- acreage of direct ground survey, 100 (ha),
- survey method consists of two modes: a traverse survey and a plan table survey,
- contour lines should delineate with 25 cm intervals,
- creation of a topographical map with the scale of 1:1,000, including the existing road system, land-use, streams, households, wells, electrical power lines, and so on.

(3) Case Study of the Sample Area

In order to propose the most economical facility plan for the irrigation system, a case study of three systems has been carried out based on DTW yields and the following assumptions:

- one pump station is proposed for the beneficiary area of 100 ha (yield of DTW = 90 l/sec)
- two pump stations are proposed for the beneficiary area of 100 ha (yield of DTW = 45 l/sec)
- three pump stations are proposed for the beneficiary area of 100 ha (yield of DTW = 30 l/sec)

As a result of the above case studies, one pump station (case study I) is the most recommended facility from the point of view of construction costs and O/M costs. However, as far as the break-even point is concerned, an economical analysis including benefits is required.

6.3.2. Irrigation Facility

Irrigation facilities consist of the following three categories in the DTW Development Project:

- water resources (deep tubewell)
- pumping facilities (pump and motor)
- water distribution system (pipeline and open canal system)

Specific conditions of the preliminary design for above categories are summarized below.

(1) Deep Tubewell (DTW)

DTWs are suitable in the Terai Plain because higher yields can be expected consistently compared with shallow tubewell yields in the proposed three sub-areas in each district.

Jhapa	(60-160)	120 l/sec
Mahottari	(28-120)	66 l/sec
	(19-120)	97 l/sec
Banke	(89-120)	110 l/sec

In connection with the yield of 120 l/sec, a typical deep tubewell with ND 250 mm steel liner to a depth of 130 m is required to drill in a minimum spacing at approximately 1.0 km.

For the standard design, the pump housing pipe with a diameter of 400 mm is provided to the depth of 50 m below the ground surface. The housing, casing, and reducer pipes are made from black mild steel pipe with a wall thickness of 10 mm for the housing and reducer pipes, and 9 mm for the casing pipe.

(2) Pump and Motor

For a proposed deep tubewell, a vertical shaft multi-stage turbine pump driven with an electric motor will be installed inside the pump housing casing.

The static head for three sub-areas is estimated at 30 m, and the diameter of the pump is assumed at approximately 250 mm, therefore, the following power outputs are required in three sub-areas.

Jhapa	120 l/s	H = 30 m	P = 62 kw
Mahottari	66 l/s	H = 30 m	P = 35 kw
Mahottari	97 l/s	H = 30 m	P = 54 kw
Banke	110 l/s	H = 30 m	P = 57 kw

The power is supplied from NEA 11 kv distribution system through a transformer and a three phase connection line to the control panel for the star-delta starter.

(3) Water Distribution System

As mentioned in sub-chapter 6.1.3, an arborescent pipeline system will be applied to the main canal and the branch canals to the inlets of irrigation blocks with 4 ha to 5 ha. Distribution system in each irrigation block is constructed with the open canal system (terminal canal) in one or two upper sides of block.

The outlet of the pipeline in the irrigation block is prepared with an alfalfa valve, which makes it possible to control the discharge depend on the water demands.

According to the case study in the sample area, the canal intensity of the pipeline system is required to be approximately 40 m/ha, and the diameter of these pipes varied from 100 mm to 350 mm, all of which are constructed with PVC. Earth canals are adapted as tertiary canals and as canals in the irrigation block. Typical sections of the canals are prepared in Appendix 4-4.

6.3.3. Drainage Facility

The design discharge of the drainage system has been studied during the preceding projects in the Terai Plain.

According to results of these studies, the design discharge is estimated at 4 l/sec/ha to 5 l/sec/ha.

The minimum canal section should be considered from the view point of the construction stage. The canal capacity of the minimum section has been examined in the case study of the sample area and has the capacity to sufficiently cover the design discharge (4 l/s/ha). Canal type and dimensions are shown in Appendix 4.4.

6.3.4. Road Network

Through a field investigation of the selected sub-area, the road network is considered to be very poor in connecting village to village and village to town, presenting a problem to farmers in terms of farm management.

Based on this background, an all-weather road network is required to provide farmers access to markets; to allow the introduction of new farm inputs and other project extension services; and to facilitate the operation and maintenance of tubewells.

In order to construct an efficient road network for the above mentioned purposes, roads are classified into three categories: district roads, class 1 village roads, and class 2 village roads.

The planning and construction of district roads are the responsibility of the Highway Division, therefore, this report deals only with class 1 and class 2 village roads.

(1) Village Road-Class 1

These roads are intended to link the cluster of villages each other and to connect with the district road. The proposed class 1 village road is designed for light and sporadic traffic, and its width of 6.0 m provides a 3.5 m traffic lane and two shoulders 1.25 m each. Gravel pavement provides for stable all-weather surface, which will require only limited maintenance work As many of the drilling sites are situated adjacent to these roads, the roads will serve as a means of access to the construction sites.

Based on the preceding projects in the Terai Plain, the length of class 1 roads required for the proposed sub-areas are estimated as follows:

Proposed Sub-area	Unit. L (m/ha)	Beneficial A (ha)	Total L (km)
Jhapa	4.5	17,000	76.5
Mahottari	4.5	7,000	31.5
Banke	4.5	8,000	36.0
Total		32,000	144.0

(2) Village Road-Class 2

Class 2 roads will be constructed as means of access to isolated drilling sites or villages which is not situated adjacent to a class 1 village road. The formation width is only 3.5 m, sufficient for occasional vehicles with no passing traffic.

Based on the same assumption as above, the length of the required class 2 road is calculated as follows. A typical section of a village road is compiled in Appendix 4.4.

Proposed Sub-area	Unit. L (m/ha)	Beneficial A (ha)	Total L (km)
Jhapa	5.4	17,000	91.8
Mahottari	5.4	7,000	37.8
Banke	5.4	8,000	43.2
Total		32,000	172.8

6.3.5. Power Supply System

As mentioned in the general maps, the existing and proposed power line network with 11 kv is not sufficient to cover the proposed sub-area in each district. Jhapa and the northern part of Mahottari are especially suffering from a lack of generation capacity.

According to the preceding project in Terai, the length of required transmission line with 11 kv or 32 kv is approximately 10 m/ha, as an average value for a beneficiary area.

In the case of the three proposed sub-areas, the length of transmission line with 11 kv for each beneficiary area is based on considerations of the existing available facilities, and are summarized below.

Proposed Area	B.A (ha)	Unit. L (m/ha)	Total L (km)
Jhapa	17,000	10.0	170
Mahottari	7,000	10.0	70
Banke	8,000	10.0	80
Total	32,000		320

6.3.6. Technical Supporting Office for Post Project

(1) Background and Objective

Agricultural development in the Irrigation Project is divided into two stages: a project implementation stage and an operation and maintenance stage.

At present the Project Office of the large-scale development project is achieving two objectives during the construction period. One objective is supervision of the construction works, and the second objective is the water management and farm management, and so on, for farmers groups in completed project areas. However, after the project is completed, the support system for the farmers groups in the beneficiary area does not seem to be sufficient, especially because of lacking of training in the operation and maintenance, such as pumps, motors, diesel engines, pipeline systems, and the treatment of wells.

Furthermore, there are other major problems such as the supply of spare parts for the above facilities and relation with the finance of the farmer groups.

In order to alleviate these problems, the establishment of a Technical Supporting Office for Operation and Maintenance has been proposed in the project area.

(2) Organization of the Technical Supporting Office (TSO)

The organization of TSO will be established in consideration of the relationship between the relevant governmental agencies and farmer groups (WUG).

Farmer groups will be established according to governmental policies. In this connection, minimum units will be organized within each beneficiary area of one well, which is assumed to cover approximately 70 ha to 150 ha.

TABLE 6.2.1

WATER DEMANDS of PRIORTY SUB-AREA FOR DISTRICTS

District	Crop	Month JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Total/Year (10^3m^3)
JHAPA	Spring Maize A=2,550 (ha)			3,782	5,830	3,241								12,853
	Spring Paddy A=6,800 (ha)			10,227	23,820	13,532	–	–						47,579
	Main Paddy A=17,000 (ha)							–	4,420	–	27,591	19,805	1,122	52,938
	Wheat A=5,100 (ha)	3,550	6,207	6,411	–								1,230	17,398
Total $V=10^3m^3$		3,550	6,207	20,420	29,650	16,773	–	–	4,420	–	27,591	19,805	2,352	130,768
MAHOTTARI	Spring Paddy A=700 (ha)				3,512	2,548	1,138	–						7,198
	Main Paddy A=7,000 (ha)							2,093	14,672	10,122	15,372	8,351	427	51,037
	Wheat A=3,430 (ha)	2,518	4,981	5,204	521								892	14,116
Total $V=10^3m^3$		2,518	4,981	5,204	4,033	2,548	1,138	2,093	14,672	10,122	15,372	8,351	1,319	72,351
BANKE-BARDIYA	Spring Maize A=1,200 (ha)			1,832	3,724	4,294	926							10,776
	Main Paddy A=6,960 (ha)							202	10,509	6,918	15,291	8,011	285	41,216
	Wheat A=4,000 (ha)	2,296	4,316	5,372	1,012								680	13,676
Total $V=10^3m^3$		2,296	4,316	7,204	4,736	4,294	926	202	10,509	6,918	15,291	8,011	965	65,668

Note : Arable land of Priority Sub-area for District
JHAPA : 17,000 (ha)
MAHOTTARI : 7,000 (ha)
BANKE-BARDIYA : 8,000 (ha)

TABLE 6.2.2

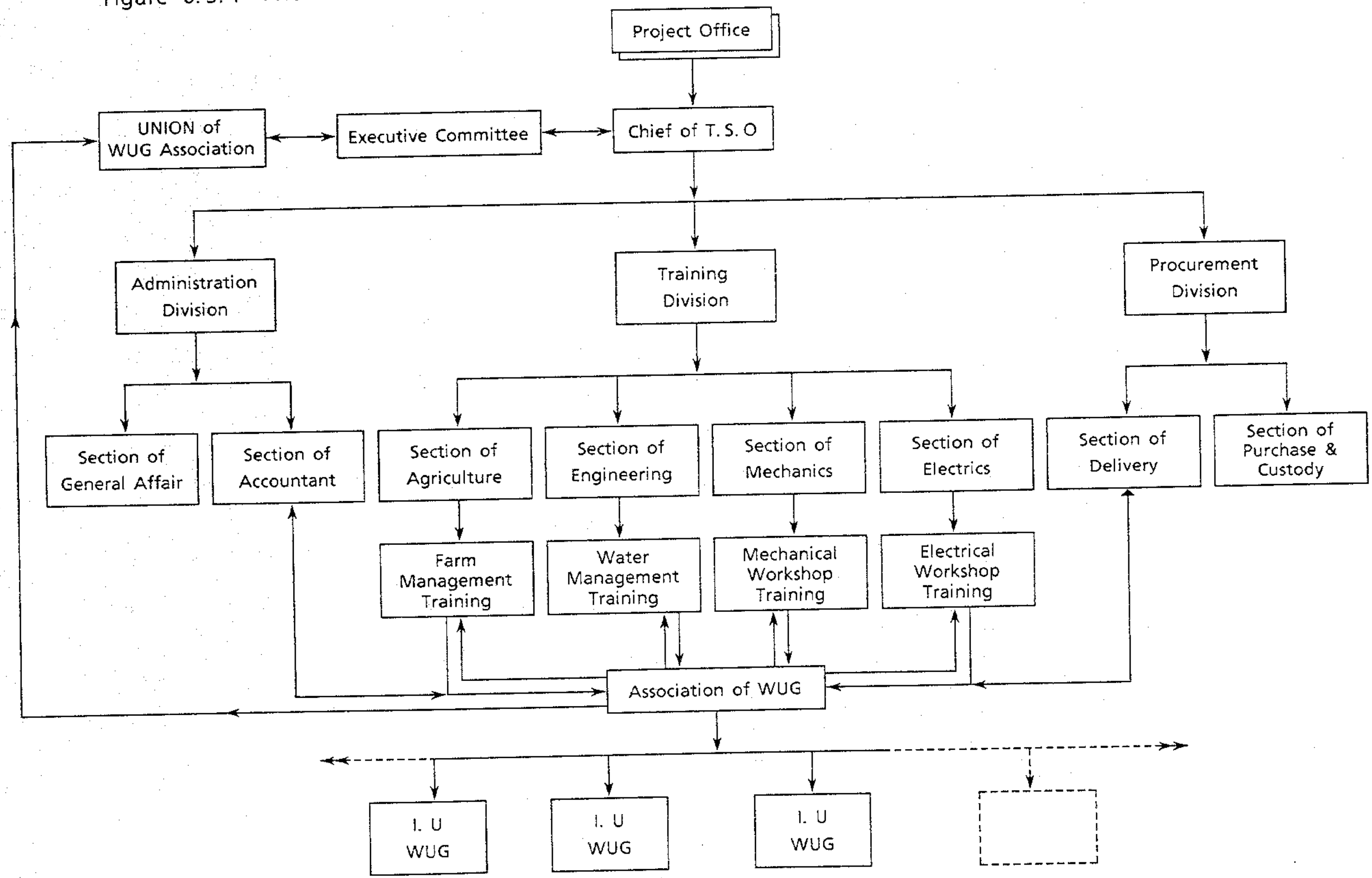
DESIGN DISCHARGE OF PRIORITY SUB-AREA IN EACH DISTRICTS

(Unit: ℓ/s/ha and ℓ/s)

	Month																								Remarks
	JAN.		FEB.		MAR.		APR.		MAY		JUN.		JUL.		AUG.		SEP.		OCT.		NOV.		DEC.		
Spring Maize A=15 (ha)						1.1	0.9	0.9	0.5	0.5	-	-													ℓ/s/ha
						16.5	13.5	13.5	7.5	7.5															ℓ/s
Spring Paddy A=40 (ha)						1.1	1.6	1.2	0.7	0.8															ℓ/s/ha
						44	64	48	28	32															ℓ/s
Main Paddy A=100 (ha)															0.2	-	-	-	0.6	0.6	0.6	0.3	0.1	-	ℓ/s/ha
															20				60	60	60	30	10		ℓ/s
Wheat A=30 (ha)	0.2	0.3	0.5	0.5	0.6	0.4	-	-															-	0.1	ℓ/s/ha
	6	9	15	15	18	12																		3	ℓ/s
Total	6	9	15	15	18	73	*78	62	36	40					20				60	60	60	30	10	3	ℓ/s
Spring Paddy A=10 (ha)							1.5	2.3	1.4	1.4	0.8	0.4													ℓ/s/ha
							15	23	14	14	8	4													ℓ/s
Main Paddy A=100 (ha)														0.2	1.0	0.6	0.6	0.6	0.8	0.8	0.6	0.3	0.1	-	ℓ/s/ha
														20	*100	60	60	60	80	80	60	30	10		ℓ/s
Wheat A=49 (ha)	0.2	0.3	0.6	0.6	0.7	0.4	0.1	-																	ℓ/s/ha
	9.8	14.7	29.4	29.4	34.3	19.6	4.9	-																	ℓ/s
Total	10	15	30	30	34	20	20	23	14	14	8	4		20	100	60	60	60	80	80	60	30	10		ℓ/s
Spring Maize A=15 (ha)						1.1	1.2	1.2	1.3	1.3	0.6														ℓ/s/ha
						16.5	18.0	18.0	19.5	19.5	9.0														ℓ/s
Main Paddy A=87 (ha)															0.8	0.4	0.4	0.4	0.8	0.8	0.6	0.3	-		ℓ/s/ha
															69.6	34.8	34.8	34.8	69.6	69.6	52.2	26.1	-		ℓ/s
Wheat A=50 (ha)	0.2	0.3	0.4	0.5	0.6	0.4	0.1	0.1																	ℓ/s/ha
	10	15	20	25	30	20	5	5																	ℓ/s
Total	10	15	20	25	30	37	23	23	20	20	9				70	35	35	35	70	70	52	26			ℓ/s

Note: Beneficial area is fixed as a hundred hectares.
Acreage of each cropping area are estimated by the percentage of cropped area in proposed cropping pattern.
* JHAPA. D. D 0.8ℓ/s/ha * MAHOTTARI. D. D 1.0ℓ/s/ha *BANKE-BARDIYA D. D 0.7ℓ/s/ha

Figure 6.3.1 PROPOSED ORGANIZATION CHART OF TECHNICAL SUPPORTING OFFICE (T. O. S)



6.4. Project Plan

6.4.1. Basic Strategy

The most significant feature of the deep tubewell irrigation project is the self-sufficient, independent system in the command area of each deep tubewell. The system is essentially a grouping of the above individual systems, regardless of the size of the project area.

Designing the necessary facilities for a standard individual area is required for establishment of the project plan.

From the above perspective, a sample area with 100 ha is selected as a representative area, and the topographical map is created based on the direct survey measurements (scale 1:1,000); and the standard design for the required scheduled facility is constructed (refer to Fig. 6.4.1).

The following chapters discuss the project plan based on the above standard design and examples from the preceding project in Terai plain.

6.4.2. Project Component

The major project components are as follows.

(1) Deep Tubewell Development

As mentioned in Chapter 2.5 Groundwater Potential, the average yield potential of the wells in each district is different but the facility scale for each district is considered as same scale.

(2) Pump Facility

Pumps have a high pump head of 30 m. Considering the parts' supply, operation, and maintenance, a shaft turbine pump already widely used in Terai will be used. An electric motor will be used from the viewpoint of operation and maintenance. Ancillary facilities include a pump shed, operator house, and an elevated water tank. The required distance for the power transmission line is estimated from the example of the preceding project in Terai plain.

(3) Pipeline System

A pipeline system is required for the project site. The total length, pipe diameter, and type of pipe are determined based on the standard design of the sample area.

(4) Terminal Irrigation Canal System

The type of canal system, total length, and canal cross-section are determined based on the standard design of the sample area.

(5) Drainage System

The drainage system's canal layout, cross-section, and total length are determined based on the standard design in the sample area.

(6) Road Network

The road network's layout, total length, and type of paving are determined based on examples of the preceding project.

6.4.3. Project Facilities

Based on the standard design in the sample area, and similar prior projects in the Terai Plain, the project dimensions required in each project area are determined and summarized in Table 6.4.1.

6.4.4. Project Implementation Plan

The project implementation schedule is determined based on the project components and project quantities in the each project area. Figure 6.4.2 summarizes the scheduled project implementation preparation and regular project implementation, including detailed designs.

The preparation stages, such as the details design, creation of tender documents, tenders, and construction of offices, will require three years for each district. Organizing WUGs and land acquistion land for roads and canals will require five years in Jhapa Study area and four years in the other two districts. Road construction will be implemented prior to regular facility construction. This construction will require five years in Jhapa Study area and four years in the other two study areas. Regular facility construction, such as wells, transmission lines, canals, and drainage, will require six years in Jhapa Study area, five years in Mahottari Study area, and four years in Banke Study area.

Based on the above, the total project period for Jhapa Study area is estimated at 10 years, nine years for Mahottari Study area, and eight years for Banke Study area.

Based on economic evaluation related to the project area in each district, the greatest economic effects will occur in Jhapa Study area, followed by Banke and Mahottari. Given this fact, beginning the project in Jhapa Study area will have the most effective results.

Table 6.4.1 Planned Project Quantities List

Work Items / Project	JHAPA	MAHOTTARI	BANKE-BARDIYA	Remarks
	A=17,000 ha	A=7,000 ha	A=8,000 ha	
1. Deep-Tube Well				A; Irrigable Area
Well Depth	130 m	130 m	130 m	
Length of Casing	50 m	50 m	50 m	
ND of Casing	250 mm	250 mm	250 mm	
Length of Screen	30 m	30 m	30 m	
Housing	L=50 m D=400 mm	L=50 m D=400 mm	L=50 m D=400 mm	
No of Well	113	92	51	
2. Pump Facility				
Type of Pump	Shaft Turbine Pump	Shaft Turbine Pump	Shaft Turbine Pump	
Total Head	30 m	30 m : 30 m	30 m	
Diameter	250 mm	250 mm : 200 mm	250 mm	
Out-put of Motor	65 kw	54 kw : 35 kw	57 kw	
No. of Pump	113	31 : 61	51	
Length of Power-line	170 km	70 km	80 km	11 KV line
No. of Transformer	113	92	51	11 KV/400 V
3. Pipe line System				
Length of Pipeline	680 km	300 km	320 km	
Diameter (D)	100-400 mm	100-350 mm	100-400 mm	
Type of Pipe	PVC	PVC	PVC	
No. of Valve	4,070 Set	1,750 Set	1,940 Set	Alfalfa Valve ø =100mm
4. Terminal Canals	1,240 km	560 km	610 km	Earth Canal
5. Drainage System	770 km	330 km	360 km	
6. Road System	170 km	74 km	77 km	Village Road
7. Building	2	2	2	

