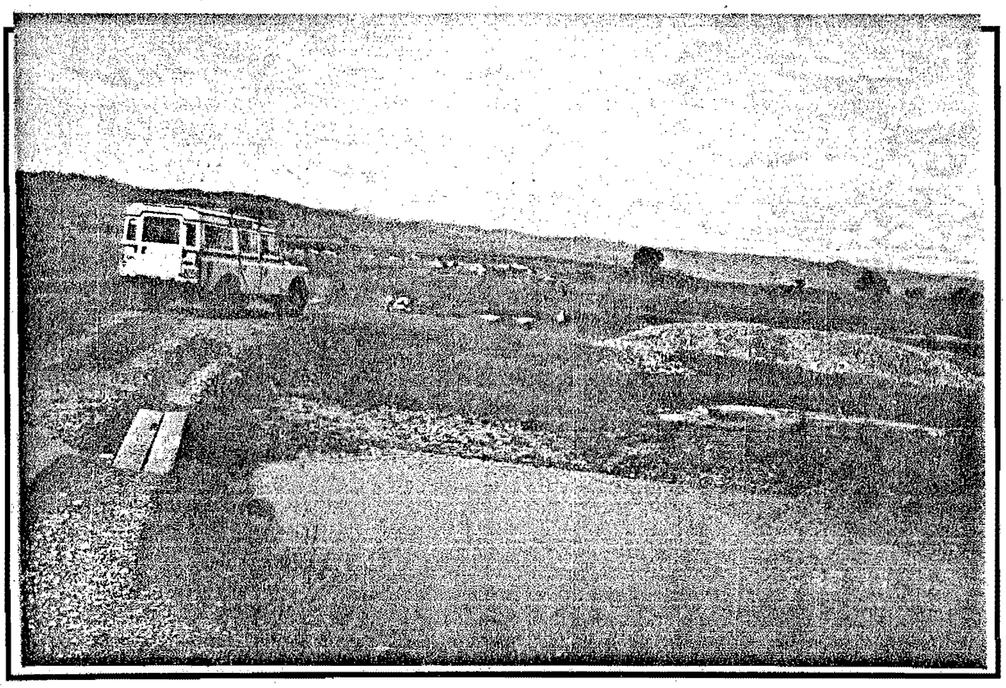


MEDIUM TUBEWELL OF NAWALPARASI

GW WATER IS BEING USED FOR DOMESTIC PURPOSE



GW SCHEME USED IN FISH POND



STUDY TEAM IN THE FIELD