Figure 6.4.1 Model Design in the Irrigation Unit

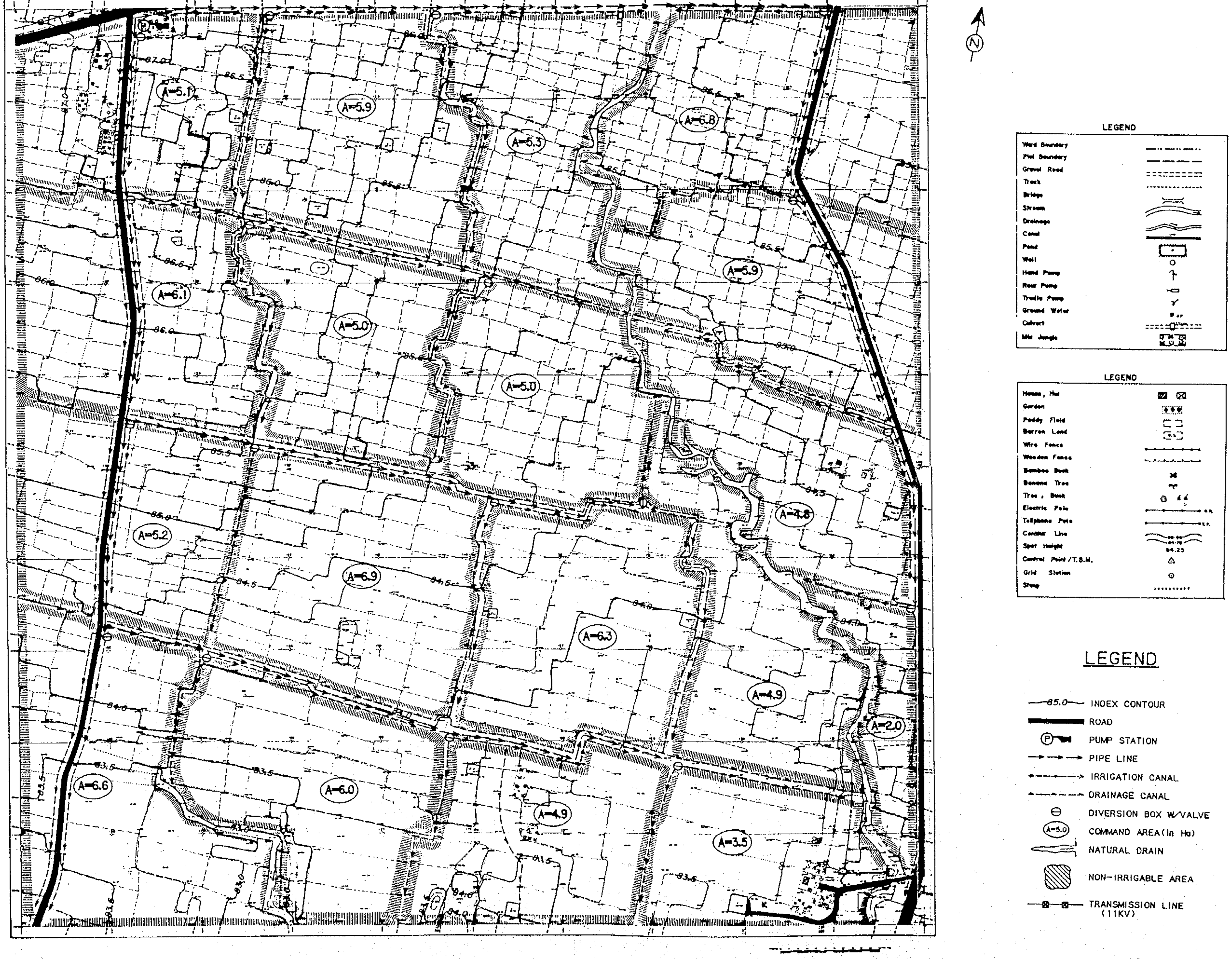
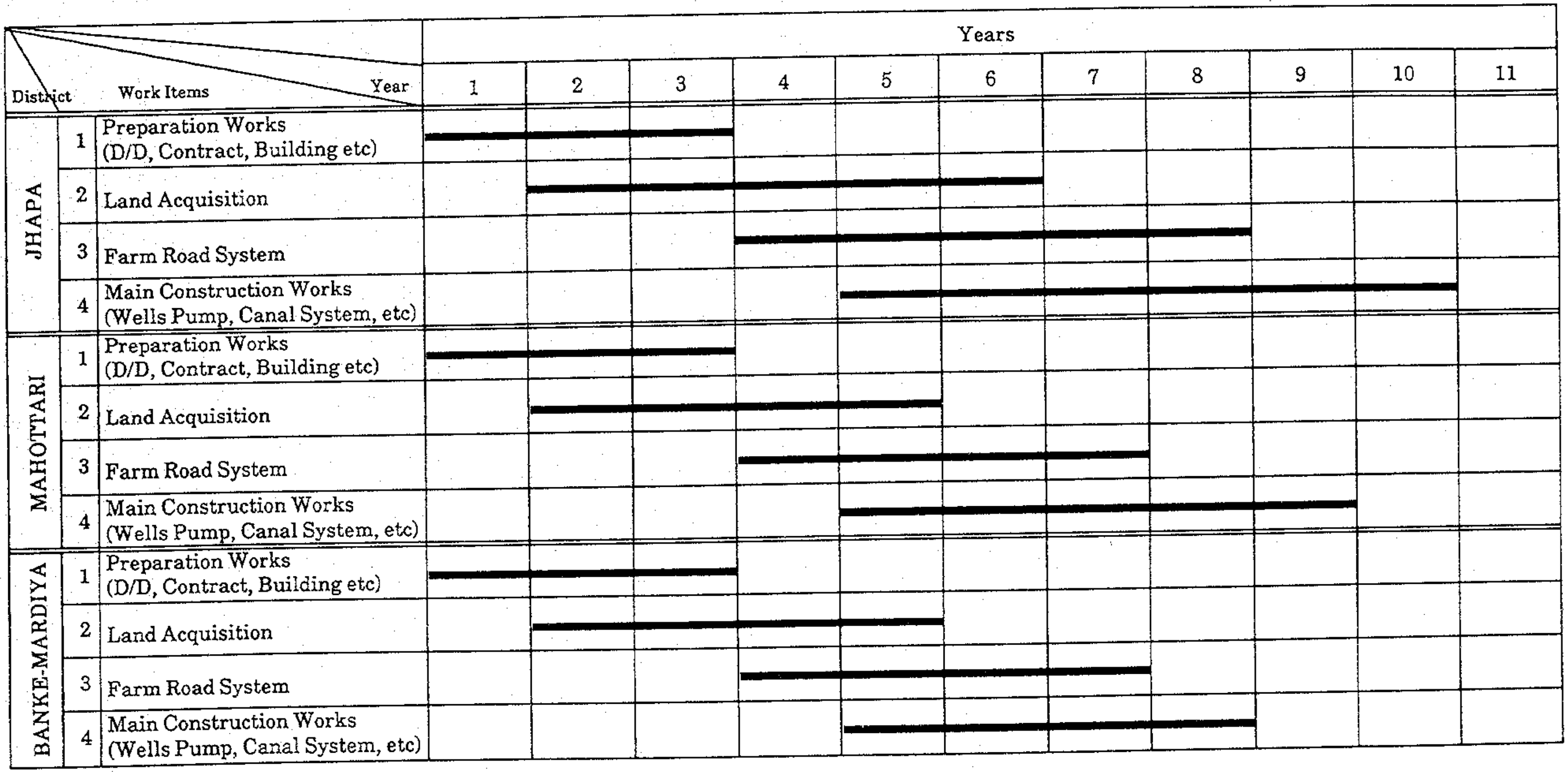


Figure 6.4.2 Project Implementation Schedule Plan



6.5. Environmental Considerations

Environmental considerations in groundwater development include (1) water privileges, (2) groundwater, (3) water pollution, (4) noise and vibration, and (5) land subsidence (JICA, Environmental Consideration Guidelines, 1994). The environment impact of the above items related to groundwater development in this project are estimated and counter-measures are discussed.

(1) Water Right

Water right for existing wells are interfered by the reduction of pumping in existing wells and a drawdown of the groundwater head by new groundwater development.

The current groundwater usage in Jhapa District includes two deep tubewells at the Chandragadhi water source located north of the project site, shallow well usage for domestic water, and small-scale irrigation projects using spring water in the northern part of the area.

Based on the groundwater development simulation for the project area, the maximum groundwater head drawdown, compared with the current water head, is 20 m in every aquifer in the northern terrace and approximately 10 m further north and in the southern area (refer to Fig. 6.5.1). The water head drawdown will influence spring water and shallow well usage to some degree, therefore a careful evaluation in the process of project implementation as well as compensation, such as water source transfers, are necessary. For domestic water use in the project area, irrigation wells can be used.

In Banke District, groundwater usage is based on Nepal Ganges water source deep tubewells and domestic water usage from shallow wells. Irrigation by deep tubewells is fairly developed in Mahottari District. Although simulations have not been conducted in these areas, considerations similar to those in Jhapa District are necessary as a significant groundwater head drawdown is expected. There is no agreement in regard to groundwater privileges between Nepal and India.

(2) Groundwater

This environmental item refers to the groundwater head drawdown caused by excessive pumping, depleting groundwater resources, and water pollution caused by the entry of brine.

The groundwater head drawdown is discussed in the previous section.

The simulation shows that there is sufficient groundwater resources in Jhapa District for the degree of development. Although the other two districts are expected to be similar in this regard, future examinations must be conducted to confirmed this point.

There are no pollutants, such as brine, in the three project areas, and groundwater pollution due to groundwater development is not expected. However, excessive use of chemical fertilizers or agro-chemicals may accumulate in the groundwater system. Careful monitoring of groundwater resources and appropriate countermeasures are essential.

(3) Water Pollution

This refers to surface water and groundwater pollution caused by mud water and oil entering rivers or aquifers as a result of the construction of irrigation facilities such as deep tubewells.

(4) Noise and Vibration

This refers to the noise and vibration caused during the construction of irrigation facilities such as deep tubewells. Noise and vibration are caused especially by deep tubewell drilling machines and construction vehicles. Careful consideration is necessary when undertaking construction near schools, hospitals, public facilities, or animal barns.

(5) Land Subsidence

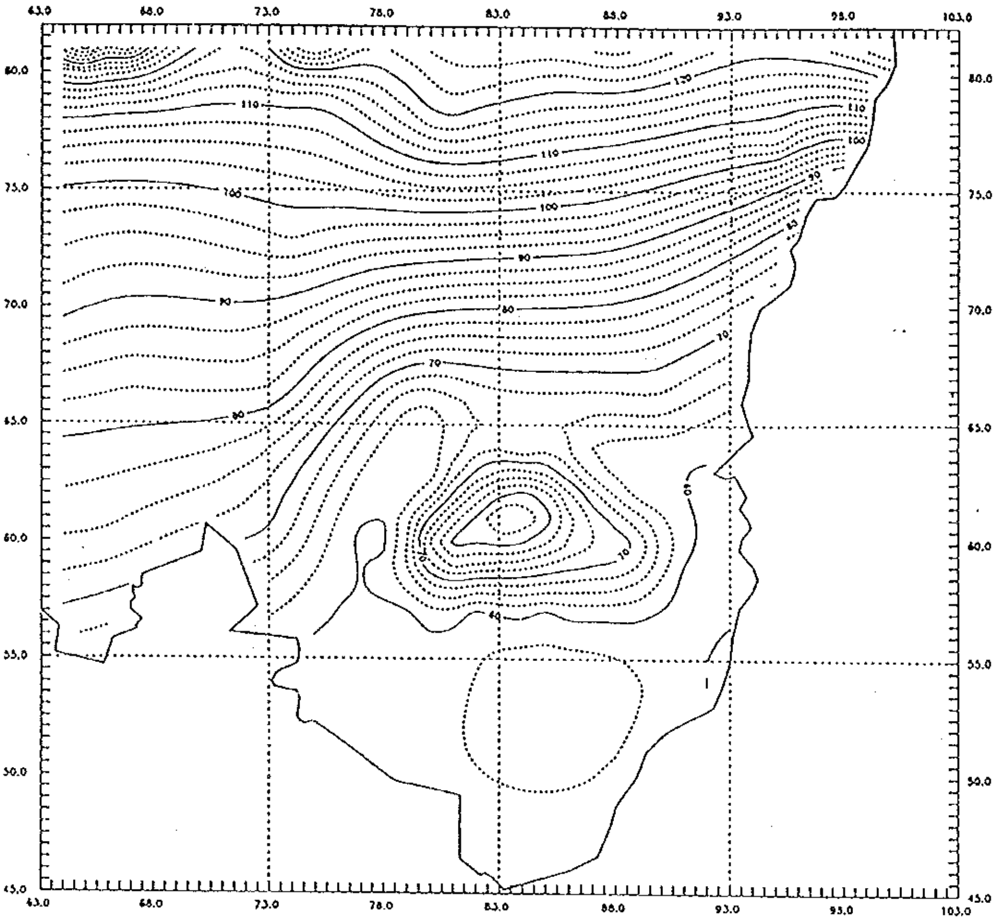
Land subsidence refers to compaction of clay layers because of a drawdown in the groundwater head. The result is land deformation and a deterioration of the social infrastructures, such as canals, roads, bridges, and building, which are most seriously damaged by groundwater development. Land subsidence is a phenomenon which occurs in the weak alluvial sedimentary zones dominated by clay formed at the mouth of rivers.

Gravel dominates the alluvial sedimentary layer in the Terai Plain. As the clay layers have been already been compacted, there is little possibility of damage caused by land subsidence.

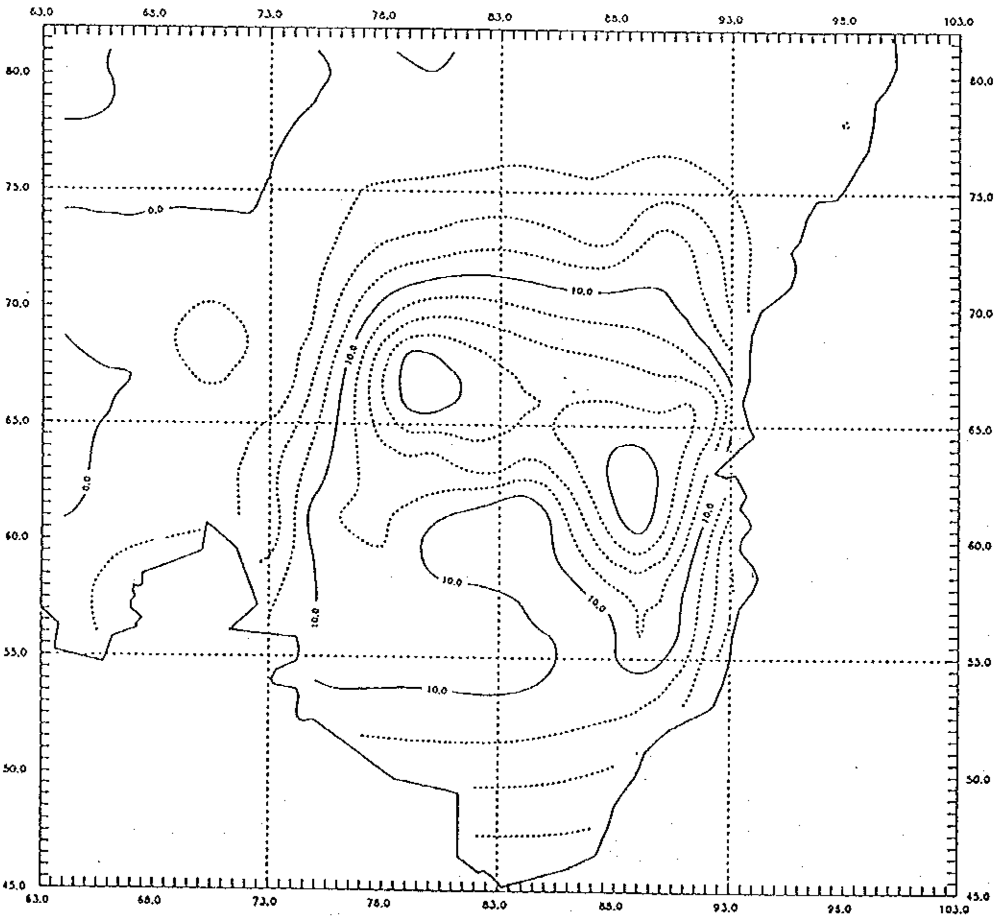
Figure 6.5.1

(a) Groundwater Head on Unconfined Aquifer (UAQ)

Groundwater Head (UAQ) – full development –



(b) Drawdown from the normal condition



CHAPTER SEVEN

PROJECT COST ESTIMATE

CHAPTER-SEVEN: PROJECT COST ESTIMATE

7.1. Quantity and Unit Cost

As mentioned in the previous section, the quantity of the proposed facilities is estimated depending upon the sample area prepared by the Study Team and the preceding projects in Terai Plain.

The basic cost for the project cost has been calculated based on the data collected by the Study Team and the construction costs utilized in similar preceding projects in the Terai Plain. All costs are estimated based on unit prices in June 1993, and the exchange rate is US$ 1 = NRs 50 = JYE 112.

The project cost is comprised of the direct construction cost for tubewells and civil works, procurement cost, technical support, project administration cost, and physical and price contingencies. The project cost of the three projects in each district is as follows.

(1) JHAPA District : 57.8 Mil. NRs (US$3,400/ha)
(2) MAHOTTARI District : 31.7 Mil. NRs (US$4,500/ha)
(3) BANKE-BARDIYA District : 30.2 Mil. NRs (US$3,800/ha)

A summary of the project cost is tabulated in Tables 7.1.1 to 7.1.3., and further breakdown is shown in 7.3.1.

7.2. Operation and Maintenance Cost

O & M cost includes (1) O & M equipment cost, (2) operation cost, and (3) maintenance cost. The operation and maintenance cost of the three representative projects is estimated as follows, and further details are shown in 7.3.2.

(1) Jhapa (A=150 ha) Unit: NRs

O & M Equipment	:	12,350
Operation	:	290,200
Maintenance	:	4,500
Total		347,550
		2,317=2,320 NRs/ha

(2) Mahottari (A=66 ha)

O & M Equipment	:	11,550
Operation	:	173,800
Maintenance	:	24,000
Total		209,350
		3,172 NRs/ha

Mahottari (A=97 ha)

O & M Equipment	:	11,550
Operation	:	236,880
Maintenance	:	30,000
Total		278,430
		2,780 NRs/ha
Average Cost =		3,000 NRs/ha

(3) Banke-Bardiya (A=157 ha)

O & M Equipment	:	12,350
Operation	:	263,640
Maintenance	:	45,000
Total		320,990
		2,050 NRs/ha

7.3. Breakdown of Cost Estimation

7.3.1. Breakdown of Project Cost Estimation

The cost estimation of the Project was carried out referring to the cost estimation of Birganj Project (referred to as B.G.P.) as a rule.

Jhapa District

(1) Well Development

Dimensions of the production well are almost the same as the one applied in the Birganj Project (referred to as B.G.P.). Therefore, the cost estimation on "Well Development" is the same as the B.G.P. (Table H-6 and H-15, Vol.II, B.G.P. Report).

	L/ C	F/C	Total	(NRs'000)
1) Construction	185	655	840	
2) Maintenance	34	642	676	
Sub-total	219	1,297	1,516	

(2) Pump Station

1) Pump Set & Motor: B.G.P. 40 kw, This Project 623 kw

62.3 kw/40=1.6 times

	L/ C	F/C	Total	Remarks
	288	1,488	1,776	1.6 times of Tab. H-16
2) Pump House	198	116	314	Tab. H-12
3) Control Chamber	116	140	256	Tab. H-12
4) Power Supply	474	1,142	1,616	Tab. H-16
Sub-total	1,076	2,886	3,962	

(3) Irrigation Canal System

	L/ C	F/C	Total	Remarks
1) Pipeline System	1,044	828	1,872	Case Study 100 ha 1.5 times of B.G.P.
2) Alfalfa Valve	125	120	245	"
3) Terminal Irrigation	126	-	126	"
Sub-total	1,295	948	2,243	
(4) Drainage System	380	87	467	Sample Area 1.5 times of B.G.P.
(5) Farm Road System	1,535	1,023	2,588	"
(6) Land Acquisition	2,100	-	2,100	7.0 ha
(7) Above (total 1-6) x 113				
(8) Building for O&M	7,527	3,980	11,507	Tab. H-14 x 1.5 times
(9) Procurement of O&M	2,940	52,170	55,110	Tab. H-17 x 1.5 times
(10) Technical Support	108,030	304,530	412,560	Tab. H-18 x 1.5 times
(11) Project Administration	107,730	-	107,730	Tab. H-15 x 1.5 times

Mahottari District (A1: 4,000 ha)

(1) Well Development	L/ C	F/C	Total	Remarks
same as Jhapa	219	1,297	1,516	

(2) Pump Station

35 kw/40 kw = 0.87 ≒ 0.9 times of B.G.P.

1) Pump Set & Motor	162	837	999	0.9 times
2) Pump House	198	116	314	"

3) Control Chamber	116	140	256	"
4) Power Supply	221	532	753	0.7 times (area ratio)
Sub-total	697	1,625	2,322	
(3) Irrigation Canal System	L/ C	F/C	Total	Remarks
1) Pipeline System	487	386	873	Area ratio x 0,7 times
2) Alfalfa Valve	58	56	114	"
3) Terminal Irrigation	59	-	59	"
Sub-total	604	442	1,046	
(4) Drainage System	177	41	218	Area ratio x 0.7 times
(5) Farm Road	716	477	1,193	"
(6) Land Acquisition	990	-	990	3.3 ha

(8) ~ (11) Converted from the estimation of B.G.P. through the area ratio (7,000 ha).

Mahottari District (A2: 3,000 ha)

(1) Well Development: same as A1 area

(2) Pump Station

54 kw/40 kw = 1.35 times

	L/ C	F/C	Total	Remarks
1) Pump Set & Motor	243	1,256	1,499	1.35 times
2) Pump House	198	116	314	"
3) Control Chamber	116	140	256	"
4) Power Supply	307	738	1,045	0.97 times (Area ratio)
Sub-total	864	2,250	3,114	
(3) Irrigation Canal System				
1) Pipeline system	675	535	1,210	0.97 times
2) Alfalfa Valve	21	78	159	"
3) Terminal Irrigation	81	-	81	"
Sub-total	837	613	1,450	
	L/ C	F/C	Total	Remarks
(4) Drainage System	245	56	301	0.97 times
(5) Farm Road	992	662	1,654	"
(6) Land Acquisition	1,380	-	1,380	4,6 ha

(8) ~ (11) same as above area (7.3.2.)

Banke-Bardiya District

(1) Well Development
same as other District

(2) Pump Station
57.1 kw/40 kw≠ 1.4 times

	L/ C	F/C	Total	Remarks
1) Pump Set & Motor	252	1,302	1,554	1.4 times
2) Pump House	198	116	314	"
3) Control Chamber	116	140	256	"
4) Power Supply	506	1,218	1,724	1.6 times (Area ratio)
Sub-total	1,072	2,776	3,848	
(3) Irrigation System				
1) Pipeline System	1,114	883	1,997	1.6 times
2) Alfalfa Valve	133	128	261	"
3) Terminal Irrigation	134	-	134	"
Sub-total	1,381	1,011	2,392	
(4) Drainage System	405	93	498	1.6 times
(5) Farm Road	1,637	1,091	2,728	"
(6) Land Acquisition	2,250	-	2,250	7.5 ha

(8) ~ (11) same as other Districts

7.3.2. Breakdown of O&M costs

Jhapa District (A = 17,000h, qt = 150 ha)

(1) O&M Equipment Costs

Motorcycle	1unit	36,000/5year	=	7,200 Rs
Bicycle	3units	4,000 x 3/5year	=	2,400 Rs
Tools (mechanic)		30,000/20year	=	1,500 Rs
Tools (electric)		25,000/20year	=	1,250 Rs
Sub-total				12,350 Rs

(2) Operation Costs (power output 65 kw)

Electricity charge (fixed)	65 kw x 20 Rs x 12 month	=	15,600 Rs
" (consumption)	65 kw x 2,200 h x 1,4 Rs/kwH	=	200,200 Rs
Operator	1 x 2,000 x 12 month	=	24,000 Rs
Asst. Operator	3 x 1,400 x 12	=	50,400 Rs
Sub-total			290,200 Rs

(3) Maintenance Cost

Civil Work	LS/year	15,000 Rs
Mechanical	"	15,000 Rs
Electrics	"	15,000 Rs
Sub-total		45,000 Rs
Total		347,550 Rs

for 1 ha 347,550/150 ≒ 2,320 Rs/ha
2,320 x 17,000 ha = 39.4 M.Rs

Mahottari District

[Area 1] (A=4,000 ha, qt = 66 ha)

(1) O&M Equipment Costs			
Motorcycle	1 unit 36,00/5 yen	=	7,200 Rs
Bicycle	2 unit 4,000 x 2/5 yen	=	1,600 Rs
Tools (mechanic)	30,000/20 yen	=	1,500 Rs
Tools (electric)	25,000/20 yen	=	1,250 Rs
Sub-total			11,550 Rs
(2) Operation Costs (P = 35 kw)			
Electricity charge (fixed)	35 kw x 20 Rs x 12 month	=	8,400 Rs
" (consumption)	35 x 2,200 h x 1.4 Rs/kwH	=	107,800 Rs
Operation	1 x 2,000 x 12 month	=	24,000 Rs
Asst. Operator	2 x 1,400 x 12 month	=	33,600 Rs
Sub-total			173,800 Rs
(3) Maintenance Costs			
Civil Work	LS/year		8,000 Rs
Mechanical	"		8,000 Rs
Electrics	"		8,000 Rs
Sub-total			24,000 Rs
Total			209,350 Rs

for 1 ha 209,350/66 = 3,172 Rs/ha

[Area 2] (A=3,000 ha, qt = 97 ha)

(1) O&M Equipment Costs
same as Area 1 11,550 Rs

(2) Operation Cost (P = 54 kw)

Electricity charge (fixed)	54 x 20 x 12	=	12,960 Rs
" (consumption)	57 x 2,200 x 1.4	=	166,320 Rs
Operator	1 x 2,000 x 12	=	24,000 Rs
Asst. Operator	2 x 1,400 x 12	=	33,600 Rs
Sub-total			226,880 Rs

(3) Maintenance Cost

Civil Works	LS/year	10,000 Rs
Mechanical	"	10,000 Rs
Electrics	"	10,000 Rs
Sub-total		30,000 Rs
Total		278,430 Rs

for 1 ha 278,430 / 97 = 2,870 Rs/ha

weighted average for A1 and A2

(3,172 x 66 + 2,870 x 97) / 163 = 2,992 Rs/ha ≒3,000 Rs/ha

3,000 x 7,000 ha = 21.0 M.Rs

Banke District (A = 8,000 ha, qt = 157 ha)

(1) O&M Costs

same as Jhapa District 12,350 Rs

(2) Operation Costs (P = 57 kw)

Electricity charge (fixed)	57 x 20 x 12	=	13,680 Rs
" (consumption)	57 x 2,200 x 1.4	=	175,560 Rs
Operator	1 x 2,000 x 12	=	24,000 Rs
Asst. Operator	3 x 1,400 x 12	=	50,400 Rs
Sub-total			263.640 Rs

(3) Maintenance Costs

Civil Works	LS/year	15,000 Rs
Mechanical	"	15,000 Rs
Electrics	"	15,000 Rs
Sub-total		45,000 Rs
Total		320,990 Rs

for 1 ha 320,990 / 157 = 2,044.5 ≒2,050 Rs/ha

2,050 x 8,000 ha ≒16 M.Rs

Table 7.1.1 Jhapa District Priority Sub-Area (150 ha/D.T.W Q = 120 l/s)
Summary of Project Cost Estimate

(Unit: 1,000 NRs)

No.	Work Items	Cost L/C	Cost F/C	Cost Total	Remarks
1	Well Development	219	1,297	1,516	T.A= 17,000 ha L/C; Local Currency F/C; Foreign Currency
2	Pump Station	1,076	2,886	3,962	
3	Irrigation Canal System	1,295	948	2,243	
4	Drainage System	380	87	467	
5	Farm Road System	1,535	1,023	2,558	
6	Land Acquisition	2,100	-	2,100	
	Total (1-6)	6,605	6,241	12,846	Cost of One D.T.W Area
7	Whole Area Cost	746,365	705,233	1,451,598	No of D.T.W: 113
8	Building for O & M	7,527	3,980	11,507	
9	Procurement of O&M and Office Equipment	2,940	52,170	55,110	
10	Technical Support	108,030	304,530	412,560	
11	Project Administration	107,730		107,730	
12	Total Investment Cost	972,592	1,065,913	2,038,505	(7 - 11)
	US Dollar Equivalent	19,452	21,318	40,770	(×1,000)
	Per (ha)	1,144	1,254	2,398	≒ 2,400 US$/ha
13	Physical Contingencies	97,259	106,591	203,850	(12 × 0.10)
14	Price Escalation	486,296	159,887	646,183	
15	Total Project Cost	1,556,147	1,332,391	2,888,538	
	US Dollar Equivalent	31,123	26,648	57,771	(× 1,000)

Table 7.1.2 Mahottari District Priority Sub-Area A_1 (66 ha/D.T.W Q = 66 l/s)

A_2 (97 ha/D.T.W Q = 97 l/s)

Summary of Project Cost Estimate

(Unit: 1,000 NRs)

No.	Work Items	Cost L/C	Cost F/C	Cost Total	Remarks
1	Well Development A_1	219	1,297	1,516	T.A= 7,000 ha
	Well Development A_2	219	1,297	1,516	L/C; Local Currency F/C; Foreign Currency
2	Pump Station A_1	697	1,625	2,322	A_1; 4,000 ha
	Pump Station A_2	864	2,250	3,114	A_2; 3,000 ha
3	Irrigation Canal System A_1	604	442	1,046	
	Irrigation Canal System A_2	837	613	1,450	
4	Drainage System A_1	177	41	218	
	Drainage System A_2	245	56	301	
5	Farm Road System A_1	716	477	1,193	
	Farm Road System A_2	992	662	1,654	
6	Land Acquisition A_1	990	-	990	
	Land Acquisition A_2	1,380	-	1,380	
	Total A_1 (1-6)	3,403	3,882	7,285	Cost of One D.T.W Area
	Total A_2 (1-6)	4,537	4,878	9,415	Cost of One D.T.W Area
7	Whole Area Cost A_1	207,583	236,802	444,385	No of D.T.W: 61
	A_2	140,647	151,218	291,865	No of D.T.W: 31
	Total (A_1 + A_2)	348,230	388,020	736,250	
8	Building for O & M	5,018	2,653	7,671	
9	Procurement of O&M and Office Equipment	1,960	34,780	36,740	
10	Technical Support	72,020	203,020	275,040	
11	Project Administration	71,820	-	71,820	
12	Total Investment Cost	499,048	628,473	1,127,521	(7 - 11)
	US Dollar Equivalent	9,981	12,569	22,550	(×1,000)
	Per (ha)	1,426	1,796	3,222	≒ 3,200 US$/ha
13	Physical Contingencies	49,905	62,847	112,752	(12 × 0.10)
14	Price Escalation	249,524	94,271	343,795	
15	Total Project Cost	798,447	785,591	1,584,068	
	US Dollar Equivalent	15,970	15,712	31,682	(× 1,000)

Table 7.1.3 Banke-Bardiya District Priority Sub-Area (157 ha/D.T.W Q = 110 l/s)
Summary of Project Cost Estimate

(Unit: 1,000 NRs)

No.	Work Items	Cost L/C	Cost F/C	Cost Total	Remarks
1	Well Development	219	1,297	1,516	T.A= 8,000 ha L/C; Local Currency F/C; Foreign Currency
2	Pump Station	1,072	2,776	3,848	
3	Irrigation Canal System	1,381	1,011	2,392	
4	Drainage System	405	93	498	
5	Farm Road System	1,637	1,091	2,728	
6	Land Acquisition	2,250	-	2,250	
	Total (1-6)	6,964	6,268	13,232	Cost of One D.T.W Area
7	Whole Area Cost	355,164	319,668	674,832	No of D.T.W: 51
8	Building for O & M	5,018	2,653	7,671	
9	Procurement of O&M and Office Equipment	1,960	34,780	36,740	
10	Technical Support	72,020	203,020	275,040	
11	Project Administration	71,820	-	71,820	
12	Total Investment Cost	505,982	560,121	1,066,103	
	US Dollar Equivalent	10,120	11,202	21,322	(×1,000)
	Per (ha)	1,265	1,400	2,665	≒ 2,700 US$/ha
13	Physical Contingencies	50,598	56,012	106,610	(12 × 0.10)
14	Price Escalation	252,991	84,018	337,009	
15	Total Project Cost	809,571	700,151	1,509,722	
	US Dollar Equivalent	16,191	14,003	30,194	(× 1,000)

CHAPTER EIGHT

PROJECT EVALUATION

[illegible]

[illegible]

CHAPTER-EIGHT: PROJECT EVALUATION

8.1. General

The objectives of this Project are to carry out the following items in the three districts of Jhapa, Mahottari, Banke: a) evaluation of groundwater resources, b) Master Plan for DTW irrigation, and b) formulation of guidelines for DTW irrigation.

Groundwater pumped from DTWs is used for irrigation and to increase agricultural production and farm incomes, which will result in the alleviation of poverty.

Agriculture is the backbone of the economy of Nepal, providing employment opportunities for 91% (1991) of the people living in rural areas. Therefore, it is considered that improving the living standard of farm households through the implementation of DTW irrigation projects will lead to a rise in the incomes of the vast majority of people; and these objectives coincide with the policies of the Eighth Development Plan (1992-1997), which aim at sustainable economic growth, reduction of regional imbalances, and the alleviation of poverty.

Financial and economic analyses from the perspective of the private and national economy are carried out for the project cost, O & M cost, and benefits generated from DTW irrigation. The evaluation is based on a project life of 50 years. The replacement costs for DTWs, pumps, and O & M equipment are calculated every 20 years, 15 years and 10 years, respectively. The replacement cost for road system by 50% of initial cost is considered in each 25 years.

8.2. Project Cost

The total project cost in the three Study Areas is estimated as follows;

(Rs. million)

	Financial	Economic
Jhapa	2,899	1,932
Mahottari	1,584	1,098
Banke	1,510	1,019

Taxes are deducted from the local portion of the financial project cost because of transfer expenditures. The local portion of the financial project cost is converted to the border price by multiplying by the standard conversion factor (SCF), which is calculated from the amount of exports and imports over the past five years. As a result, SCF is calculated at 0.911. The annual O & M cost is also estimated below.

(Rs. million/year)

	Financial	Economic
Jhapa	39	36
Mahottari	21	19
Banke	16	15

Table 8.2.1(1) Economic Project Costs(Jhapa)

(Rs.1000)

Description	LC	FC	Total
1) Well Development	22,545	146,561	169,106
2) Pump Stations	110,767	326,118	436,885
3) Irrigation Canal System	133,311	107,124	240,435
4) Drainage System	39,118	9,831	48,949
5) Farm Road System	158,018	115,599	273,617
6) Land Acquisition	0	0	0
7) Building for O & M	6,857	3,980	10,837
8) Procurement of O & M and Office Equipments	2,678	52,170	54,848
9) Technical Support	98,415	304,530	402,945
10) Project Administration	98,142	0	98,142
11) Toatl Investment Cost	669,851	1,065,913	1,735,764
12) Physical Contingencies	89,572	106,591	196,163
13) Price Escalation	0	0	0
Total Project Cost	759,423	1,172,504	1,931,927

Table 8.2.1(2) Economic Project Costs(Mahottari)

(Rs.1000)

Description	LC	FC	Total
1) Well Development	18,355	119,324	137,679
2) Pump Stations	63,133	168,875	232,008
3) Irrigation Canal System	57,177	45,965	103,142
4) Drainage System	16,755	4,237	20,992
5) Farm Road System	67,804	49,619	117,423
6) Land Acquisition	0	0	0
7) Building for O & M	4,571	2,653	7,224
8) Procurement of O & M and Office Equipments	1,786	34,780	36,566
9) Technical Support	65,610	203,020	268,630
10) Project Administration	65,428	0	65,428
11) Toatl Investment Cost	360,620	628,473	989,093
12) Physical Contingencies	45,791	62,847	108,638
13) Price Escalation	0	0	0
Total Project Cost	406,411	691,320	1,097,731

Table 8.2.1(3) Economic Project Costs(Banke)

(Rs.1000)

Description	LC	FC	Total
1) Well Development	10,175	66,147	76,322
2) Pump Stations	49,806	141,576	191,382
3) Irrigation Canal System	64,163	51,561	115,724
4) Drainage System	18,817	4,743	23,560
5) Farm Road System	76,055	55,641	131,696
6) Land Acquisition	0	0	0
7) Building for O & M	4,571	2,653	7,224
8) Procurement of O & M and Office Equipments	1,786	34,780	36,566
9) Technical Support	65,610	203,020	268,630
10) Project Administration	65,428	0	65,428
11) Toatl Investment Cost	356,411	560,121	916,532
12) Physical Contingencies	46,095	56,012	102,107
13) Price Escalation	0	0	0
Total Project Cost	402,505	616,133	1,018,638

8.3. Project Benefits

8.3.1. Agricultural Benefits

Agricultural benefits in the three districts will be generated by stable irrigation water distribution and sustainable agricultural extension services, thereby increasing the cropping intensity and crop yield.

	Net Irrigable Area (ha)	Agricultural Benefit (Rs million)
Jhapa	17,000	585
Mahottari	7,000	203
Banke	8,000	210

8.3.2. Socio-economic Impact

Along with tangible benefits such as agricultural benefits, indirect socio-economic benefits will be generated by the Project. These include,

- increased agricultural production in the Terai Plain as a result of the Project will contribute to the Nepal's self sufficiency in foods.
- living standards and nutrient levels of farm households will be improved by a rise in farm incomes.
- the Project will contribute to alleviating poverty, which is one of the main policies of the Eighth National Development Plan (1992-1997).
- regional imbalances will be reduced.
- results of DTW irrigation in the three districts will impact the surrounding areas, and farms in terms of cropping techniques, agricultural management, and so on will become the model cases of DTW irrigation in the Terai Plain.
- harmony and communication among beneficiaries will be generated by establishing WUAs in the districts, creating stable security within the nation.

Table 8.3.1 (1) Incremental Agricultural Benefit (Jhapa)

	M. Paddy Rainfed	M.Paddy Irrigated	S.Paddy Irrigated	Maize	Wheat	Miscellaneous (Mustard)	Total
Without Project							
Yield (ton/ha)	2.33	-	-	1.31	1.59	-	
Price (Rs/ton)	10,106	-	-	9,567	12,312	-	
GPV (RS/ha)	24,321	-	-	12,815	19,951	-	
Production Cost (Rs/ha)	8,935	-	-	7,368	10,588	-	
NPV (Rs/ha)	15,386	-	-	5,447	9,363	-	
Cropping Area (ha)	15,300	-	-	1,700	4,420	-	21,420
Total NPV (RS1000)	235,406	-	-	9,260	41,384	-	286,050
With Project							
Yield (ton/ha)	-	4.00	3.80	2.70	2.70	0.80	
Price (Rs/ton)	-	10,106	10,106	9,567	12,312	23,110	
GPV (RS/ha)	-	42,152	39,987	26,412	33,880	18,673	
Production Cost (Rs/ha)	-	12,839	10,276	11,168	12,895	9,055	
NPV (Rs/ha)	-	29,313	29,711	15,244	20,985	9,618	
Cropping Area (ha)	-	17,000	6,800	2,550	5,100	2,550	34,000
Total NPV (RS1000)	-	498,321	202,035	38,872	107,024	24,526	870,777
Incremental NPV (Rs1000)	-235,406	498,321	202,035	29,612	65,639	24,526	584,727

Note:GVP includes income from by-products

Table 8.3.1 (2) Incremental Agricultural Benefit (Mahottari)

	M.Paddy Rainfed	M.Paddy Irrigated	S.Paddy Irrigated	Wheat	Pulses (Lentil)	Onion	Potato	Others (Oilseeds)	Total
Without Project									
Yield (ton/ha)	2.29	-	-	1.48	0.60	-	-	0.54	
Price (Rs/ton)	10,361	-	-	12,704	14,940	-	-	23,480	
GPV (RS/ha)	24,733	-	-	19,212	9,086	-	-	12,805	
Production Cost (Rs/ha)	9,338	-	-	11,479	3,673	-	-	6,483	
NPV (Rs/ha)	15,395	-	-	7,733	5,413	-	-	6,322	
Cropping Area (ha)	6,300	-	-	1,400	1,400	-	-	700	9,800
Total NPV (RS1000)	*96,989	-	-	10,826	7,578	-	-	4,425	119,818
With Project									
Yield (ton/ha)	-	3.40	3.60	2.60	-	13.00	12.00	-	
Price (Rs/ton)	-	10,361	10,361	12,704	-	4,140	4,530	-	
GPV (RS/ha)	-	36,837	38,983	33,751	-	53,820	54,360	-	
Production Cost (Rs/ha)	-	12,697	10,584	13,583	-	26,899	35,598	-	
NPV (Rs/ha)	-	24,140	28,399	20,168	-	26,921	18,762	-	
Cropping Area (ha)	-	7,000	700	3,430	-	1,330	1,540	-	14,000
Total NPV (RS1000)	-	168,980	19,879	69,176	-	35,805	28,893	-	322,734
Incremental NPV (Rs1000)	-96,989	168,980	19,879	58,350	-7,578	35,805	28,893	-4,425	202,916

Table 8.3.1 (3) Incremental Agricultural Benefit (Banke)

	M.Paddy Rainfed	M.Paddy Irrigated	Maize	Mustard	Wheat	Pulses (Lentil)	Potato	Others (Cauliflower)	Total
Without Project									
Yield (ton/ha)	1.95	-	1.61	0.55	1.40	0.68	-	-	
Price (Rs/ton)	10,584	-	10,302	20,330	13,049	21,600	-	-	
GPV (RS/ha)	21,552	-	17,030	11,309	18,598	14,826	-	-	
Production Cost (Rs/Ha)	9,618	-	8,626	6,593	10,575	3,763	-	-	
NPV (Rs/ha)	11,934	-	8,404	4,716	8,023	11,063	-	-	
Cropping Area (ha)	6,400	-	800	800	2,400	800	-	-	11,200
Total NPV (RS1000)	76,378	-	6,723	3,773	19,255	8,850	-	-	114,979
With Project									
Yield (ton/ha)	-	3.50	2.60	0.80	2.10	1.00	14.00	11.00	
Price (Rs/ton)	-	10,584	10,302	20,330	13,049	21,600	3,600	7,000	
GPV (RS/ha)	-	38,608	27,498	16,417	27,897	21,807	50,400	77,000	
Production Cost (Rs/ha)	-	13,428	13,058	10,680	13,491	6,058	22,546	19,934	
NPV (Rs/ha)	-	25,180	14,440	5,737	14,406	15,749	27,854	57,066	
Cropping Area (ha)	-	6,960	1,200	1,040	4,000	1,360	1,200	240	16,000
Total NPV (RS1000)	-	175,253	17,328	5,966	57,624	21,419	33,425	13,696	324,711
Incremental NPV (Rs1000)	-76,378	175,253	10,605	2,194	38,369	12,568	33,425	13,696	209,731

Note:GVP includes income from by-products

Table 8.3.2 (1) Farmgate Prices (Jhapa)

	Unit	Price		Remarks
		Financial	Economic	
1. Seeds				
Paddy	Rs/kg	10.00	10.61	
Wheat	Rs/kg	11.65	23.90	
Maize	Rs/kg	14.20	25.12	
Mustard	Rs/kg	23.00	21.95	
Pigeon Peas	Rs/kg	16.00	14.58	
Lentil	Rs/kg	18.00	16.40	
Cauliflower	Rs/kg	300.00	273.30	
Potato	Rs/kg	10.00	9.11	
Onion	Rs/kg	225.00	204.97	
Vegetables (cabbage)	Rs/kg	305.00	277.86	
2. Crops				
Paddy	Rs/ton	4790	10106	
Wheat	Rs/ton	4250	12312	
Maize	Rs/ton	4590	9567	
Mustard (oilseeds)	Rs/ton	23110	23110	
Pigeon Peas	Rs/ton	17190	17190	
Lentil	Rs/ton	14940	14940	
Cauliflower	Rs/ton	7690	7690	
Potato	Rs/ton	3880	3880	
Onion	Rs/ton	8940	8940	
Vegetables (cabbage)	Rs/ton	6740	6740	
3. By-products				
Paddy Straw	Rs/kg	0.40	0.36	
Wheat Straw	Rs/kg	0.25	0.23	
Maize Stalks	Rs/kg	0.20	0.18	
Lentil Stalks	Rs/kg	0.25	0.23	
Mustard Stalks	Rs/kg	0.20	0.18	
4. Fertilizer				
Nitrogen	Rs/kg	12.17	26.32	
Phosphate	Rs/kg	17.39	24.68	
Potash	Rs/kg	14.17	17.35	
Barnyard Manure	Rs/ton	200.00	182.00	
5. Agri-Chemicals				
Parathion	Rs/kg	338.5	308.4	
BHC Dust	Rs/kg	5.9	5.4	
Malathion Dust	Rs/kg	12.6	11.5	
Hinosan	Rs/lit.	463.0	421.8	
2-4D	Rs/kg	203.8	185.7	
6. Farm Labor				
Hired Labor	Rs/day	32	22	
Hired Bullock with Labour	Rs/day	100	68	

Table 8.3.2 (2) Farmgate Prices (Mahottari)

	Unit	Price		Remarks
		Financial	Economic	
1. Seeds				
Paddy	Rs/kg	8.50	9.01	
Wheat	Rs/kg	10.50	21.50	
Maize	Rs/kg	15.00	26.51	
Mustard	Rs/kg	22.00	20.04	
Pigeon Peas	Rs/kg	16.00	14.58	
Lentil	Rs/kg	18.00	16.39	
Cauliflower	Rs/kg	300.00	273.30	
Potato	Rs/kg	8.00	7.29	
Onion	Rs/kg	225.00	204.97	
Vegetables (cabbage)	Rs/kg	300.00	273.30	
2. Crops				
Paddy	Rs/ton	6070	10361	
Wheat	Rs/ton	6010	12704	
Maize	Rs/ton	4920	9959	
Mustard (oilseeds)	Rs/ton	23480	23480	
Pigeon Peas	Rs/ton	15420	15420	
Lentil	Rs/ton	14940	14940	
Cauliflower	Rs/ton	6000	6000	
Potato	Rs/ton	4530	4530	
Onion	Rs/ton	4140	4140	
Vegetables (cabbage)	Rs/ton	3430	3430	
3. By-products				
Paddy Straw	Rs/kg	0.50	0.46	
Wheat Straw	Rs/kg	0.30	0.27	
Maize Stalks	Rs/kg	0.20	0.18	
Lentil Stalks	Rs/kg	0.25	0.23	
Mustard Stalks	Rs/kg	0.20	0.18	
4. Fertilizer				
Nitrogen	Rs/kg	11.22	27.17	
Phosphate	Rs/kg	17.39	25.35	
Potash	Rs/kg	13.58	18.00	
Barnyard Manure	Rs/ton	200.00	182.00	
5. Agri-Chemicals				
Parathion	Rs/kg	338.5	308.4	
BHC Dust	Rs/kg	5.9	5.4	
Malathion Dust	Rs/kg	12.6	11.5	
Hinosan	Rs/lit.	463.0	421.8	
2-4D	Rs/kg	203.8	185.7	
6. Farm Labor				
Hired Labor	Rs/day	35	24	
Hired Bullock with Labour	Rs/day	100	68	

Table 8.3.2 (3) Farmgate Prices (Banke)

	Unit	Price		Remarks
		Financial	Economic	
1. Seeds				
Paddy	Rs/kg	9.05	9.59	
Wheat	Rs/kg	11.65	23.90	
Maize	Rs/kg	14.90	26.37	
Mustard	Rs/kg	30.00	27.33	
Pigeon Peas	Rs/kg	20.00	18.22	
Lentil	Rs/kg	18.50	16.85	
Cauliflower	Rs/kg	550.00	501.05	
Potato	Rs/kg	8.00	7.29	
Onion	Rs/kg	225.00	204.97	
Vegetables (cabbage)	Rs/kg	340.00	309.74	
2. Crops				
Paddy	Rs/ton	5270	10584	
Wheat	Rs/ton	6310	13049	
Maize	Rs/ton	5570	10302	
Mustard (oilseeds)	Rs/ton	20330	20330	
Pigeon Peas	Rs/ton	24230	24230	
Lentil	Rs/ton	21600	21600	
Cauliflower	Rs/ton	7000	7000	
Potato	Rs/ton	3600	3600	
Onion	Rs/ton	8940	8940	
Vegetables (cabbage)	Rs/ton	12060	12060	
3. By-products				
Paddy Straw	Rs/kg	0.50	0.46	
Wheat Straw	Rs/kg	0.25	0.23	
Maize Stalks	Rs/kg	0.25	0.23	
Lentil Stalks	Rs/kg	0.25	0.23	
Mustard Stalks	Rs/kg	0.20	0.18	
4. Fertilizer				
Nitrogen	Rs/kg	12.17	27.91	
Phosphate	Rs/kg	18.08	26.28	
Potash	Rs/kg	14.16	18.57	
Barnyard Manure	Rs/ton	200.00	182.00	
5. Agri-Chemicals				
Parathion	Rs/kg	338.5	308.4	
BHC Dust	Rs/kg	5.9	5.4	
Malathion Dust	Rs/kg	12.6	11.5	
Hinosan	Rs/lit.	463.0	421.8	
2-4D	Rs/kg	203.8	185.7	
6. Farm Labor				
Hired Labor	Rs/day	37	25	
Hired Bullock with Labour	Rs/day	100	68	

8.4. Economic and Financial Analysis of the Project

8.4.1. Economic Internal Rate of Return (EIRR)

As a result of a comparison of project costs and benefits in the three study areas, EIRR is calculated as below, and the projects are judged to be economically viable.

	EIRR(%)
Jhapa	21.0
Mahottari	13.5
Banke	14.3

8.4.2. Financial Analysis of Typical Farms

A financial analysis has been carried out to compare the farm budgets of typical farms in the three study areas, with and without the Project. Living standards are expected to improve as a result of the DTW irrigation projects, as shown below.

	Jhapa	Mahottari	Banke
a) Without Project			
Farm Size (ha)	1.41	1.09	1.37
Farm Incomes (Rs)	12,504	15,916	15,844
Off-farm Incomes (Rs)	521	838	273
Living Expenses (Rs)	11,552	9,984	11,328
Disposable Income (Rs)	1,473	6,769	4,790
b) With Project			
Farm Size (ha)	1.41	1.09	1.37
Farm Incomes (Rs)	44,825	46,547	51,313
Off-farm Incomes (Rs)	1,868	2,450	885
Living Expenses (Rs)	44,013	40,416	43,160
Disposable Income (Rs)	2,680	8,581	9,038

Table 8.4.1 (1) Calculation of EIRR (Jhapa)

(Unit: Rs. Million)

Year	Project Cost: Initial Invest. Cost	Project Cost: Replacement Cost	Project Cost: O & M Cost	Project Cost: Total (1)	Project Benefit (2)	Net Benefit (2)-(1)	Present Worth Value, D. Rate= 0.10: Project Cost	Present Worth Value, D. Rate= 0.10: Project Benefit	Present Worth Value, 0.20: Net Benefit	Present Worth Value, 0.21: Net Benefit
1	138	0	0	138	0	-138	125.5	0.0	-115.0	-114.0
2	166	0	0	166	0	-166	137.2	0.0	-115.3	-113.4
3	154	0	0	154	0	-154	115.7	0.0	-89.1	-86.9
4	116	0	0	116	0	-116	79.2	0.0	-55.9	-54.1
5	254	0	0	254	0	-254	157.7	0.0	-102.1	-97.9
6	256	0	10	266	257	-9	150.2	145.1	-3.0	-2.9
7	252	0	15	267	310	43	137.0	159.1	12.0	11.3
8	252	0	22	274	380	106	127.8	177.3	24.7	23.1
9	185	0	29	214	432	218	90.8	183.2	42.2	39.2
10	160	0	36	196	473	277	75.6	182.4	44.7	41.2
11	0	0	36	36	508	472	12.6	178.1	63.5	58.0
12	0	22	36	58	531	473	18.5	169.2	53.1	48.0
13	0	16	36	52	549	497	15.1	159.0	46.5	41.7
14	0	16	36	52	561	509	13.7	147.7	39.6	35.3
15	0	0	36	36	569	533	8.6	136.2	34.6	30.5
16	0	0	36	36	573	537	7.8	124.7	29.0	25.4
17	0	0	36	36	585	549	7.1	115.7	24.7	21.5
18	0	0	36	36	585	549	6.5	105.2	20.6	17.8
19	0	0	36	36	585	549	5.9	95.7	17.2	14.7
20	0	74	36	110	585	475	16.4	87.0	12.4	10.5
21	0	74	36	110	585	475	14.9	79.1	10.3	8.7
22	0	96	36	132	585	453	16.2	71.9	8.2	6.8
23	0	90	36	126	585	459	14.1	65.3	6.9	5.7
24	0	90	36	126	585	459	12.8	59.4	5.8	4.7
25	0	95	36	131	585	454	12.1	54.0	4.8	3.9
26	0	29	36	65	585	520	5.5	49.1	4.5	3.7
27	0	29	36	65	585	520	5.0	44.6	3.8	3.0
28	0	29	36	65	585	520	4.5	40.6	3.2	2.5
29	0	29	36	65	585	520	4.1	36.9	2.6	2.1
30	0	25	36	61	585	524	3.5	33.5	2.2	1.7
31	0	0	36	36	585	549	1.9	30.5	1.9	1.5
32	0	22	36	58	585	527	2.7	27.7	1.5	1.2
33	0	16	36	52	585	533	2.2	25.2	1.3	1.0
34	0	16	36	52	585	533	2.0	22.9	1.1	0.8
35	0	74	36	110	585	475	3.9	20.8	0.8	0.6
36	0	74	36	110	585	475	3.6	18.9	0.7	0.5
37	0	74	36	110	585	475	3.2	17.2	0.6	0.4
38	0	74	36	110	585	475	2.9	15.6	0.5	0.3
39	0	74	36	110	585	475	2.7	14.2	0.4	0.3
40	0	66	36	102	585	483	2.3	12.9	0.3	0.2
41	0	0	36	36	585	549	0.7	11.8	0.3	0.2
42	0	22	36	58	585	527	1.1	10.7	0.2	0.2
43	0	16	36	52	585	533	0.9	9.7	0.2	0.1
44	0	16	36	52	585	533	0.8	8.8	0.2	0.1
45	0	0	36	36	585	549	0.5	8.0	0.2	0.1
46	0	0	36	36	585	549	0.4	7.3	0.1	0.1
47	0	0	36	36	585	549	0.4	6.6	0.1	0.1
48	0	0	36	36	585	549	0.4	6.0	0.1	0.1
49	0	0	36	36	585	549	0.3	5.5	0.1	0.0
50	0	99	36	135	585	450	1.2	5.0	0.0	0.0
Total	1,933	1,357	1,552	4,842	25,033	20,191	1,435.4	2,985.2	47.4	-0.4

EIRR= 21.0

B/C Ratio at 10% 2.08

Table 8.4.1 (2) Calculation of EIRR (Mahottari)

(Unit: Rs. Million)

Year	Project Cost				Project Benefit	Net Benefit	Present Worth Value			
	Initial Invest. Cost	Replacement Cost	O & M Cost	Total (1)	(2)	(2)-(1)	D. Rate= 0.10 Project Cost	0.10 Project Benefit	0.13 Net Benefit	0.14 Net Benefit
1	93	0	0	93	0	-93	84.5	0.0	-82.3	-81.6
2	115	0	0	115	0	-115	95.0	0.0	-90.1	-88.5
3	111	0	0	111	0	-111	83.4	0.0	-76.9	-74.9
4	65	0	0	65	0	-65	44.4	0.0	-39.9	-38.5
5	159	0	0	159	0	-159	98.7	0.0	-86.3	-82.6
6	157	0	6	163	91	-72	92.0	51.4	-34.6	-32.8
7	157	0	12	169	132	-37	86.7	67.7	-15.7	-14.8
8	121	0	19	140	162	22	65.3	75.6	8.3	7.7
9	118	0	19	137	183	46	58.1	77.6	15.3	14.1
10	0	0	19	19	193	174	7.3	74.4	51.3	46.9
11	0	0	19	19	198	179	6.7	69.4	46.7	42.4
12	0	18	19	37	203	166	11.8	64.7	38.3	34.5
13	0	18	19	37	203	166	10.7	58.8	33.9	30.2
14	0	0	19	19	203	184	5.0	53.5	33.2	29.4
15	0	0	19	19	203	184	4.5	48.6	29.4	25.8
16	0	0	19	19	203	184	4.1	44.2	26.0	22.6
17	0	0	19	19	203	184	3.8	40.2	23.0	19.8
18	0	0	19	19	203	184	3.4	36.5	20.4	17.4
19	0	0	19	19	203	184	3.1	33.2	18.0	15.3
20	0	46	19	65	203	138	9.7	30.2	12.0	10.0
21	0	46	19	65	203	138	8.8	27.4	10.6	8.8
22	0	64	19	83	203	120	10.2	24.9	8.2	6.7
23	0	64	19	83	203	120	9.3	22.7	7.2	5.9
24	0	46	19	65	203	138	6.6	20.6	7.3	5.9
25	0	44	19	63	203	140	5.8	18.7	6.6	5.3
26	0	44	19	63	203	140	5.3	17.0	5.8	4.6
27	0	44	19	63	203	140	4.8	15.5	5.2	4.1
28	0	44	19	63	203	140	4.4	14.1	4.6	3.6
29	0	28	19	47	203	156	3.0	12.8	4.5	3.5
30	0	0	19	19	203	184	1.1	11.6	4.7	3.6
31	0	0	19	19	203	184	1.0	10.6	4.2	3.2
32	0	18	19	37	203	166	1.8	9.6	3.3	2.5
33	0	18	19	37	203	166	1.6	8.7	2.9	2.2
34	0	0	19	19	203	184	0.7	7.9	2.9	2.1
35	0	46	19	65	203	138	2.3	7.2	1.9	1.4
36	0	46	19	65	203	138	2.1	6.6	1.7	1.2
37	0	46	19	65	203	138	1.9	6.0	1.5	1.1
38	0	46	19	65	203	138	1.7	5.4	1.3	0.9
39	0	46	19	65	203	138	1.6	4.9	1.2	0.8
40	0	0	19	19	203	184	0.4	4.5	1.4	1.0
41	0	0	19	19	203	184	0.4	4.1	1.2	0.9
42	0	18	19	37	203	166	0.7	3.7	1.0	0.7
43	0	18	19	37	203	166	0.6	3.4	0.9	0.6
44	0	0	19	19	203	184	0.3	3.1	0.8	0.6
45	0	28	19	47	203	156	0.6	2.8	0.6	0.4
46	0	28	19	47	203	156	0.6	2.5	0.6	0.4
47	0	28	19	47	203	156	0.5	2.3	0.5	0.3
48	0	28	19	47	203	156	0.5	2.1	0.4	0.3
49	0	28	19	47	203	156	0.4	1.9	0.4	0.3
50	0	62	19	81	203	122	0.7	1.7	0.3	0.2
Total	1,096	1,010	835	2,941	8,876	5,935	858.0	1,110.3	23.8	-24.4

EIRR= 13.5

B/C Ratio at 10% 1.29

Table 8.4.1 (3) Calculation of EIRR (Banke)

(Unit: Rs. Million)

Year	Project Cost				Project Benefit	Net Benefit	Present Worth Value			
	Initial Invest. Cost	Replace-ment Cost	O & M Cost	Total (1)	(2)	(2)-(1)	D. Rate= Project Cost	0.10 Project Benefit	0.14 Net Benefit	0.15 Net Benefit
1	93	0	0	93	0	-93	84.5	0.0	-81.6	-80.9
2	116	0	0	116	0	-116	95.9	0.0	-89.3	-87.7
3	112	0	0	112	0	-112	84.1	0.0	-75.6	-73.6
4	61	0	0	61	0	-61	41.7	0.0	-36.1	-34.9
5	173	0	0	173	0	-173	107.4	0.0	-89.9	-86.0
6	170	0	5	175	95	-80	98.8	53.6	-36.4	-34.6
7	170	0	10	180	126	-54	92.4	64.7	-21.6	-20.3
8	121	0	15	136	158	22	63.4	73.7	7.7	7.2
9	0	0	15	15	174	159	6.4	73.8	48.9	45.2
10	0	0	15	15	189	174	5.8	72.9	46.9	43.0
11	0	0	15	15	197	182	5.3	69.0	43.1	39.1
12	0	18	15	33	204	171	10.5	65.0	35.5	32.0
13	0	18	15	33	206	173	9.6	59.7	31.5	28.1
14	0	0	15	15	210	195	3.9	55.3	31.1	27.6
15	0	0	15	15	210	195	3.6	50.3	27.3	24.0
16	0	0	15	15	210	195	3.3	45.7	24.0	20.8
17	0	0	15	15	210	195	3.0	41.5	21.0	18.1
18	0	0	15	15	210	195	2.7	37.8	18.4	15.8
19	0	0	15	15	210	195	2.5	34.3	16.2	13.7
20	0	48	15	63	210	147	9.4	31.2	10.7	9.0
21	0	48	15	63	210	147	8.5	28.4	9.4	7.8
22	0	66	15	81	210	129	10.0	25.8	7.2	6.0
23	0	66	15	81	210	129	9.0	23.5	6.3	5.2
24	0	0	15	15	210	195	1.5	21.3	8.4	6.8
25	0	36	15	51	210	159	4.7	19.4	6.0	4.8
26	0	36	15	51	210	159	4.3	17.6	5.3	4.2
27	0	36	15	51	210	159	3.9	16.0	4.6	3.7
28	0	36	15	51	210	159	3.5	14.6	4.1	3.2
29	0	0	15	15	210	195	0.9	13.2	4.4	3.4
30	0	0	15	15	210	195	0.9	12.0	3.8	2.9
31	0	0	15	15	210	195	0.8	10.9	3.4	2.6
32	0	18	15	33	210	177	1.6	9.9	2.7	2.0
33	0	18	15	33	210	177	1.4	9.0	2.3	1.8
34	0	0	15	15	210	195	0.6	8.2	2.3	1.7
35	0	48	15	63	210	147	2.2	7.5	1.5	1.1
36	0	48	15	63	210	147	2.0	6.8	1.3	1.0
37	0	48	15	63	210	147	1.9	6.2	1.2	0.8
38	0	48	15	63	210	147	1.7	5.6	1.0	0.7
39	0	0	15	15	210	195	0.4	5.1	1.2	0.8
40	0	0	15	15	210	195	0.3	4.6	1.0	0.7
41	0	0	15	15	210	195	0.3	4.2	0.9	0.6
42	0	18	15	33	210	177	0.6	3.8	0.7	0.5
43	0	18	15	33	210	177	0.5	3.5	0.6	0.4
44	0	0	15	15	210	195	0.2	3.2	0.6	0.4
45	0	19	15	34	210	176	0.5	2.9	0.5	0.3
46	0	19	15	34	210	176	0.4	2.6	0.4	0.3
47	0	19	15	34	210	176	0.4	2.4	0.4	0.2
48	0	19	15	34	210	176	0.4	2.2	0.3	0.2
49	0	0	15	15	210	195	0.1	2.0	0.3	0.2
50	0	65	15	80	210	130	0.7	1.8	0.2	0.1
Total	1,016	813	660	2,489	9,119	6,630	798.2	1,122.8	14.2	-29.9

EIRR=	14.3
B/C Ratio at 10%	1.41

Table 8.4.2 (1) Financial Analysis for Typical Farm (Jhapa)

Farm Model-Without Project
Jhapa (farm size 1.41ha)

1. Crop Production

	Area (ha)	Yield (ton/ha) Main Product	Yield (ton/ha) By-Product	Production (ton) Main Product	Production (ton) By-Product	Price (Rs/ton) Main Product	Price (Rs/ton) By-Product	Value of Production (Rs) Main Product	Value of Production (Rs) By-Product	Value of Production (Rs) Total	Production Cost (Rs)	Net Income (Rs)
M. Paddy-raifed	1.27	2.33	2.15	2.96	2.73	4790	400	14163	1091	15254	6635	8619
Maize	0.14	1.31	1.57	0.18	0.22	4590	200	848	44	892	289	603
Wheat	0.37	1.59	1.63	0.58	0.60	4250	250	2477	149	2627	1429	1198
Total	1.78							17488	1285	18773	8353	10420

2. Income from Livestock (Rs)	2084
3. Off-farm Income (Rs/year)	521
4. Total Income (Rs)	13025
5. Living Expence (Rs/year)-Family size 5.36 person/family	11552
Food (Rs)	7220
Non-food (Rs)	4332
6. Disposable Income (Rs/year)	1473

Farm Model-With Project
Jhapa (farm size 1.41ha)

1. Crop Production

	Area (ha)	Yield (ton/ha) Main Product	Yield (ton/ha) By-Product	Production (ton) Main Product	Production (ton) By-Product	Price (Rs/ton) Main Product	Price (Rs/ton) By-Product	Value of Production (Rs) Main Product	Value of Production (Rs) By-Product	Value of Production (Rs) Total	Production Cost (Rs)	Net Income (Rs)
M. Paddy-irrigated	1.41	4.00	4.80	5.64	6.77	4790	400	27016	2707	29723	9141	20582
S. Paddy-irrigated	0.56	3.80	4.40	2.14	2.48	4790	400	10266	993	11259	3080	8179
Maize	0.21	2.70	3.23	0.57	0.68	4590	200	2621	137	2758	792	1966
Wheat	0.42	2.70	2.77	1.14	1.17	4250	250	4854	293	5147	2014	3133
Miscellaneous	0.21	0.80	1.03	0.17	0.22	23110	200	3910	5034	8945	5449	3496
Total	2.82							48667	9164	57831	20476	37354

2. Income from Livestock (Rs)	7471
3. Off-farm Income (Rs/year)	1868
4. Total Income (Rs)	46693
5. Living Expence (Rs/year)-Family size 5.36 person/family	44013
Food (Rs)	27508
Non-food (Rs)	16505
6. Disposable Income (Rs/year)	2680

Table 8.4.2 (2) Financial Analysis for Typical Farm (Mahottari)

Farm Model-Without Project
Mahottari (farm size 1.09ha)

1. Crop Production

	Area	Yield (ton/ha)		Production (ton)		Price (Rs/ton)		Value of Production (Rs)			Produ-ction	Net Income
	(ha)	Main Product	By-Product	Main Product	By-Product	Main Product	By-Product	Main Product	By-Product	Total	Cost (Rs)	(Rs)
M.Paddy-raifed	0.98	2.29	2.30	2.25	2.26	6070	500	13636	1128	14764	4797	9967
Wheat	0.22	1.48	1.52	0.32	0.33	6010	300	1939	99	2038	860	1179
Pulses	0.22	0.60	0.53	0.13	0.12	14940	250	1954	29	1983	301	1683
Others	0.11	0.54	0.70	0.06	0.08	23480	200	1382	15	1397	265	1133
Total	1.53							18911	1272	20183	6222	13961

2. Income from Livestock (Rs)	1955
3. Off-farm Income (Rs/year)	838
4. Total Income (Rs)	16753
5. Living Expence (Rs/year)-Family size 5.48 person/family	9984
Food (Rs)	6240
Non-food (Rs)	3744
6. Disposable Income (Rs/year)	6769

Farm Model-With Project
Mahottari (farm size 1.09ha)

1. Crop Production

	Area	Yield (ton/ha)		Production (ton)		Price (Rs/ton)		Value of Production (Rs)			Produ-ction	Net Income
	(ha)	Main Product	By-Product	Main Product	By-Product	Main Product	By-Product	Main Product	By-Product	Total	Cost (Rs)	(Rs)
M.Paddy-irrigated	1.09	3.40	3.50	3.71	3.82	6070	500	22495	1908	24403	6987	17416
S.Paddy-irrigated	0.11	3.60	3.66	0.39	0.40	6070	500	2382	199	2581	607	1975
Wheat	0.53	2.60	2.67	1.39	1.43	6010	300	8346	428	8774	2484	6290
Onion	0.21	13.00	0.50	2.69	0.10	4140	0	11146	0	11146	2719	8427
Potato	0.24	12.00	0.00	2.88	0.00	4530	0	13036	0	13036	6312	6724
Total	2.18							57405	2535	59940	19109	40831

2. Income from Livestock (Rs)	5716
3. Off-farm Income (Rs/year)	2450
4. Total Income (Rs)	48997
5. Living Expence (Rs/year)-Family size 5.48 person/family	40416
Food (Rs)	23774
Non-food (Rs)	16642
6. Disposable Income (Rs/year)	8581

Table 8.4.2 (3) Financial Analysis for Typical Farm (Banke)

Farm Model-Without Project
Banke (farm size 1.37ha)

1. Crop Production

	Area (ha)	Yield (ton/ha) Main Product	Yield (ton/ha) By-Product	Production (ton) Main Product	Production (ton) By-Product	Price (Rs/ton) Main Product	Price (Rs/ton) By-Product	Value of Production (Rs) Main Product	Value of Production (Rs) By-Product	Value of Production (Rs) Total	Production Cost (Rs)	Net Income (Rs)
M. Paddy-raifed	1.22	1.95	2.10	2.38	2.56	5270	500	12537	1281	13818	5118	8700
Maize	0.14	1.61	1.93	0.22	0.26	5570	250	1229	66	1295	257	1038
Mustard	0.14	0.55	0.71	0.08	0.10	20330	200	1532	19	1551	213	1339
Wheat	0.30	1.40	1.43	0.42	0.43	6310	250	2650	107	2757	2010	747
Pulses	0.13	0.68	0.60	0.09	0.08	21600	250	1909	20	1929	94	1835
Total	1.92							19857	1493	21351	7692	13659

2. Income from Livestock (Rs)	2185
3. Off-farm Income (Rs/year)	273
4. Total Income (Rs)	16118
5. Living Expence (Rs/year) - Family size 5.9 person/family	11328
Food (Rs)	7080
Non-food (Rs)	4248
6. Disposable Income (Rs/year)	4790

Farm Model-With Project
Banke (farm size 1.37ha)

1. Crop Production

	Area (ha)	Yield (ton/ha) Main Product	Yield (ton/ha) By-Product	Production (ton) Main Product	Production (ton) By-Product	Price (Rs/ton) Main Product	Price (Rs/ton) By-Product	Value of Production (Rs) Main Product	Value of Production (Rs) By-Product	Value of Production (Rs) Total	Production Cost (Rs)	Net Income (Rs)
M. Paddy-irrigated	1.19	3.50	3.40	4.17	4.05	5270	500	21950	2023	23973	7501	16472
Mustard	0.18	0.80	0.85	0.14	0.15	20330	200	2897	30	2927	621	2306
Wheat	0.69	2.10	2.15	1.45	1.48	6310	250	9143	371	9514	3378	6136
Pulses	0.23	1.00	0.90	0.23	0.21	21600	250	5031	52	5083	422	4661
Maize	0.21	2.60	3.10	0.53	0.64	5570	250	2976	159	3135	950	2186
Potato	0.21	14.00	0.00	2.88	0.00	3600	0	10357	0	10357	539	9818
Others	0.04	11.00	0.00	0.45	0.00	7000	0	3165	0	3165	508	2657
Total	2.74							55518	2636	58154	13918	44235

2. Income from Livestock (Rs)	7078
3. Off-farm Income (Rs/year)	885
4. Total Income (Rs)	52198
5. Living Expence (Rs/year) - Family size 5.9 person/family	43160
Food (Rs)	26975
Non-food (Rs)	16185
6. Disposable Income (Rs/year)	9038

CHAPTER NINE

GUIDELINES FOR DTW IRRIGATION

CHAPTER-NINE: GUIDELINES FOR DTW IRRIGATION

9.1. General

Guideline are applied for deep tubewell irrigation planned in the Terai Plain. These guidelines consist of the following two items.

The first guideline is related to "LFCA," which is an economically appropriate command area for one deep tubewell facility, as well as related to "LFWY," which is appropriate for irrigation in this command area.

The second is guideline is related to the "evaluation of aquifer capacity" in the Terai Plain, the "design of production wells," and the "construction of production wells."

9.2. LFCA and LFWY

9.2.1. Electric Pump Basis

The purpose of studying guidelines for the DTW irrigation project is to study the least feasible command area (LFCA) irrigated by one DTW and to grasp the least feasible well yield (LFWY) in order to offer the materials for assessing the economic feasibility of DTW irrigation projects in the future in the case that the electric power supply is available.

LFCA is considered as the least feasible command area irrigated by one DTW under variable conditions such as nature, the socio-economy, and agriculture in the project areas. After determining the LCFA, LFWY can be estimated automatically as the water requirements necessary for LCFA.

An economic analysis has been carried out based on the same conditions used in Chapter 8 "Project Evaluation," and the priority area of Jhapa District has been selected for the study. The conditions used in the study are shown below.

Command area by one DTW	100 ha
Cropping Intensity without project	126%
Cropping Intensity with project	200%
Cropping patterns	Refer to Figure 4.3.1
Farmgate Prices	Refer to Table 8.3.2 (vol-2)
Production Costs	Refer to Appendix Table 4.7.10
Incremental Benefit	Table 9.2.1

Project Life	50 years
Construction Period	1 year
Replacement	
DTW	20 years
Pumps	15 years
OM Equipment	10 years

The following three cases are analyzed in regard to the yield of DTWs and the number of pump stations.

	Yield of DTW	Pump Stations
Case-1	90 lit/sec	1 place
Case-2	45	2
Case-3	30	3

The project costs for each case are estimated per 100 ha for a) irrigated by one DTW, b) irrigated by two DTW, and c) irrigated by three DTW. These cost estimations are based on a topographical map survey in the sample area conducted in the Phase III study.

When estimating the economic project cost, the land acquisition cost and price escalation cost are excluded as transfer expenditures, and local portions in the financial project cost are converted to border prices by multiplying the SCF.

The following shows the economic project cost and O & M costs per 100 ha for the three cases.

Project Costs

(Unit: Rs 1,000/100 ha)

	Case-1	Case-2	Case-3
LC	5,129	5,727	6,358
FC	8,901	10,956	13,308
Total	14,030	16,683	19,666

O & M Costs

(Unit: Rs 1,000/100 ha/year)

	Case-1	Case-2	Case-3
LC	200	287	344
FC	25	35	42
Total	225	322	386

Increased agricultural impact per 100 ha is shown in Table 9.2.1. Under the above conditions, the EIRR and B/C for the three cases are listed below.

a) Jhapa

	Case-1	Case-2	Case-3
EIRR(%)	16.77	13.94	11.75
B/C	1.53	1.26	1.07

b) Mahottari

	Case-1	Case-2	Case-3
EIRR(%)	15.51	12.69	10.53
B/C	1.38	1.14	0.97

c) Banke

	Case-1	Case-2	Case-3
EIRR(%)	15.59	12.81	1.67
B/C	1.40	1.15	0.98

Based on the economic analysis, the following points can be made:

- the number of pump stations can be reduced where the well yield is large;
- the annual O & M costs will be higher where the well yield is small and the number of pump stations is high;
- the total length of the buried pipelines will be longer where the well yield is high and the number of pump stations is small;
- EIRR and B/C ratios will be higher where the well yield is high and lower where the yield of the DTW is small (refer to Figure 9.2.1 (1) (2) (3));
- the ratio of B/C will be less than 1.0 where the well yield is approximately 30 l/sec;
- LFCA irrigated at approximately 30 l/sec is estimated at approximately 30 ha; and
- LFWY will be approximately 30 l/sec.

Table 9.2.1(1) Incremental Agricultural Benefit(Jhapa)

	M. Paddy Rainfed	M.Paddy Irrigated	S.Paddy Irrigated	Maize	Wheat	Miscellaneous (Mustard)	Total
Without Project							
Yield(ton/ha)	2.33	-	-	1.31	1.59	-	
Price(Rs/ton)	10,106	-	-	9,567	12,312	-	
GPV(RS/ha)	24,321	-	-	12,815	19,951	-	
Production Cost(Rs/ha)	8,935	-	-	7,368	10,588	-	
NPV(Rs/ha)	15,386	-	-	5,447	9,363	-	
Cropping Area(ha)	90	-	-	10	26	-	126
Total NPV(RS1000)	1,385	-	-	54	243	-	1,683
With Project							
Yield(ton/ha)	-	4.00	3.80	2.70	2.70	0.80	
Price(Rs/ton)	-	10,106	10,106	9,567	12,312	23,110	
GPV(RS/ha)	-	42,152	39,987	26,412	33,880	18,673	
Production Cost(Rs/ha)	-	12,839	10,276	11,168	12,895	9,055	
NPV(Rs/ha)	-	29,313	29,711	15,244	20,985	9,618	
Cropping Area(ha)	-	100	40	15	30	15	200
Total NPV(RS1000)	-	2,931	1,188	229	630	144	5,122
Incremental NPV(Rs1000)	-1,385	2,931	1,188	174	386	144	3,440

Note:GVP includes income from by-products

Table 9.2.1(2) Incremental Agricultural Benefit(Mahottari)

	M.Paddy Rainfed	M.Paddy Irrigated	S.Paddy Irrigated	Wheat	Pulses (Lentil)	Onion	Potato	Others (Oilseeds)	Total
Without Project									
Yield(ton/ha)	2.29	-	-	1.48	0.60	-	-	0.54	
Price(Rs/ton)	10,361	-	-	12,704	14,940	-	-	23,480	
GPV(RS/ha)	24,733	-	-	19,212	9,086	-	-	12,805	
Production Cost(Rs/ha)	9,338	-	-	11,479	3,673	-	-	6,483	
NPV(Rs/ha)	15,395	-	-	7,733	5,413	-	-	6,322	
Cropping Area(ha)	90	-	-	20	20	-	-	10	140
Total NPV(RS1000)	1,386	-	-	155	108	-	-	63	1,712
With Project									
Yield(ton/ha)	-	3.40	3.60	2.60	-	13.00	12.00	-	
Price(Rs/ton)	-	10,361	10,361	12,704	-	4,140	4,530	-	
GPV(RS/ha)	-	36,837	38,983	33,751	-	53,820	54,360	-	
Production Cost(Rs/ha)	-	12,697	10,584	13,583	-	26,899	35,598	-	
NPV(Rs/ha)	-	24,140	28,399	20,168	-	26,921	18,762	-	
Cropping Area(ha)	-	100	10	49	-	19	22	-	200
Total NPV(RS1000)	-	2,414	284	988	-	511	413	-	4,610
Incremental NPV(Rs1000)	-1,386	2,414	284	834	-108	511	413	-63	2,899

Note:GVP includes income from by-products

Table 9.2.1(3) Incremental Agricultural Benefit(Banke)

	M.Paddy Rainfed	M.Paddy Irrigated	Maize	Mustard	Wheat	Pulses (Lentil)	Potato	Others (Cauliflower)	Total
Without Project									
Yield(ton/ha)	1.95	-	1.61	0.55	1.40	0.68	-	-	
Price(Rs/ton)	10,584	-	10,302	20,330	13,049	21,600	-	-	
GPV(RS/ha)	21,552	-	17,030	11,309	18,598	14,826	-	-	
Production Cost(Rs/ha)	9,618	-	8,626	6,593	10,575	3,763	-	-	
NPV(Rs/ha)	11,934	-	8,404	4,716	8,023	11,063	-	-	
Cropping Area(ha)	80	-	10	10	30	10	-	-	140
Total NPV(RS1000)	955	-	84	47	241	111	-	-	1,437
With Project									
Yield(ton/ha)	-	3.50	2.60	0.8	2.10	1.00	14.00	11.00	
Price(Rs/ton)	-	10,584	10,302	20,330	13,049	21,600	5,420	7,000	
GPV(RS/ha)	-	38,608	27,498	16,417	27,897	21,807	75,880	77,000	
Production Cost(Rs/ha)	-	13,428	13,058	10,680	13,491	6,058	22,546	19,934	
NPV(Rs/ha)	-	25,180	14,440	5,737	14,406	15,749	53,334	57,066	
Cropping Area(ha)	-	87	15	13	50	17	15	3	200
Total NPV(RS1000)	-	2,191	217	75	720	268	800	171	4,441
Incremental NPV(Rs1000)	-955	2,191	133	27	480	157	800	171	3,004

Note:GVP includes income from by-products

Table 9.2.2(1) Calculation of EIRR-Jhapa Representative Area-Case-1(90 lit/sec)(Motor Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV		NPV		NPV	
						Int. =	0.1	Int. =	0.2	Int. =	0.25
						Cost	Benefit	Cost	Benefit	Cost	Benefit
1	14030	0	14030	0	-14030	14030.0	0.0	14030.0	0.0	14030.0	0.0
2	0	225	225	1514	1289	186.0	1250.9	156.3	1051.1	144.0	968.7
3	0	225	225	1823	1598	169.0	1369.8	130.2	1055.1	115.2	933.5
4	0	225	225	2236	2011	153.7	1527.2	108.5	1078.3	92.2	915.9
5	0	225	225	2546	2321	139.7	1580.6	90.4	1023.0	73.7	834.1
6	0	225	225	2786	2561	127.0	1572.9	75.4	933.2	59.0	730.4
7	0	225	225	2993	2768	115.5	1535.8	62.8	835.2	47.2	627.6
8	0	225	225	3130	2905	105.0	1460.4	52.3	728.0	37.7	525.2
9	0	225	225	3234	3009	95.4	1371.4	43.6	626.7	30.2	434.0
10	484	225	709	3302	2593	273.4	1273.2	114.5	533.4	76.1	354.6
11	0	225	225	3354	3129	78.9	1175.6	30.3	451.4	19.3	288.1
12	0	225	225	3378	3153	71.7	1076.4	25.2	378.9	15.5	232.1
13	0	225	225	3440	3215	65.2	996.4	21.0	321.5	12.4	189.1
14	0	225	225	3440	3215	59.2	905.9	17.5	267.9	9.9	151.3
15	1290	225	1515	3440	1925	362.7	823.5	98.3	223.3	53.3	121.0
16	0	225	225	3440	3215	49.0	748.6	12.2	186.1	6.3	96.8
17	0	225	225	3440	3215	44.5	680.6	10.1	155.1	5.1	77.5
18	0	225	225	3440	3215	40.5	618.7	8.5	129.2	4.1	62.0
19	0	225	225	3440	3215	36.8	562.5	7.0	107.7	3.2	49.6
20	1157	225	1382	3440	2058	205.4	511.3	36.0	89.7	15.9	39.7
21	0	225	225	3440	3215	30.4	464.8	4.9	74.8	2.1	31.7
22	0	225	225	3440	3215	27.6	422.6	4.1	62.3	1.7	25.4
23	0	225	225	3440	3215	25.1	384.2	3.4	51.9	1.3	20.3
24	0	225	225	3440	3215	22.8	349.2	2.8	43.3	1.1	16.2
25	0	225	225	3440	3215	20.8	317.5	2.4	36.1	0.9	13.0
26	0	225	225	3440	3215	18.9	288.6	2.0	30.1	0.7	10.4
27	0	225	225	3440	3215	17.2	262.4	1.6	25.0	0.5	8.3
28	0	225	225	3440	3215	15.6	238.5	1.4	20.9	0.4	6.7
29	0	225	225	3440	3215	14.2	216.9	1.1	17.4	0.3	5.3
30	1774	225	1999	3440	1441	114.6	197.1	8.4	14.5	2.5	4.3
31	0	225	225	3440	3215	11.7	179.2	0.8	12.1	0.2	3.4
32	0	225	225	3440	3215	10.7	162.9	0.7	10.1	0.2	2.7
33	0	225	225	3440	3215	9.7	148.1	0.5	8.4	0.1	2.2
34	0	225	225	3440	3215	8.8	134.7	0.5	7.0	0.1	1.7
35	0	225	225	3440	3215	8.0	122.4	0.4	5.8	0.1	1.4
36	0	225	225	3440	3215	7.3	111.3	0.3	4.9	0.1	1.1
37	0	225	225	3440	3215	6.6	101.2	0.3	4.0	0.1	0.9
38	0	225	225	3440	3215	6.0	92.0	0.2	3.4	0.0	0.7
39	0	225	225	3440	3215	5.5	83.6	0.2	2.8	0.0	0.6
40	1157	225	1382	3440	2058	30.5	76.0	0.9	2.3	0.2	0.5
41	0	225	225	3440	3215	4.5	69.1	0.1	2.0	0.0	0.4
42	0	225	225	3440	3215	4.1	62.8	0.1	1.6	0.0	0.3
43	0	225	225	3440	3215	3.7	57.1	0.1	1.4	0.0	0.2
44	0	225	225	3440	3215	3.4	51.9	0.1	1.1	0.0	0.2
45	1290	225	1515	3440	1925	20.8	47.2	0.4	0.9	0.1	0.1
46	0	225	225	3440	3215	2.8	42.9	0.1	0.8	0.0	0.1
47	0	225	225	3440	3215	2.6	39.0	0.0	0.7	0.0	0.1
48	0	225	225	3440	3215	2.3	35.5	0.0	0.5	0.0	0.1
49	0	225	225	3440	3215	2.1	32.2	0.0	0.5	0.0	0.1
50	484	225	709	3440	2731	6.0	29.3	0.1	0.4	0.0	0.0
Total						16872.7	25861.9	15168.1	10621.5	14863.1	7789.7
								EIRR =		16.77	
								B/C at 10%=		1.53	

Calculation of EIRR-Jhapa Representative Area-Case-2 (45 lit/sec) (Motor Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV Int.= 0.1 Cost	NPV Int.= 0.1 Benefit	NPV Int.= 0.2 Cost	NPV Int.= 0.2 Benefit	NPV Int.= 0.25 Cost	NPV Int.= 0.25 Benefit
1	16683	0	16683	0	-16683	16683.0	0.0	16683.0	0.0	16683.0	0.0
2	0	322	322	1514	1192	266.1	1250.9	223.6	1051.1	206.1	968.7
3	0	322	322	1823	1501	241.9	1369.8	186.3	1055.1	164.9	933.5
4	0	322	322	2236	1914	219.9	1527.2	155.3	1078.3	131.9	915.9
5	0	322	322	2546	2224	199.9	1580.6	129.4	1023.0	105.5	834.1
6	0	322	322	2786	2464	181.8	1572.9	107.8	933.2	84.4	730.4
7	0	322	322	2993	2671	165.2	1535.8	89.9	835.2	67.5	627.6
8	0	322	322	3130	2808	150.2	1460.4	74.9	728.0	54.0	525.2
9	0	322	322	3234	2912	136.6	1371.4	62.4	626.7	43.2	434.0
10	484	322	806	3302	2496	310.7	1273.2	130.2	533.4	86.5	354.6
11	0	322	322	3354	3032	112.9	1175.6	43.3	451.4	27.7	288.1
12	0	322	322	3378	3056	102.6	1076.4	36.1	378.9	22.1	232.1
13	0	322	322	3440	3118	93.3	996.4	30.1	321.5	17.7	189.1
14	0	322	322	3440	3118	84.8	905.9	25.1	267.9	14.2	151.3
15	1313	322	1635	3440	1805	391.4	823.5	106.1	223.3	57.5	121.0
16	0	322	322	3440	3118	70.1	748.6	17.4	186.1	9.1	96.8
17	0	322	322	3440	3118	63.7	680.6	14.5	155.1	7.3	77.5
18	0	322	322	3440	3118	57.9	618.7	12.1	129.2	5.8	62.0
19	0	322	322	3440	3118	52.6	562.5	10.1	107.7	4.6	49.6
20	1561	322	1883	3440	1557	279.9	511.3	49.1	89.7	21.7	39.7
21	0	322	322	3440	3118	43.5	464.8	7.0	74.8	3.0	31.7
22	0	322	322	3440	3118	39.6	422.6	5.8	62.3	2.4	25.4
23	0	322	322	3440	3118	36.0	384.2	4.9	51.9	1.9	20.3
24	0	322	322	3440	3118	32.7	349.2	4.1	43.3	1.5	16.2
25	0	322	322	3440	3118	29.7	317.5	3.4	36.1	1.2	13.0
26	0	322	322	3440	3118	27.0	288.6	2.8	30.1	1.0	10.4
27	0	322	322	3440	3118	24.6	262.4	2.3	25.0	0.8	8.3
28	0	322	322	3440	3118	22.3	238.5	2.0	20.9	0.6	6.7
29	0	322	322	3440	3118	20.3	216.9	1.6	17.4	0.5	5.3
30	1797	322	2119	3440	1321	121.4	197.1	8.9	14.5	2.6	4.3
31	0	322	322	3440	3118	16.8	179.2	1.1	12.1	0.3	3.4
32	0	322	322	3440	3118	15.3	162.9	0.9	10.1	0.3	2.7
33	0	322	322	3440	3118	13.9	148.1	0.8	8.4	0.2	2.2
34	0	322	322	3440	3118	12.6	134.7	0.7	7.0	0.2	1.7
35	0	322	322	3440	3118	11.5	122.4	0.5	5.8	0.1	1.4
36	0	322	322	3440	3118	10.4	111.3	0.5	4.9	0.1	1.1
37	0	322	322	3440	3118	9.5	101.2	0.4	4.0	0.1	0.9
38	0	322	322	3440	3118	8.6	92.0	0.3	3.4	0.1	0.7
39	0	322	322	3440	3118	7.8	83.6	0.3	2.8	0.1	0.6
40	1561	322	1883	3440	1557	41.6	76.0	1.3	2.3	0.3	0.5
41	0	322	322	3440	3118	6.5	69.1	0.2	2.0	0.0	0.4
42	0	322	322	3440	3118	5.9	62.8	0.2	1.6	0.0	0.3
43	0	322	322	3440	3118	5.3	57.1	0.1	1.4	0.0	0.2
44	0	322	322	3440	3118	4.9	51.9	0.1	1.1	0.0	0.2
45	1313	322	1635	3440	1805	22.4	47.2	0.4	0.9	0.1	0.1
46	0	322	322	3440	3118	4.0	42.9	0.1	0.8	0.0	0.1
47	0	322	322	3440	3118	3.7	39.0	0.1	0.7	0.0	0.1
48	0	322	322	3440	3118	3.3	35.5	0.1	0.5	0.0	0.1
49	0	322	322	3440	3118	3.0	32.2	0.0	0.5	0.0	0.1
50	484	322	806	3440	2634	6.9	29.3	0.1	0.4	0.0	0.0
Total						20475.4	25861.9	18237.6	10621.5	17832.0	7789.7

EIRR = 13.94

B/C at 10%= 1.26

Calculation of EIRR-Jhapa Representative Area-Case-3(30 lit/sec)(Motor Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV Int.= 0.1		NPV Int.= 0.2		NPV Int.= 0.25	
						Cost	Benefit	Cost	Benefit	Cost	Benefit
1	19666	0	19666	0	-19666	19666.0	0.0	19666.0	0.0	19666.0	0.0
2	0	386	386	1514	1128	319.0	1250.9	268.1	1051.1	247.0	968.7
3	0	386	386	1823	1437	290.0	1369.8	223.4	1055.1	197.6	933.5
4	0	386	386	2236	1850	263.6	1527.2	186.1	1078.3	158.1	915.9
5	0	386	386	2546	2160	239.7	1580.6	155.1	1023.0	126.5	834.1
6	0	386	386	2786	2400	217.9	1572.9	129.3	933.2	101.2	730.4
7	0	386	386	2993	2607	198.1	1535.8	107.7	835.2	81.0	627.6
8	0	386	386	3130	2744	180.1	1460.4	89.8	728.0	64.8	525.2
9	0	386	386	3234	2848	163.7	1371.4	74.8	626.7	51.8	434.0
10	484	386	870	3302	2432	335.4	1273.2	140.5	533.4	93.4	354.6
11	0	386	386	3354	2968	135.3	1175.6	52.0	451.4	33.2	288.1
12	0	386	386	3378	2992	123.0	1076.4	43.3	378.9	26.5	232.1
13	0	386	386	3440	3054	111.8	996.4	36.1	321.5	21.2	189.1
14	0	386	386	3440	3054	101.6	905.9	30.1	267.9	17.0	151.3
15	1313	386	1699	3440	1741	406.7	823.5	110.3	223.3	59.8	121.0
16	0	386	386	3440	3054	84.0	748.6	20.9	186.1	10.9	96.8
17	0	386	386	3440	3054	76.4	680.6	17.4	155.1	8.7	77.5
18	0	386	386	3440	3054	69.4	618.7	14.5	129.2	7.0	62.0
19	0	386	386	3440	3054	63.1	562.5	12.1	107.7	5.6	49.6
20	2099	386	2485	3440	955	369.4	511.3	64.8	89.7	28.7	39.7
21	0	386	386	3440	3054	52.2	464.8	8.4	74.8	3.6	31.7
22	0	386	386	3440	3054	47.4	422.6	7.0	62.3	2.8	25.4
23	0	386	386	3440	3054	43.1	384.2	5.8	51.9	2.3	20.3
24	0	386	386	3440	3054	39.2	349.2	4.9	43.3	1.8	16.2
25	0	386	386	3440	3054	35.6	317.5	4.0	36.1	1.5	13.0
26	0	386	386	3440	3054	32.4	288.6	3.4	30.1	1.2	10.4
27	0	386	386	3440	3054	29.4	262.4	2.8	25.0	0.9	8.3
28	0	386	386	3440	3054	26.8	238.5	2.3	20.9	0.7	6.7
29	0	386	386	3440	3054	24.3	216.9	2.0	17.4	0.6	5.3
30	1797	386	2183	3440	1257	125.1	197.1	9.2	14.5	2.7	4.3
31	0	386	386	3440	3054	20.1	179.2	1.4	12.1	0.4	3.4
32	0	386	386	3440	3054	18.3	162.9	1.1	10.1	0.3	2.7
33	0	386	386	3440	3054	16.6	148.1	0.9	8.4	0.2	2.2
34	0	386	386	3440	3054	15.1	134.7	0.8	7.0	0.2	1.7
35	0	386	386	3440	3054	13.7	122.4	0.7	5.8	0.2	1.4
36	0	386	386	3440	3054	12.5	111.3	0.5	4.9	0.1	1.1
37	0	386	386	3440	3054	11.4	101.2	0.5	4.0	0.1	0.9
38	0	386	386	3440	3054	10.3	92.0	0.4	3.4	0.1	0.7
39	0	386	386	3440	3054	9.4	83.6	0.3	2.8	0.1	0.6
40	2099	386	2485	3440	955	54.9	76.0	1.7	2.3	0.3	0.5
41	0	386	386	3440	3054	7.8	69.1	0.2	2.0	0.0	0.4
42	0	386	386	3440	3054	7.0	62.8	0.2	1.6	0.0	0.3
43	0	386	386	3440	3054	6.4	57.1	0.2	1.4	0.0	0.2
44	0	386	386	3440	3054	5.8	51.9	0.1	1.1	0.0	0.2
45	1313	386	1699	3440	1741	23.3	47.2	0.5	0.9	0.1	0.1
46	0	386	386	3440	3054	4.8	42.9	0.1	0.8	0.0	0.1
47	0	386	386	3440	3054	4.4	39.0	0.1	0.7	0.0	0.1
48	0	386	386	3440	3054	4.0	35.5	0.1	0.5	0.0	0.1
49	0	386	386	3440	3054	3.6	32.2	0.1	0.5	0.0	0.1
50	484	386	870	3440	2570	7.4	29.3	0.1	0.4	0.0	0.0
Total						24126.6	25861.9	21501.7	10621.5	21026.1	7789.7

EIRR = 11.75

B/C at 10%= 1.07

Table 9.2.2(2) Calculation of EIRR-Mahottari-Case-1(90 lit/sec) (Motor Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV Int.= 0.1 Cost	NPV Int.= 0.1 Benefit	NPV Int.= 0.2 Cost	NPV Int.= 0.2 Benefit	NPV Int.= 0.25 Cost	NPV Int.= 0.25 Benefit
1	14030	0	14030	0	-14030	14030.0	0.0	14030.0	0.0	14030.0	0.0
2	0	225	225	1305	1080	186.0	1078.1	156.3	905.9	144.0	834.9
3	0	225	225	1884	1659	169.0	1415.7	130.2	1090.5	115.2	964.8
4	0	225	225	2319	2094	153.7	1584.0	108.5	1118.4	92.2	949.9
5	0	225	225	2609	2384	139.7	1620.0	90.4	1048.5	73.7	854.9
6	0	225	225	2754	2529	127.0	1554.6	75.4	922.3	59.0	722.0
7	0	225	225	2827	2602	115.5	1450.5	62.8	788.8	47.2	592.8
8	0	225	225	2899	2674	105.0	1352.4	52.3	674.2	37.7	486.4
9	0	225	225	2899	2674	95.4	1229.5	43.6	561.8	30.2	389.1
10	484	225	709	2899	2190	273.4	1117.7	114.5	468.2	76.1	311.3
11	0	225	225	2899	2674	78.9	1016.1	30.3	390.2	19.3	249.0
12	0	225	225	2899	2674	71.7	923.7	25.2	325.1	15.5	199.2
13	0	225	225	2899	2674	65.2	839.7	21.0	271.0	12.4	159.4
14	0	225	225	2899	2674	59.2	763.4	17.5	225.8	9.9	127.5
15	1290	225	1515	2899	1384	362.7	694.0	98.3	188.2	53.3	102.0
16	0	225	225	2899	2674	49.0	630.9	12.2	156.8	6.3	81.6
17	0	225	225	2899	2674	44.5	573.6	10.1	130.7	5.1	65.3
18	0	225	225	2899	2674	40.5	521.4	8.5	108.9	4.1	52.2
19	0	225	225	2899	2674	36.8	474.0	7.0	90.7	3.2	41.8
20	1157	225	1382	2899	1517	205.4	430.9	36.0	75.6	15.9	33.4
21	0	225	225	2899	2674	30.4	391.7	4.9	63.0	2.1	26.7
22	0	225	225	2899	2674	27.6	356.1	4.1	52.5	1.7	21.4
23	0	225	225	2899	2674	25.1	323.8	3.4	43.8	1.3	17.1
24	0	225	225	2899	2674	22.8	294.3	2.8	36.5	1.1	13.7
25	0	225	225	2899	2674	20.8	267.6	2.4	30.4	0.9	11.0
26	0	225	225	2899	2674	18.9	243.2	2.0	25.3	0.7	8.8
27	0	225	225	2899	2674	17.2	221.1	1.6	21.1	0.5	7.0
28	0	225	225	2899	2674	15.6	201.0	1.4	17.6	0.4	5.6
29	0	225	225	2899	2674	14.2	182.8	1.1	14.7	0.3	4.5
30	1774	225	1999	2899	900	114.6	166.1	8.4	12.2	2.5	3.6
31	0	225	225	2899	2674	11.7	151.0	0.8	10.2	0.2	2.9
32	0	225	225	2899	2674	10.7	137.3	0.7	8.5	0.2	2.3
33	0	225	225	2899	2674	9.7	124.8	0.5	7.1	0.1	1.8
34	0	225	225	2899	2674	8.8	113.5	0.5	5.9	0.1	1.5
35	0	225	225	2899	2674	8.0	103.2	0.4	4.9	0.1	1.2
36	0	225	225	2899	2674	7.3	93.8	0.3	4.1	0.1	0.9
37	0	225	225	2899	2674	6.6	85.3	0.3	3.4	0.1	0.8
38	0	225	225	2899	2674	6.0	77.5	0.2	2.8	0.0	0.6
39	0	225	225	2899	2674	5.5	70.5	0.2	2.4	0.0	0.5
40	1157	225	1382	2899	1517	30.5	64.1	0.9	2.0	0.2	0.4
41	0	225	225	2899	2674	4.5	58.2	0.1	1.6	0.0	0.3
42	0	225	225	2899	2674	4.1	52.9	0.1	1.4	0.0	0.2
43	0	225	225	2899	2674	3.7	48.1	0.1	1.1	0.0	0.2
44	0	225	225	2899	2674	3.4	43.7	0.1	1.0	0.0	0.2
45	1290	225	1515	2899	1384	20.8	39.8	0.4	0.8	0.1	0.1
46	0	225	225	2899	2674	2.8	36.2	0.1	0.7	0.0	0.1
47	0	225	225	2899	2674	2.6	32.9	0.0	0.6	0.0	0.1
48	0	225	225	2899	2674	2.3	29.9	0.0	0.5	0.0	0.1
49	0	225	225	2899	2674	2.1	27.2	0.0	0.4	0.0	0.1
50	484	225	709	2899	2190	6.0	24.7	0.1	0.3	0.0	0.0
Total						16872.7	23332.5	15168.1	9918.3	14863.1	7351.0

EIRR = 15.51

B/C at 10%= 1.38

Calculation of EIRR-Mahottari-Case-2 (45 lit/sec) (Motor Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV Int.= 0.1 Cost	NPV Int.= 0.1 Benefit	NPV Int.= 0.2 Cost	NPV Int.= 0.2 Benefit	NPV Int.= 0.25 Cost	NPV Int.= 0.25 Benefit
1	16683	0	16683	0	-16683	16683.0	0.0	16683.0	0.0	16683.0	0.0
2	0	322	322	1306	983	266.1	1078.1	223.6	905.9	206.1	834.9
3	0	322	322	1884	1562	241.9	1415.7	186.3	1090.6	164.9	964.8
4	0	322	322	2319	1997	219.9	1584.0	155.3	1118.4	131.9	949.9
5	0	322	322	2609	2287	199.9	1620.0	129.4	1048.5	105.5	854.9
6	0	322	322	2754	2432	181.8	1554.6	107.8	922.3	84.4	722.0
7	0	322	322	2827	2505	165.2	1450.5	89.9	788.8	67.5	592.8
8	0	322	322	2899	2577	150.2	1352.4	74.9	674.2	54.0	486.4
9	0	322	322	2899	2577	136.6	1229.5	62.4	561.8	43.2	389.1
10	484	322	806	2899	2093	310.7	1117.7	130.2	468.2	86.5	311.3
11	0	322	322	2899	2577	112.9	1016.1	43.3	390.2	27.7	249.0
12	0	322	322	2899	2577	102.6	923.7	36.1	325.1	22.1	199.2
13	0	322	322	2899	2577	93.3	839.7	30.1	271.0	17.7	159.4
14	0	322	322	2899	2577	84.8	763.4	25.1	225.8	14.2	127.5
15	1313	322	1635	2899	1264	391.4	694.0	106.1	188.2	57.5	102.0
16	0	322	322	2899	2577	70.1	630.9	17.4	156.8	9.1	81.6
17	0	322	322	2899	2577	63.7	573.6	14.5	130.7	7.3	65.3
18	0	322	322	2899	2577	57.9	521.4	12.1	108.9	5.8	52.2
19	0	322	322	2899	2577	52.6	474.0	10.1	90.7	4.6	41.8
20	1561	322	1883	2899	1016	279.9	430.9	49.1	75.6	21.7	33.4
21	0	322	322	2899	2577	43.5	391.7	7.0	63.0	3.0	26.7
22	0	322	322	2899	2577	39.6	356.1	5.8	52.5	2.4	21.4
23	0	322	322	2899	2577	36.0	323.8	4.9	43.8	1.9	17.1
24	0	322	322	2899	2577	32.7	294.3	4.1	36.5	1.5	13.7
25	0	322	322	2899	2577	29.7	267.6	3.4	30.4	1.2	11.0
26	0	322	322	2899	2577	27.0	243.2	2.8	25.3	1.0	8.8
27	0	322	322	2899	2577	24.6	221.1	2.3	21.1	0.8	7.0
28	0	322	322	2899	2577	22.3	201.0	2.0	17.6	0.6	5.6
29	0	322	322	2899	2577	20.3	182.8	1.6	14.7	0.5	4.5
30	1797	322	2119	2899	780	121.4	166.1	8.9	12.2	2.6	3.6
31	0	322	322	2899	2577	16.8	151.0	1.1	10.2	0.3	2.9
32	0	322	322	2899	2577	15.3	137.3	0.9	8.5	0.3	2.3
33	0	322	322	2899	2577	13.9	124.8	0.8	7.1	0.2	1.8
34	0	322	322	2899	2577	12.6	113.5	0.7	5.9	0.2	1.5
35	0	322	322	2899	2577	11.5	103.2	0.5	4.9	0.1	1.2
36	0	322	322	2899	2577	10.4	93.8	0.5	4.1	0.1	0.9
37	0	322	322	2899	2577	9.5	85.3	0.4	3.4	0.1	0.8
38	0	322	322	2899	2577	8.6	77.5	0.3	2.8	0.1	0.6
39	0	322	322	2899	2577	7.8	70.5	0.3	2.4	0.1	0.5
40	1561	322	1883	2899	1016	41.6	64.1	1.3	2.0	0.3	0.4
41	0	322	322	2899	2577	6.5	58.2	0.2	1.6	0.0	0.3
42	0	322	322	2899	2577	5.9	52.9	0.2	1.4	0.0	0.2
43	0	322	322	2899	2577	5.3	48.1	0.1	1.1	0.0	0.2
44	0	322	322	2899	2577	4.9	43.7	0.1	1.0	0.0	0.2
45	1313	322	1635	2899	1264	22.4	39.8	0.4	0.8	0.1	0.1
46	0	322	322	2899	2577	4.0	36.2	0.1	0.7	0.0	0.1
47	0	322	322	2899	2577	3.7	32.9	0.1	0.6	0.0	0.1
48	0	322	322	2899	2577	3.3	29.9	0.1	0.5	0.0	0.1
49	0	322	322	2899	2577	3.0	27.2	0.0	0.4	0.0	0.1
50	484	322	806	2899	2093	6.9	24.7	0.1	0.3	0.0	0.0
Total						20475.4	23332.5	18237.6	9918.3	17832.0	7351.0

EIRR = 12.69

B/C at 10%= 1.14

Calculation of EIRR-Mahottari-Case-3(30 lit/sec) (Motor Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV		NPV		NPV	
						Int.= 0.1		Int.= 0.2		Int.= 0.25	
						Cost	Benefit	Cost	Benefit	Cost	Benefit
1	19666	0	19666	0	-19666	19666.0	0.0	19666.0	0.0	19666.0	0.0
2	0	386	386	1305	919	319.0	1078.1	268.1	905.9	247.0	834.9
3	0	386	386	1884	1498	290.0	1415.7	223.4	1090.5	197.6	964.8
4	0	386	386	2319	1933	263.6	1584.0	186.1	1118.4	158.1	949.9
5	0	386	386	2609	2223	239.7	1620.0	155.1	1048.5	126.5	854.9
6	0	386	386	2754	2368	217.9	1554.6	129.3	922.3	101.2	722.0
7	0	386	386	2827	2441	198.1	1450.5	107.7	788.8	81.0	592.8
8	0	386	386	2899	2513	180.1	1352.4	89.8	674.2	64.8	486.4
9	0	386	386	2899	2513	163.7	1229.5	74.8	561.8	51.8	389.1
10	484	386	870	2899	2029	335.4	1117.7	140.5	468.2	93.4	311.3
11	0	386	386	2899	2513	135.3	1016.1	52.0	390.2	33.2	249.0
12	0	386	386	2899	2513	123.0	923.7	43.3	325.1	26.5	199.2
13	0	386	386	2899	2513	111.8	839.7	36.1	271.0	21.2	159.4
14	0	386	386	2899	2513	101.6	763.4	30.1	225.8	17.0	127.5
15	1313	386	1699	2899	1200	406.7	694.0	110.3	188.2	59.8	102.0
16	0	386	386	2899	2513	84.0	630.9	20.9	156.8	10.9	81.6
17	0	386	386	2899	2513	76.4	573.6	17.4	130.7	8.7	65.3
18	0	386	386	2899	2513	69.4	521.4	14.5	108.9	7.0	52.2
19	0	386	386	2899	2513	63.1	474.0	12.1	90.7	5.6	41.8
20	2099	386	2485	2899	414	369.4	430.9	64.8	75.6	28.7	33.4
21	0	386	386	2899	2513	52.2	391.7	8.4	63.0	3.6	26.7
22	0	386	386	2899	2513	47.4	356.1	7.0	52.5	2.8	21.4
23	0	386	386	2899	2513	43.1	323.8	5.8	43.8	2.3	17.1
24	0	386	386	2899	2513	39.2	294.3	4.9	36.5	1.8	13.7
25	0	386	386	2899	2513	35.6	267.6	4.0	30.4	1.5	11.0
26	0	386	386	2899	2513	32.4	243.2	3.4	25.3	1.2	8.8
27	0	386	386	2899	2513	29.4	221.1	2.8	21.1	0.9	7.0
28	0	386	386	2899	2513	26.8	201.0	2.3	17.6	0.7	5.6
29	0	386	386	2899	2513	24.3	182.8	2.0	14.7	0.6	4.5
30	1797	386	2183	2899	716	126.1	166.1	9.2	12.2	2.7	3.6
31	0	386	386	2899	2513	20.1	151.0	1.4	10.2	0.4	2.9
32	0	386	386	2899	2513	18.3	137.3	1.1	8.5	0.3	2.3
33	0	386	386	2899	2513	16.6	124.8	0.9	7.1	0.2	1.8
34	0	386	386	2899	2513	15.1	113.5	0.8	5.9	0.2	1.5
35	0	386	386	2899	2513	13.7	103.2	0.7	4.9	0.2	1.2
36	0	386	386	2899	2513	12.5	93.8	0.5	4.1	0.1	0.9
37	0	386	386	2899	2513	11.4	85.3	0.5	3.4	0.1	0.8
38	0	386	386	2899	2513	10.3	77.5	0.4	2.8	0.1	0.6
39	0	386	386	2899	2513	9.4	70.5	0.3	2.4	0.1	0.5
40	2099	386	2485	2899	414	54.9	64.1	1.7	2.0	0.3	0.4
41	0	386	386	2899	2513	7.8	58.2	0.2	1.6	0.0	0.3
42	0	386	386	2899	2513	7.0	52.9	0.2	1.4	0.0	0.2
43	0	386	386	2899	2513	6.4	48.1	0.2	1.1	0.0	0.2
44	0	386	386	2899	2513	5.8	43.7	0.1	1.0	0.0	0.2
45	1313	386	1699	2899	1200	23.3	39.8	0.5	0.8	0.1	0.1
46	0	386	386	2899	2513	4.8	36.2	0.1	0.7	0.0	0.1
47	0	386	386	2899	2513	4.4	32.9	0.1	0.6	0.0	0.1
48	0	386	386	2899	2513	4.0	29.9	0.1	0.5	0.0	0.1
49	0	386	386	2899	2513	3.6	27.2	0.1	0.4	0.0	0.1
50	484	386	870	2899	2029	7.4	24.7	0.1	0.3	0.0	0.0
Total						24126.6	23332.5	21501.7	9918.3	21026.1	7351.0

EIRR = 10.53

B/C at 10%= 0.97

Table 9.2.2(3) **Calculation of EIRR-Banke-Case-1 (90 lit/sec)** (Motor Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV Int.= 0.1 Cost	NPV Int.= 0.1 Benefit	NPV Int.= 0.2 Cost	NPV Int.= 0.2 Benefit	NPV Int.= 0.25 Cost	NPV Int.= 0.25 Benefit
1	14030	0	14030	0	-14030	14030.0	0.0	14030.0	0.0	14030.0	0.0
2	0	225	225	1352	1127	186.0	1117.2	156.3	938.8	144.0	865.2
3	0	225	225	1802	1577	169.0	1354.2	130.2	1043.1	115.2	922.8
4	0	225	225	2253	2028	153.7	1538.8	108.5	1086.5	92.2	922.8
5	0	225	225	2493	2268	139.7	1548.2	90.4	1002.0	73.7	817.0
6	0	225	225	2704	2479	127.0	1526.1	75.4	905.4	59.0	708.7
7	0	225	225	2824	2599	115.5	1449.0	62.8	788.1	47.2	592.2
8	0	225	225	2914	2689	105.0	1369.3	52.3	677.7	37.7	488.9
9	0	225	225	2944	2719	95.4	1248.5	43.6	570.6	30.2	395.1
10	484	225	709	3004	2295	273.4	1158.2	114.5	485.2	76.1	322.6
11	0	225	225	3004	2779	78.9	1052.9	30.3	404.3	19.3	258.0
12	0	225	225	3004	2779	71.7	957.2	25.2	336.9	15.5	206.4
13	0	225	225	3004	2779	65.2	870.2	21.0	280.8	12.4	165.1
14	0	225	225	3004	2779	59.2	791.0	17.5	234.0	9.9	132.1
15	1290	225	1515	3004	1489	362.7	719.1	98.3	195.0	53.3	105.7
16	0	225	225	3004	2779	49.0	653.8	12.2	162.5	6.3	84.6
17	0	225	225	3004	2779	44.5	594.3	10.1	135.4	5.1	67.6
18	0	225	225	3004	2779	40.5	540.3	8.5	112.8	4.1	54.1
19	0	225	225	3004	2779	36.8	491.2	7.0	94.0	3.2	43.3
20	1157	225	1382	3004	1622	205.4	446.5	36.0	78.4	15.9	34.6
21	0	225	225	3004	2779	30.4	405.9	4.9	65.3	2.1	27.7
22	0	225	225	3004	2779	27.6	369.0	4.1	54.4	1.7	22.2
23	0	225	225	3004	2779	25.1	335.5	3.4	45.3	1.3	17.7
24	0	225	225	3004	2779	22.8	305.0	2.8	37.8	1.1	14.2
25	0	225	225	3004	2779	20.8	277.3	2.4	31.5	0.9	11.3
26	0	225	225	3004	2779	18.9	252.1	2.0	26.2	0.7	9.1
27	0	225	225	3004	2779	17.2	229.1	1.6	21.9	0.6	7.3
28	0	225	225	3004	2779	15.6	208.3	1.4	18.2	0.4	5.8
29	0	225	225	3004	2779	14.2	189.4	1.1	15.2	0.3	4.6
30	1774	225	1999	3004	1005	114.6	172.2	8.4	12.7	2.5	3.7
31	0	225	225	3004	2779	11.7	156.5	0.8	10.5	0.2	3.0
32	0	225	225	3004	2779	10.7	142.3	0.7	8.8	0.2	2.4
33	0	225	225	3004	2779	9.7	129.3	0.5	7.3	0.1	1.9
34	0	225	225	3004	2779	8.8	117.6	0.5	6.1	0.1	1.5
35	0	225	225	3004	2779	8.0	106.9	0.4	5.1	0.1	1.2
36	0	225	225	3004	2779	7.3	97.2	0.3	4.2	0.1	1.0
37	0	225	225	3004	2779	6.6	88.3	0.3	3.5	0.1	0.8
38	0	225	225	3004	2779	6.0	80.3	0.2	2.9	0.0	0.6
39	0	225	225	3004	2779	5.5	73.0	0.2	2.5	0.0	0.5
40	1157	225	1382	3004	1622	30.5	66.4	0.9	2.0	0.2	0.4
41	0	225	225	3004	2779	4.5	60.3	0.1	1.7	0.0	0.3
42	0	225	225	3004	2779	4.1	54.9	0.1	1.4	0.0	0.3
43	0	225	225	3004	2779	3.7	49.9	0.1	1.2	0.0	0.2
44	0	225	225	3004	2779	3.4	45.3	0.1	1.0	0.0	0.2
45	1290	225	1515	3004	1489	20.8	41.2	0.4	0.8	0.1	0.1
46	0	225	225	3004	2779	2.8	37.5	0.1	0.7	0.0	0.1
47	0	225	225	3004	2779	2.6	34.1	0.0	0.6	0.0	0.1
48	0	225	225	3004	2779	2.3	31.0	0.0	0.5	0.0	0.1
49	0	225	225	3004	2779	2.1	28.1	0.0	0.4	0.0	0.1
50	484	225	709	3004	2295	6.0	25.6	0.1	0.3	0.0	0.0
Total						16872.7	23625.3	15168.1	9921.4	14863.1	7325.3

EIRR = 15.59

B/C at 10%= 1.40

Calculation of EIRR-Banke-Case-2 (45 lit/sec) (Motor Pump)

(Unit: Rs. 1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV Int. = 0.1		NPV Int. = 0.2		NPV Int. = 0.25	
						Cost	Benefit	Cost	Benefit	Cost	Benefit
1	16683	0	16683	0	-16683	16683.0	0.0	16683.0	0.0	16683.0	0.0
2	0	322	322	1352	1030	266.1	1117.2	223.6	938.8	206.1	865.2
3	0	322	322	1802	1480	241.9	1354.2	186.3	1043.1	164.9	922.8
4	0	322	322	2263	1931	219.9	1538.8	155.3	1086.5	131.9	922.8
5	0	322	322	2493	2171	199.9	1548.2	129.4	1002.0	105.5	817.0
6	0	322	322	2704	2382	181.8	1526.1	107.8	905.4	84.4	708.7
7	0	322	322	2824	2502	165.2	1449.0	89.9	788.1	67.5	592.2
8	0	322	322	2914	2592	150.2	1359.3	74.9	677.7	54.0	488.9
9	0	322	322	2944	2622	136.6	1248.5	62.4	570.6	43.2	395.1
10	484	322	806	3004	2198	310.7	1158.2	130.2	485.2	86.5	322.6
11	0	322	322	3004	2682	112.9	1052.9	43.3	404.3	27.7	258.0
12	0	322	322	3004	2682	102.6	957.2	36.1	336.9	22.1	206.4
13	0	322	322	3004	2682	93.3	870.2	30.1	280.8	17.7	165.1
14	0	322	322	3004	2682	84.8	791.0	25.1	234.0	14.2	132.1
15	1313	322	1635	3004	1369	391.4	719.1	106.1	195.0	57.5	105.7
16	0	322	322	3004	2682	70.1	653.8	17.4	162.5	9.1	84.6
17	0	322	322	3004	2682	63.7	594.3	14.5	135.4	7.3	67.6
18	0	322	322	3004	2682	57.9	540.3	12.1	112.8	5.8	54.1
19	0	322	322	3004	2682	52.6	491.2	10.1	94.0	4.6	43.3
20	1561	322	1883	3004	1121	279.9	446.5	49.1	78.4	21.7	34.6
21	0	322	322	3004	2682	43.5	405.9	7.0	65.3	3.0	27.7
22	0	322	322	3004	2682	39.6	369.0	5.8	54.4	2.4	22.2
23	0	322	322	3004	2682	36.0	335.5	4.9	45.3	1.9	17.7
24	0	322	322	3004	2682	32.7	305.0	4.1	37.8	1.5	14.2
25	0	322	322	3004	2682	29.7	277.3	3.4	31.5	1.2	11.3
26	0	322	322	3004	2682	27.0	252.1	2.8	26.2	1.0	9.1
27	0	322	322	3004	2682	24.6	229.1	2.3	21.9	0.8	7.3
28	0	322	322	3004	2682	22.3	208.3	2.0	18.2	0.6	5.8
29	0	322	322	3004	2682	20.3	189.4	1.6	15.2	0.5	4.6
30	1797	322	2119	3004	885	121.4	172.2	8.9	12.7	2.6	3.7
31	0	322	322	3004	2682	16.8	156.5	1.1	10.5	0.3	3.0
32	0	322	322	3004	2682	15.3	142.3	0.9	8.8	0.3	2.4
33	0	322	322	3004	2682	13.9	129.3	0.8	7.3	0.2	1.9
34	0	322	322	3004	2682	12.6	117.6	0.7	6.1	0.2	1.5
35	0	322	322	3004	2682	11.5	106.9	0.6	5.1	0.1	1.2
36	0	322	322	3004	2682	10.4	97.2	0.5	4.2	0.1	1.0
37	0	322	322	3004	2682	9.5	88.3	0.4	3.5	0.1	0.8
38	0	322	322	3004	2682	8.6	80.3	0.3	2.9	0.1	0.6
39	0	322	322	3004	2682	7.8	73.0	0.3	2.5	0.1	0.5
40	1561	322	1883	3004	1121	41.6	66.4	1.3	2.0	0.3	0.4
41	0	322	322	3004	2682	6.5	60.3	0.2	1.7	0.0	0.3
42	0	322	322	3004	2682	5.9	54.9	0.2	1.4	0.0	0.3
43	0	322	322	3004	2682	5.3	49.9	0.1	1.2	0.0	0.2
44	0	322	322	3004	2682	4.9	45.3	0.1	1.0	0.0	0.2
45	1313	322	1635	3004	1369	22.4	41.2	0.4	0.8	0.1	0.1
46	0	322	322	3004	2682	4.0	37.5	0.1	0.7	0.0	0.1
47	0	322	322	3004	2682	3.7	34.1	0.1	0.6	0.0	0.1
48	0	322	322	3004	2682	3.3	31.0	0.1	0.5	0.0	0.1
49	0	322	322	3004	2682	3.0	28.1	0.0	0.4	0.0	0.1
50	484	322	806	3004	2198	6.9	25.6	0.1	0.3	0.0	0.0
Total						20475.4	23625.3	18237.6	9921.4	17832.0	7325.3

EIRR = 12.81

B/C at 10% = 1.15

Calculation of EIRR-Banke-Case-3 (30 lit/sec) (Motor Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV Int.= 0.1 Cost	NPV Int.= 0.1 Benefit	NPV Int.= 0.2 Cost	NPV Int.= 0.2 Benefit	NPV Int.= 0.25 Cost	NPV Int.= 0.25 Benefit
1	19666	0	19666	0	-19666	19666.0	0.0	19666.0	0.0	19666.0	0.0
2	0	386	386	1352	966	319.0	1117.2	268.1	938.8	247.0	865.2
3	0	386	386	1802	1416	290.0	1354.2	223.4	1043.1	197.6	922.8
4	0	386	386	2253	1867	263.6	1538.8	186.1	1086.5	158.1	922.8
5	0	386	386	2493	2107	239.7	1548.2	155.1	1002.0	126.5	817.0
6	0	386	386	2704	2318	217.9	1526.1	129.3	905.4	101.2	708.7
7	0	386	386	2824	2438	198.1	1449.0	107.7	788.1	81.0	592.2
8	0	386	386	2914	2528	180.1	1359.3	89.8	677.7	64.8	488.9
9	0	386	386	2944	2558	163.7	1248.5	74.8	570.6	51.8	395.1
10	484	386	870	3004	2134	335.4	1158.2	140.5	485.2	93.4	322.6
11	0	386	386	3004	2618	135.3	1052.9	52.0	404.3	33.2	258.0
12	0	386	386	3004	2618	123.0	957.2	43.3	336.9	26.5	206.4
13	0	386	386	3004	2618	111.8	870.2	36.1	280.8	21.2	165.1
14	0	386	386	3004	2618	101.6	791.0	30.1	234.0	17.0	132.1
15	1313	386	1699	3004	1305	406.7	719.1	110.3	195.0	59.8	105.7
16	0	386	386	3004	2618	84.0	653.8	20.9	162.5	10.9	84.6
17	0	386	386	3004	2618	76.4	594.3	17.4	135.4	8.7	67.6
18	0	386	386	3004	2618	69.4	540.3	14.5	112.8	7.0	54.1
19	0	386	386	3004	2618	63.1	491.2	12.1	94.0	5.6	43.3
20	2099	386	2485	3004	519	369.4	446.5	64.8	78.4	28.7	34.6
21	0	386	386	3004	2618	52.2	405.9	8.4	65.3	3.6	27.7
22	0	386	386	3004	2618	47.4	369.0	7.0	54.4	2.8	22.2
23	0	386	386	3004	2618	43.1	335.5	5.8	45.3	2.3	17.7
24	0	386	386	3004	2618	39.2	305.0	4.9	37.8	1.8	14.2
25	0	386	386	3004	2618	35.6	277.3	4.0	31.5	1.5	11.3
26	0	386	386	3004	2618	32.4	252.1	3.4	26.2	1.2	9.1
27	0	386	386	3004	2618	29.4	229.1	2.8	21.9	0.9	7.3
28	0	386	386	3004	2618	26.8	208.3	2.3	18.2	0.7	5.8
29	0	386	386	3004	2618	24.3	189.4	2.0	15.2	0.6	4.6
30	1797	386	2183	3004	821	125.1	172.2	9.2	12.7	2.7	3.7
31	0	386	386	3004	2618	20.1	156.5	1.4	10.5	0.4	3.0
32	0	386	386	3004	2618	18.3	142.3	1.1	8.8	0.3	2.4
33	0	386	386	3004	2618	16.6	129.3	0.9	7.3	0.2	1.9
34	0	386	386	3004	2618	15.1	117.6	0.8	6.1	0.2	1.5
35	0	386	386	3004	2618	13.7	106.9	0.7	5.1	0.2	1.2
36	0	386	386	3004	2618	12.5	97.2	0.5	4.2	0.1	1.0
37	0	386	386	3004	2618	11.4	88.3	0.5	3.5	0.1	0.8
38	0	386	386	3004	2618	10.3	80.3	0.4	2.9	0.1	0.6
39	0	386	386	3004	2618	9.4	73.0	0.3	2.5	0.1	0.5
40	2099	386	2485	3004	519	54.9	66.4	1.7	2.0	0.3	0.4
41	0	386	386	3004	2618	7.8	60.3	0.2	1.7	0.0	0.3
42	0	386	386	3004	2618	7.0	54.9	0.2	1.4	0.0	0.3
43	0	386	386	3004	2618	6.4	49.9	0.2	1.2	0.0	0.2
44	0	386	386	3004	2618	5.8	45.3	0.1	1.0	0.0	0.2
45	1313	386	1699	3004	1305	23.3	41.2	0.5	0.8	0.1	0.1
46	0	386	386	3004	2618	4.8	37.5	0.1	0.7	0.0	0.1
47	0	386	386	3004	2618	4.4	34.1	0.1	0.6	0.0	0.1
48	0	386	386	3004	2618	4.0	31.0	0.1	0.5	0.0	0.1
49	0	386	386	3004	2618	3.6	28.1	0.1	0.4	0.0	0.1
50	484	386	870	3004	2134	7.4	25.6	0.1	0.3	0.0	0.0
Total						24126.6	23625.3	21501.7	9921.4	21026.1	7325.3

EIRR = 10.67

B/C at 10%= 0.98

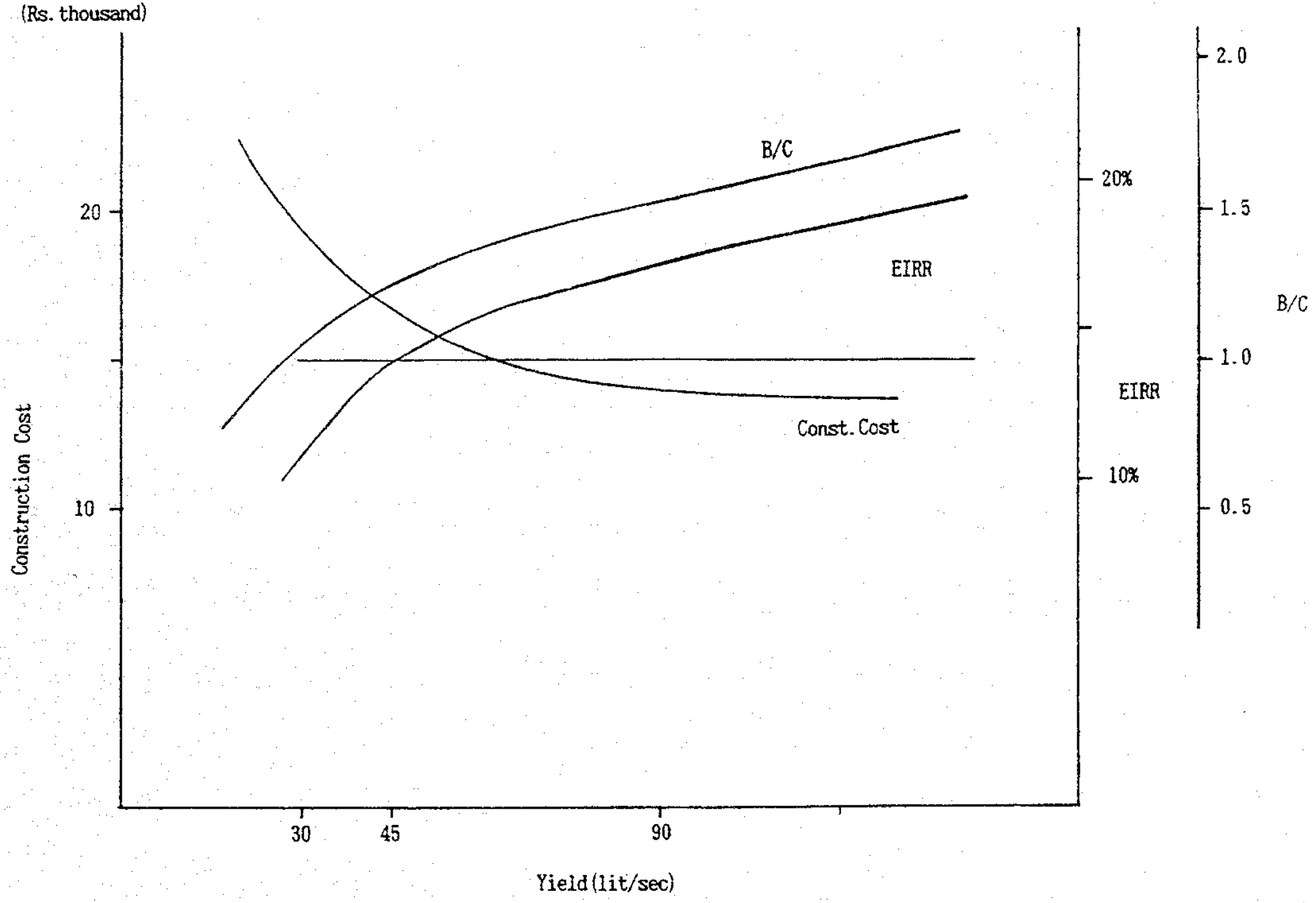


Figure 9.2.1(1) LCFA and LFWY(Jhapa)

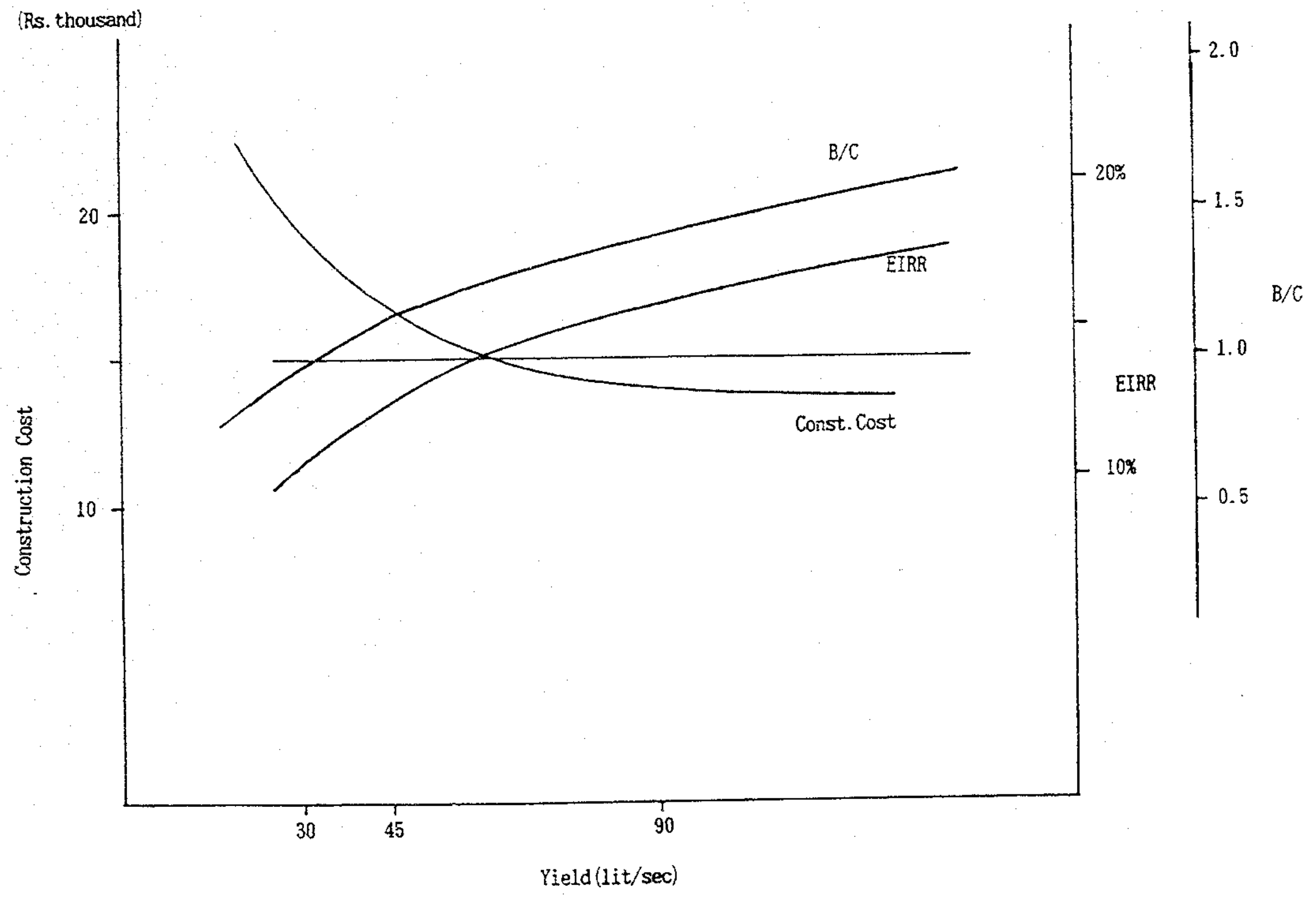


Figure 9.2.1(2) LCFA and LFWY(Mahottari)

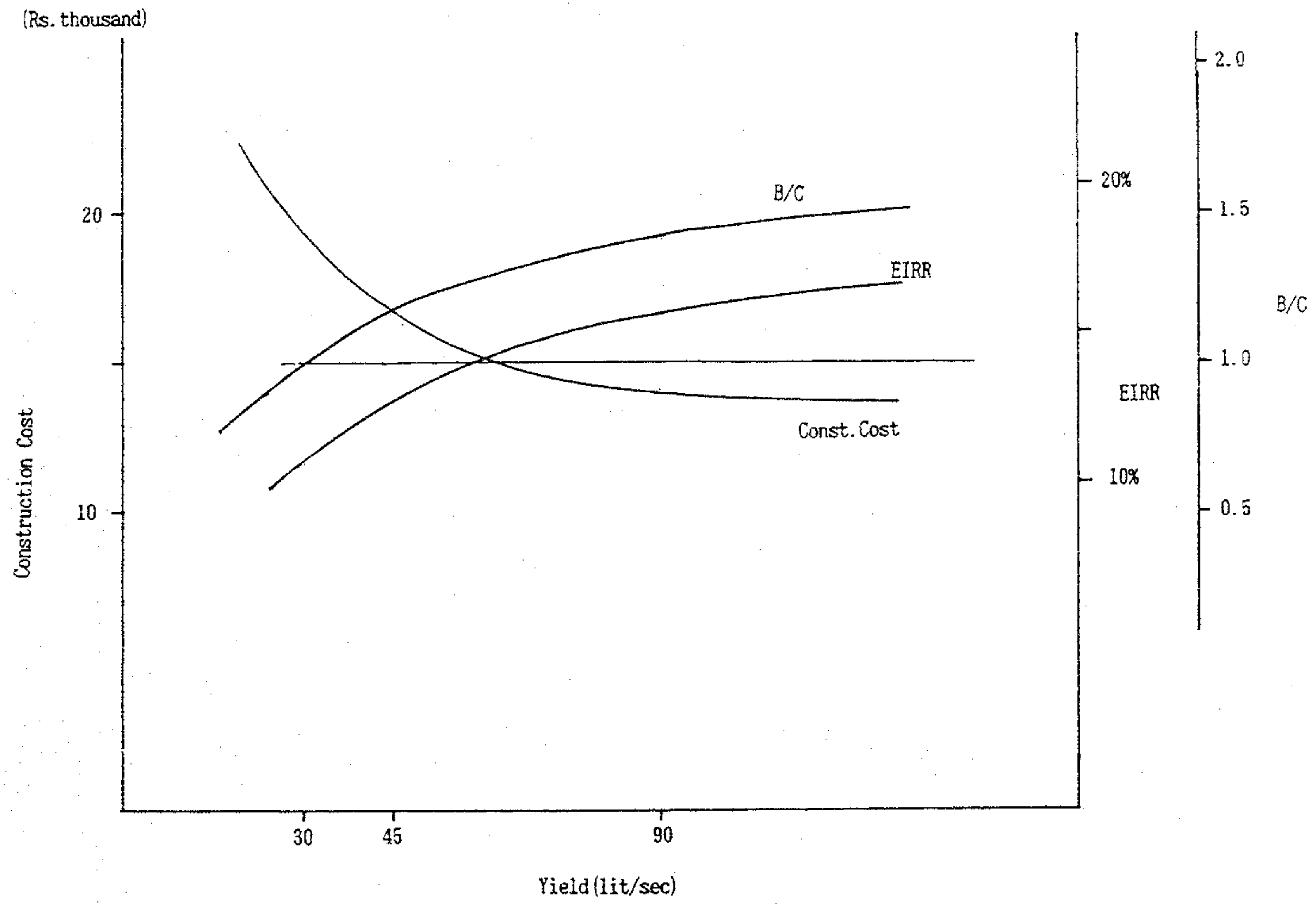


Figure 9.2.1(3) LCFA and LFWY(Banke)

9.2.2. Diesel Engine Basis

The similar study for LFCA and LFWY has been conducted but for the case of Diesel Engine Basis. Conditions of the study, cases of the study are the same as the previous section (9.2.1.).

The economic project cost and O&M costs per 100 ha for the three cases are shown below. The details of each estimation are attached in Volume III, APPENDICES (1-4).

Project Costs

(Unit: Rs 1,000/100 ha)

	Case-1	Case-2	Case-3
LC	7,558	8,483	9,187
FC	8,445	9,804	11,157
Total	16,003	18,287	20,344

O & M Costs

(Unit: Rs 1,000/100 ha/year)

	Case I	Case II	Case III
LC	513	692	807
FC	57	76	89
Total	570	768	896

Increased agricultural benefits for each District are the same as previous calculation (Table 9.2.1.). Thus, the EIRR and B/C for the three cases are calculated as shown in Table 2.9.3. (1) - (3), and summarized as listed below and in Figure 9.2.2. (1) - (3).

a) Jhapa

	Case I	Case II	Case III
EIRR (%)	15.29	12.53	10.69
B/C	1.33	1.12	0.99

b) Mahottari

	Case I	Case II	Case III
EIRR (%)	13.86	11.04	9.17
B/C	1.20	1.01	0.89

c) Banke

	Case I	Case II	Case III
EIRR (%)	13.98	11.21	9.37
B/C	1.22	1.01	0.90

As listed above, and as shown in Figure 9.2.2. (1) - (3), the B/C ratio in the case of Diesel Engine Basis will be less than 1.0 where the well yield is around 45 l/sec.

Thus, the LFWY in this case is approximately 45 l/sec, and the LFCA is estimated at around 45 ha.

Table 9.2.3 (1) Calculation of EIRR-Jhapa Representative Area-Case-1 (90 lit/sec) (Diesel Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	Present Worth Value by Discount Rate Int.= 0.10 Cost	Int.= 0.10 Benefit	Int.= 0.20 Cost	Int.= 0.20 Benefit	Int.= 0.25 Cost	Int.= 0.25 Benefit
1	13319	0	13319	0	-13319	13319.0	0.0	13319.0	0.0	13319.0	0.0
2	0	570	570	1514	944	471.1	1250.9	395.8	1051.1	364.8	968.7
3	0	570	570	1823	1253	428.2	1369.8	329.9	1055.1	291.8	933.5
4	0	570	570	2236	1666	389.3	1527.2	274.9	1078.3	233.5	915.9
5	0	570	570	2546	1976	353.9	1580.6	229.1	1023.0	186.8	834.1
6	0	570	570	2786	2216	321.8	1572.9	190.9	933.2	149.4	730.4
7	0	570	570	2993	2423	292.5	1535.8	159.1	835.2	119.5	627.6
8	0	570	570	3130	2560	265.9	1460.4	132.6	728.0	95.6	525.2
9	0	570	570	3234	2664	241.7	1371.4	110.5	626.7	76.5	434.0
10	484	570	1054	3302	2248	406.4	1273.2	170.2	533.4	113.2	354.6
11	0	570	570	3354	2784	199.8	1175.6	76.7	451.4	49.0	288.1
12	0	570	570	3378	2808	181.6	1076.4	63.9	378.9	39.2	232.1
13	0	570	570	3440	2870	165.1	996.4	53.3	321.5	31.3	189.1
14	0	570	570	3440	2870	150.1	905.9	44.4	267.9	25.1	151.3
15	1739	570	2309	3440	1131	552.8	823.5	149.9	223.3	81.2	121.0
16	0	570	570	3440	2870	124.0	748.6	30.8	186.1	16.0	96.8
17	0	570	570	3440	2870	112.8	680.6	25.7	155.1	12.8	77.5
18	0	570	570	3440	2870	102.5	618.7	21.4	129.2	10.3	62.0
19	0	570	570	3440	2870	93.2	562.5	17.8	107.7	8.2	49.6
20	1148	570	1718	3440	1722	255.4	511.3	44.8	89.7	19.8	39.7
21	0	570	570	3440	2870	77.0	464.8	12.4	74.8	5.3	31.7
22	0	570	570	3440	2870	70.0	422.6	10.3	62.3	4.2	25.4
23	0	570	570	3440	2870	63.7	384.2	8.6	51.9	3.4	20.3
24	0	570	570	3440	2870	57.9	349.2	7.2	43.3	2.7	16.2
25	0	570	570	3440	2870	52.6	317.5	6.0	36.1	2.2	13.0
26	0	570	570	3440	2870	47.8	288.6	5.0	30.1	1.7	10.4
27	0	570	570	3440	2870	43.5	262.4	4.1	25.0	1.4	8.3
28	0	570	570	3440	2870	39.5	238.5	3.5	20.9	1.1	6.7
29	0	570	570	3440	2870	35.9	216.9	2.9	17.4	0.9	5.3
30	2223	570	2793	3440	647	160.1	197.1	11.8	14.5	3.5	4.3
31	0	570	570	3440	2870	29.7	179.2	2.0	12.1	0.6	3.4
32	0	570	570	3440	2870	27.0	162.9	1.7	10.1	0.5	2.7
33	0	570	570	3440	2870	24.5	148.1	1.4	8.4	0.4	2.2
34	0	570	570	3440	2870	22.3	134.7	1.2	7.0	0.3	1.7
35	0	570	570	3440	2870	20.3	122.4	1.0	5.8	0.2	1.4
36	0	570	570	3440	2870	18.4	111.3	0.8	4.9	0.2	1.1
37	0	570	570	3440	2870	16.8	101.2	0.7	4.0	0.1	0.9
38	0	570	570	3440	2870	15.2	92.0	0.6	3.4	0.1	0.7
39	0	570	570	3440	2870	13.9	83.6	0.5	2.8	0.1	0.6
40	1148	570	1718	3440	1722	38.0	76.0	1.2	2.3	0.2	0.5
41	0	570	570	3440	2870	11.4	69.1	0.3	2.0	0.1	0.4
42	0	570	570	3440	2870	10.4	62.8	0.3	1.6	0.0	0.3
43	0	570	570	3440	2870	9.5	57.1	0.2	1.4	0.0	0.2
44	0	570	570	3440	2870	8.6	51.9	0.2	1.1	0.0	0.2
45	1739	570	2309	3440	1131	31.7	47.2	0.6	0.9	0.1	0.1
46	0	570	570	3440	2870	7.1	42.9	0.1	0.8	0.0	0.1
47	0	570	570	3440	2870	6.5	39.0	0.1	0.7	0.0	0.1
48	0	570	570	3440	2870	5.9	35.5	0.1	0.5	0.0	0.1
49	0	570	570	3440	2870	5.3	32.2	0.1	0.5	0.0	0.1
50	484	570	1054	3440	2386	9.0	29.3	0.1	0.4	0.0	0.0
Total						19406.6	25861.9	15925.3	10621.5	15272.3	7789.7

EIRR = 15.29 %

B/C at 10%= 1.33

Calculation of EIRR-Jhapa Representative Area-Case-2 (45 lit/sec) (Diesel Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	Present Worth Value by Discount Rate					
						Int.= 0.10		Int.= 0.20		Int.= 0.25	
						Cost	Benefit	Cost	Benefit	Cost	Benefit
1	15127	0	15127	0	-15127	15127.0	0.0	15127.0	0.0	15127.0	0.0
2	0	768	768	1514	746	634.7	1250.9	533.3	1051.1	491.5	968.7
3	0	768	768	1823	1055	577.0	1369.8	444.4	1055.1	393.2	933.5
4	0	768	768	2236	1468	524.6	1527.2	370.4	1078.3	314.6	915.9
5	0	768	768	2546	1778	476.9	1580.6	308.6	1023.0	251.7	834.1
6	0	768	768	2786	2018	433.5	1572.9	257.2	933.2	201.3	730.4
7	0	768	768	2993	2225	394.1	1535.8	214.3	835.2	161.1	627.6
8	0	768	768	3130	2362	358.3	1460.4	178.6	728.0	128.8	525.2
9	0	768	768	3234	2466	325.7	1371.4	148.8	626.7	103.1	434.0
10	484	768	1252	3302	2050	482.7	1273.2	202.2	533.4	134.4	354.6
11	0	768	768	3354	2586	269.2	1175.6	103.4	451.4	66.0	288.1
12	0	768	768	3378	2610	244.7	1076.4	86.1	378.9	52.8	232.1
13	0	768	768	3440	2672	222.5	996.4	71.8	321.5	42.2	189.1
14	0	768	768	3440	2672	202.2	905.9	59.8	267.9	33.8	151.3
15	2087	768	2855	3440	585	683.5	823.5	185.3	223.3	100.5	121.0
16	0	768	768	3440	2672	167.1	748.6	41.5	186.1	21.6	96.8
17	0	768	768	3440	2672	151.9	680.6	34.6	155.1	17.3	77.5
18	0	768	768	3440	2672	138.1	618.7	28.8	129.2	13.8	62.0
19	0	768	768	3440	2672	125.6	562.5	24.0	107.7	11.1	49.6
20	1561	768	2329	3440	1111	346.2	511.3	60.7	89.7	26.9	39.7
21	0	768	768	3440	2672	103.8	464.8	16.7	74.8	7.1	31.7
22	0	768	768	3440	2672	94.3	422.6	13.9	62.3	5.7	25.4
23	0	768	768	3440	2672	85.8	384.2	11.6	51.9	4.5	20.3
24	0	768	768	3440	2672	78.0	349.2	9.7	43.3	3.6	16.2
25	0	768	768	3440	2672	70.9	317.5	8.1	36.1	2.9	13.0
26	0	768	768	3440	2672	64.4	288.6	6.7	30.1	2.3	10.4
27	0	768	768	3440	2672	58.6	262.4	5.6	25.0	1.9	8.3
28	0	768	768	3440	2672	53.3	238.5	4.7	20.9	1.5	6.7
29	0	768	768	3440	2672	48.4	216.9	3.9	17.4	1.2	5.3
30	2571	768	3339	3440	101	191.4	197.1	14.1	14.5	4.1	4.3
31	0	768	768	3440	2672	40.0	179.2	2.7	12.1	0.8	3.4
32	0	768	768	3440	2672	36.4	162.9	2.2	10.1	0.6	2.7
33	0	768	768	3440	2672	33.1	148.1	1.9	8.4	0.5	2.2
34	0	768	768	3440	2672	30.1	134.7	1.6	7.0	0.4	1.7
35	0	768	768	3440	2672	27.3	122.4	1.3	5.8	0.3	1.4
36	0	768	768	3440	2672	24.8	111.3	1.1	4.9	0.2	1.1
37	0	768	768	3440	2672	22.6	101.2	0.9	4.0	0.2	0.9
38	0	768	768	3440	2672	20.5	92.0	0.8	3.4	0.2	0.7
39	0	768	768	3440	2672	18.7	83.6	0.6	2.8	0.1	0.6
40	1561	768	2329	3440	1111	51.5	76.0	1.6	2.3	0.3	0.5
41	0	768	768	3440	2672	15.4	69.1	0.4	2.0	0.1	0.4
42	0	768	768	3440	2672	14.0	62.8	0.4	1.6	0.1	0.3
43	0	768	768	3440	2672	12.7	57.1	0.3	1.4	0.1	0.2
44	0	768	768	3440	2672	11.6	51.9	0.3	1.1	0.0	0.2
45	2087	768	2855	3440	585	39.2	47.2	0.8	0.9	0.1	0.1
46	0	768	768	3440	2672	9.6	42.9	0.2	0.8	0.0	0.1
47	0	768	768	3440	2672	8.7	39.0	0.1	0.7	0.0	0.1
48	0	768	768	3440	2672	7.9	35.5	0.1	0.5	0.0	0.1
49	0	768	768	3440	2672	7.2	32.2	0.1	0.5	0.0	0.1
50	484	768	1252	3440	2188	10.7	29.3	0.1	0.4	0.0	0.0
Total						23176.2	25861.9	18593.4	10621.5	17731.4	7789.7

EIRR = 12.53 %

B/C at 10%= 1.12

Calculation of EIRR-Jhapa Representative Area-Case-3(30 lit/sec) (Diesel Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	Present Worth Value by Discount Rate Int.= 0.10 Cost	Int.= 0.10 Benefit	Int.= 0.20 Cost	Int.= 0.20 Benefit	Int.= 0.25 Cost	Int.= 0.25 Benefit
1	16907	0	16907	0	-16907	16907.0	0.0	16907.0	0.0	16907.0	0.0
2	0	896	896	1514	618	740.5	1250.9	622.2	1051.1	573.4	968.7
3	0	896	896	1823	927	673.2	1369.8	518.5	1055.1	458.8	933.5
4	0	896	896	2236	1340	612.0	1527.2	432.1	1078.3	367.0	915.9
5	0	896	896	2546	1650	556.3	1580.6	360.1	1023.0	293.6	834.1
6	0	896	896	2786	1890	505.8	1572.9	300.1	933.2	234.9	730.4
7	0	896	896	2993	2097	459.8	1535.8	250.1	835.2	187.9	627.6
8	0	896	896	3130	2234	418.0	1460.4	208.4	728.0	150.3	525.2
9	0	896	896	3234	2338	380.0	1371.4	173.7	626.7	120.3	434.0
10	484	896	1380	3302	1922	532.0	1273.2	222.9	533.4	148.2	354.6
11	0	896	896	3354	2458	314.0	1175.6	120.6	451.4	77.0	288.1
12	0	896	896	3378	2482	285.5	1076.4	100.5	378.9	61.6	232.1
13	0	896	896	3440	2544	259.5	996.4	83.7	321.5	49.3	189.1
14	0	896	896	3440	2544	235.9	905.9	69.8	267.9	39.4	151.3
15	2087	896	2983	3440	457	714.1	823.5	193.6	223.3	105.0	121.0
16	0	896	896	3440	2544	195.0	748.6	48.5	186.1	25.2	96.8
17	0	896	896	3440	2544	177.3	680.6	40.4	155.1	20.2	77.5
18	0	896	896	3440	2544	161.2	618.7	33.7	129.2	16.1	62.0
19	0	896	896	3440	2544	146.5	562.5	28.0	107.7	12.9	49.6
20	2099	896	2995	3440	445	445.2	511.3	78.1	89.7	34.5	39.7
21	0	896	896	3440	2544	121.1	464.8	19.5	74.8	8.3	31.7
22	0	896	896	3440	2544	110.1	422.6	16.2	62.3	6.6	25.4
23	0	896	896	3440	2544	100.1	384.2	13.5	51.9	5.3	20.3
24	0	896	896	3440	2544	91.0	349.2	11.3	43.3	4.2	16.2
25	0	896	896	3440	2544	82.7	317.5	9.4	36.1	3.4	13.0
26	0	896	896	3440	2544	75.2	288.6	7.8	30.1	2.7	10.4
27	0	896	896	3440	2544	68.3	262.4	6.5	25.0	2.2	8.3
28	0	896	896	3440	2544	62.1	238.5	5.4	20.9	1.7	6.7
29	0	896	896	3440	2544	56.5	216.9	4.5	17.4	1.4	5.3
30	2571	896	3467	3440	-27	198.7	197.1	14.6	14.5	4.3	4.3
31	0	896	896	3440	2544	46.7	179.2	3.1	12.1	0.9	3.4
32	0	896	896	3440	2544	42.4	162.9	2.6	10.1	0.7	2.7
33	0	896	896	3440	2544	38.6	148.1	2.2	8.4	0.6	2.2
34	0	896	896	3440	2544	35.1	134.7	1.8	7.0	0.5	1.7
35	0	896	896	3440	2544	31.9	122.4	1.5	5.8	0.4	1.4
36	0	896	896	3440	2544	29.0	111.3	1.3	4.9	0.3	1.1
37	0	896	896	3440	2544	26.3	101.2	1.1	4.0	0.2	0.9
38	0	896	896	3440	2544	24.0	92.0	0.9	3.4	0.2	0.7
39	0	896	896	3440	2544	21.8	83.6	0.7	2.8	0.1	0.6
40	2099	896	2995	3440	445	66.2	76.0	2.0	2.3	0.4	0.5
41	0	896	896	3440	2544	18.0	69.1	0.5	2.0	0.1	0.4
42	0	896	896	3440	2544	16.4	62.8	0.4	1.6	0.1	0.3
43	0	896	896	3440	2544	14.9	57.1	0.4	1.4	0.1	0.2
44	0	896	896	3440	2544	13.5	51.9	0.3	1.1	0.0	0.2
45	2087	896	2983	3440	457	40.9	47.2	0.8	0.9	0.1	0.1
46	0	896	896	3440	2544	11.2	42.9	0.2	0.8	0.0	0.1
47	0	896	896	3440	2544	10.2	39.0	0.2	0.7	0.0	0.1
48	0	896	896	3440	2544	9.2	35.5	0.1	0.5	0.0	0.1
49	0	896	896	3440	2544	8.4	32.2	0.1	0.5	0.0	0.1
50	484	896	1380	3440	2060	11.8	29.3	0.2	0.4	0.0	0.0
Total						26200.8	25861.9	20921.1	10621.5	19927.3	7789.7

EIRR = 10.69 %

B/C at 10%= 0.99

Table 9.2.3 (2) Calculation of EIRR-Mahottari-Case-1 (90 lit/sec) (Diesel Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	Present Worth Value by Discount Rate Int.= 0.10 Cost	Int.= 0.10 Benefit	Int.= 0.20 Cost	Int.= 0.20 Benefit	Int.= 0.25 Cost	Int.= 0.25 Benefit
1	13319	0	13319	0	-13319	13319.0	0.0	13319.0	0.0	13319.0	0.0
2	0	570	570	1305	735	471.1	1078.1	395.8	905.9	364.8	834.9
3	0	570	570	1884	1314	428.2	1415.7	329.9	1090.5	291.8	964.8
4	0	570	570	2319	1749	389.3	1584.0	274.9	1118.4	233.5	949.9
5	0	570	570	2609	2039	353.9	1620.0	229.1	1048.5	186.8	854.9
6	0	570	570	2754	2184	321.8	1554.6	190.9	922.3	149.4	722.0
7	0	570	570	2827	2257	292.5	1450.5	159.1	788.8	119.5	592.8
8	0	570	570	2899	2329	265.9	1352.4	132.6	674.2	95.6	486.4
9	0	570	570	2899	2329	241.7	1229.5	110.5	561.8	76.5	389.1
10	484	570	1054	2899	1845	406.4	1117.7	170.2	468.2	113.2	311.3
11	0	570	570	2899	2329	199.8	1016.1	76.7	390.2	49.0	249.0
12	0	570	570	2899	2329	181.6	923.7	63.9	325.1	39.2	199.2
13	0	570	570	2899	2329	165.1	839.7	53.3	271.0	31.3	159.4
14	0	570	570	2899	2329	150.1	763.4	44.4	225.8	25.1	127.5
15	1739	570	2309	2899	590	552.8	694.0	149.9	188.2	81.2	102.0
16	0	570	570	2899	2329	124.0	630.9	30.8	156.8	16.0	81.6
17	0	570	570	2899	2329	112.8	573.6	25.7	130.7	12.8	65.3
18	0	570	570	2899	2329	102.5	521.4	21.4	108.9	10.3	52.2
19	0	570	570	2899	2329	93.2	474.0	17.8	90.7	8.2	41.8
20	1149	570	1719	2899	1180	255.5	430.9	44.8	75.6	19.8	33.4
21	0	570	570	2899	2329	77.0	391.7	12.4	63.0	5.3	26.7
22	0	570	570	2899	2329	70.0	356.1	10.3	52.5	4.2	21.4
23	0	570	570	2899	2329	63.7	323.8	8.6	43.8	3.4	17.1
24	0	570	570	2899	2329	57.9	294.3	7.2	36.5	2.7	13.7
25	0	570	570	2899	2329	52.6	267.6	6.0	30.4	2.2	11.0
26	0	570	570	2899	2329	47.8	243.2	5.0	25.3	1.7	8.8
27	0	570	570	2899	2329	43.5	221.1	4.1	21.1	1.4	7.0
28	0	570	570	2899	2329	39.5	201.0	3.5	17.6	1.1	5.6
29	0	570	570	2899	2329	35.9	182.8	2.9	14.7	0.9	4.5
30	2223	570	2793	2899	106	160.1	166.1	11.8	12.2	3.5	3.6
31	0	570	570	2899	2329	29.7	151.0	2.0	10.2	0.6	2.9
32	0	570	570	2899	2329	27.0	137.3	1.7	8.5	0.5	2.3
33	0	570	570	2899	2329	24.5	124.8	1.4	7.1	0.4	1.8
34	0	570	570	2899	2329	22.3	113.5	1.2	5.9	0.3	1.5
35	0	570	570	2899	2329	20.3	103.2	1.0	4.9	0.2	1.2
36	0	570	570	2899	2329	18.4	93.8	0.8	4.1	0.2	0.9
37	0	570	570	2899	2329	16.8	85.3	0.7	3.4	0.1	0.8
38	0	570	570	2899	2329	15.2	77.5	0.6	2.8	0.1	0.6
39	0	570	570	2899	2329	13.9	70.5	0.5	2.4	0.1	0.5
40	1148	570	1718	2899	1181	38.0	64.1	1.2	2.0	0.2	0.4
41	0	570	570	2899	2329	11.4	58.2	0.3	1.6	0.1	0.3
42	0	570	570	2899	2329	10.4	52.9	0.3	1.4	0.0	0.2
43	0	570	570	2899	2329	9.5	48.1	0.2	1.1	0.0	0.2
44	0	570	570	2899	2329	8.6	43.7	0.2	1.0	0.0	0.2
45	1739	570	2309	2899	590	31.7	39.8	0.6	0.8	0.1	0.1
46	0	570	570	2899	2329	7.1	36.2	0.1	0.7	0.0	0.1
47	0	570	570	2899	2329	6.5	32.9	0.1	0.6	0.0	0.1
48	0	570	570	2899	2329	5.9	29.9	0.1	0.5	0.0	0.1
49	0	570	570	2899	2329	5.3	27.2	0.1	0.4	0.0	0.1
50	484	570	1054	2899	1845	9.0	24.7	0.1	0.3	0.0	0.0
Total						19406.7	23332.5	15925.4	9918.3	15272.4	7351.0

EIRR = 13.86

B/C at 10%= 1.20

Calculation of EIRR-Mahottari-Case-2 (45 lit/sec) (Diesel Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	Present Worth Value by Discount Rate					
						Int.= 0.10		Int.= 0.20		Int.= 0.25	
						Cost	Benefit	Cost	Benefit	Cost	Benefit
1	15127	0	15127	0	-15127	15127.0	0.0	15127.0	0.0	15127.0	0.0
2	0	768	768	1305	537	634.7	1078.1	533.3	905.9	491.5	834.9
3	0	768	768	1884	1116	577.0	1415.7	444.4	1090.5	393.2	964.8
4	0	768	768	2319	1551	524.6	1584.0	370.4	1118.4	314.6	949.9
5	0	768	768	2609	1841	476.9	1620.0	308.6	1048.5	251.7	854.9
6	0	768	768	2754	1986	433.5	1554.6	257.2	922.3	201.3	722.0
7	0	768	768	2827	2059	394.1	1450.5	214.3	788.8	161.1	592.8
8	0	768	768	2899	2131	358.3	1352.4	178.6	674.2	128.8	486.4
9	0	768	768	2899	2131	325.7	1229.5	148.8	561.8	103.1	389.1
10	484	768	1252	2899	1647	482.7	1117.7	202.2	468.2	134.4	311.3
11	0	768	768	2899	2131	269.2	1016.1	103.4	390.2	66.0	249.0
12	0	768	768	2899	2131	244.7	923.7	86.1	325.1	52.8	199.2
13	0	768	768	2899	2131	222.5	839.7	71.8	271.0	42.2	159.4
14	0	768	768	2899	2131	202.2	763.4	59.8	225.8	33.8	127.5
15	2087	768	2855	2899	44	683.5	694.0	185.3	188.2	100.5	102.0
16	0	768	768	2899	2131	167.1	630.9	41.5	156.8	21.6	81.6
17	0	768	768	2899	2131	151.9	573.6	34.6	130.7	17.3	65.3
18	0	768	768	2899	2131	138.1	521.4	28.8	108.9	13.8	52.2
19	0	768	768	2899	2131	125.6	474.0	24.0	90.7	11.1	41.8
20	1561	768	2329	2899	570	346.2	430.9	60.7	75.6	26.9	33.4
21	0	768	768	2899	2131	103.8	391.7	16.7	63.0	7.1	26.7
22	0	768	768	2899	2131	94.3	356.1	13.9	52.5	5.7	21.4
23	0	768	768	2899	2131	85.8	323.8	11.6	43.8	4.5	17.1
24	0	768	768	2899	2131	78.0	294.3	9.7	36.5	3.6	13.7
25	0	768	768	2899	2131	70.9	267.6	8.1	30.4	2.9	11.0
26	0	768	768	2899	2131	64.4	243.2	6.7	25.3	2.3	8.8
27	0	768	768	2899	2131	58.6	221.1	5.6	21.1	1.9	7.0
28	0	768	768	2899	2131	53.3	201.0	4.7	17.6	1.5	5.6
29	0	768	768	2899	2131	48.4	182.8	3.9	14.7	1.2	4.5
30	2571	768	3339	2899	-440	191.4	166.1	14.1	12.2	4.1	3.6
31	0	768	768	2899	2131	40.0	151.0	2.7	10.2	0.8	2.9
32	0	768	768	2899	2131	36.4	137.3	2.2	8.5	0.6	2.3
33	0	768	768	2899	2131	33.1	124.8	1.9	7.1	0.5	1.8
34	0	768	768	2899	2131	30.1	113.5	1.6	5.9	0.4	1.5
35	0	768	768	2899	2131	27.3	103.2	1.3	4.9	0.3	1.2
36	0	768	768	2899	2131	24.8	93.8	1.1	4.1	0.2	0.9
37	0	768	768	2899	2131	22.6	85.3	0.9	3.4	0.2	0.8
38	0	768	768	2899	2131	20.5	77.5	0.8	2.8	0.2	0.6
39	0	768	768	2899	2131	18.7	70.5	0.6	2.4	0.1	0.5
40	1561	768	2329	2899	570	51.5	64.1	1.6	2.0	0.3	0.4
41	0	768	768	2899	2131	15.4	58.2	0.4	1.6	0.1	0.3
42	0	768	768	2899	2131	14.0	52.9	0.4	1.4	0.1	0.2
43	0	768	768	2899	2131	12.7	48.1	0.3	1.1	0.1	0.2
44	0	768	768	2899	2131	11.6	43.7	0.3	1.0	0.0	0.2
45	2087	768	2855	2899	44	39.2	39.8	0.8	0.8	0.1	0.1
46	0	768	768	2899	2131	9.6	36.2	0.2	0.7	0.0	0.1
47	0	768	768	2899	2131	8.7	32.9	0.1	0.6	0.0	0.1
48	0	768	768	2899	2131	7.9	29.9	0.1	0.5	0.0	0.1
49	0	768	768	2899	2131	7.2	27.2	0.1	0.4	0.0	0.1
50	484	768	1252	2899	1647	10.7	24.7	0.1	0.3	0.0	0.0
Total						23176.2	23332.5	18593.4	9918.3	17731.4	7351.0

EIRR = 11.04

B/C at 10%= 1.01

Calculation of EIRR-Mahottari-Case-3 (30 lit/sec) (Diesel Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	Present Worth Value by Discount Rate					
						Int. = 0.1		Int. = 0.2		Int. = 0.25	
						Cost	Benefit	Cost	Benefit	Cost	Benefit
1	16907	0	16907	0	-16907	16907.0	0.0	16907.0	0.0	16907.0	0.0
2	0	896	896	1305	409	740.5	1078.1	622.2	905.9	573.4	834.9
3	0	896	896	1884	988	673.2	1415.7	518.5	1090.5	458.8	964.8
4	0	896	896	2319	1423	612.0	1584.0	432.1	1118.4	367.0	949.9
5	0	896	896	2609	1713	556.3	1620.0	360.1	1048.5	293.6	854.9
6	0	896	896	2754	1858	505.8	1554.6	300.1	922.3	234.9	722.0
7	0	896	896	2827	1931	459.8	1450.5	250.1	788.8	187.9	592.8
8	0	896	896	2899	2003	418.0	1352.4	208.4	674.2	150.3	486.4
9	0	896	896	2899	2003	380.0	1229.5	173.7	561.8	120.3	389.1
10	484	896	1380	2899	1519	532.0	1117.7	222.9	468.2	148.2	311.3
11	0	896	896	2899	2003	314.0	1016.1	120.6	390.2	77.0	249.0
12	0	896	896	2899	2003	285.5	923.7	100.5	325.1	61.6	199.2
13	0	896	896	2899	2003	259.5	839.7	83.7	271.0	49.3	159.4
14	0	896	896	2899	2003	235.9	763.4	69.8	225.8	39.4	127.5
15	2087	896	2983	2899	-84	714.1	694.0	193.6	188.2	105.0	102.0
16	0	896	896	2899	2003	195.0	630.9	48.5	156.8	25.2	81.6
17	0	896	896	2899	2003	177.3	573.6	40.4	130.7	20.2	65.3
18	0	896	896	2899	2003	161.2	521.4	33.7	108.9	16.1	52.2
19	0	896	896	2899	2003	146.5	474.0	28.0	90.7	12.9	41.8
20	2099	896	2995	2899	-96	445.2	430.9	78.1	75.6	34.5	33.4
21	0	896	896	2899	2003	121.1	391.7	19.5	63.0	8.3	26.7
22	0	896	896	2899	2003	110.1	356.1	16.2	52.5	6.6	21.4
23	0	896	896	2899	2003	100.1	323.8	13.5	43.8	5.3	17.1
24	0	896	896	2899	2003	91.0	294.3	11.3	36.5	4.2	13.7
25	0	896	896	2899	2003	82.7	267.6	9.4	30.4	3.4	11.0
26	0	896	896	2899	2003	75.2	243.2	7.8	25.3	2.7	8.8
27	0	896	896	2899	2003	68.3	221.1	6.5	21.1	2.2	7.0
28	0	896	896	2899	2003	62.1	201.0	5.4	17.6	1.7	5.6
29	0	896	896	2899	2003	56.5	182.8	4.5	14.7	1.4	4.5
30	2571	896	3467	2899	-568	198.7	166.1	14.6	12.2	4.3	3.6
31	0	896	896	2899	2003	46.7	151.0	3.1	10.2	0.9	2.9
32	0	896	896	2899	2003	42.4	137.3	2.6	8.5	0.7	2.3
33	0	896	896	2899	2003	38.6	124.8	2.2	7.1	0.6	1.8
34	0	896	896	2899	2003	35.1	113.5	1.8	5.9	0.5	1.5
35	0	896	896	2899	2003	31.9	103.2	1.5	4.9	0.4	1.2
36	0	896	896	2899	2003	29.0	93.8	1.3	4.1	0.3	0.9
37	0	896	896	2899	2003	26.3	85.3	1.1	3.4	0.2	0.8
38	0	896	896	2899	2003	24.0	77.5	0.9	2.8	0.2	0.6
39	0	896	896	2899	2003	21.8	70.5	0.7	2.4	0.1	0.5
40	2099	896	2995	2899	-96	66.2	64.1	2.0	2.0	0.4	0.4
41	0	896	896	2899	2003	18.0	58.2	0.5	1.6	0.1	0.3
42	0	896	896	2899	2003	16.4	52.9	0.4	1.4	0.1	0.2
43	0	896	896	2899	2003	14.9	48.1	0.4	1.1	0.1	0.2
44	0	896	896	2899	2003	13.5	43.7	0.3	1.0	0.0	0.2
45	2087	896	2983	2899	-84	40.9	39.8	0.8	0.8	0.1	0.1
46	0	896	896	2899	2003	11.2	36.2	0.2	0.7	0.0	0.1
47	0	896	896	2899	2003	10.2	32.9	0.2	0.6	0.0	0.1
48	0	896	896	2899	2003	9.2	29.9	0.1	0.5	0.0	0.1
49	0	896	896	2899	2003	8.4	27.2	0.1	0.4	0.0	0.1
50	484	896	1380	2899	1519	11.8	24.7	0.2	0.3	0.0	0.0
Total						26200.8	23332.5	20921.1	9918.3	19927.3	7351.0

EIRR = 9.17

B/C at 10%= 0.89

Table 9.2.3 (3) Calculation of EIRR-Banke-Case-1 (90 lit/sec) (Diesel Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	Present Worth Value by Discount Rate Int.= 0.10 Cost	Int.= 0.10 Benefit	Int.= 0.20 Cost	Int.= 0.20 Benefit	Int.= 0.25 Cost	Int.= 0.25 Benefit
1	13319	0	13319	0	-13319	13319.0	0.0	13319.0	0.0	13319.0	0.0
2	0	570	570	1352	782	471.1	1117.2	395.8	938.8	364.8	865.2
3	0	570	570	1802	1232	428.2	1354.2	329.9	1043.1	291.8	922.8
4	0	570	570	2253	1683	389.3	1538.8	274.9	1086.5	233.5	922.8
5	0	570	570	2493	1923	353.9	1548.2	229.1	1002.0	186.8	817.0
6	0	570	570	2704	2134	321.8	1526.1	190.9	905.4	149.4	708.7
7	0	570	570	2824	2254	292.5	1449.0	159.1	788.1	119.5	592.2
8	0	570	570	2914	2344	265.9	1359.3	132.6	677.7	95.6	488.9
9	0	570	570	2944	2374	241.7	1248.5	110.5	570.6	76.5	395.1
10	484	570	1054	3004	1950	406.4	1158.2	170.2	485.2	113.2	322.6
11	0	570	570	3004	2434	199.8	1052.9	76.7	404.3	49.0	258.0
12	0	570	570	3004	2434	181.6	957.2	63.9	336.9	39.2	206.4
13	0	570	570	3004	2434	165.1	870.2	53.3	280.8	31.3	165.1
14	0	570	570	3004	2434	150.1	791.0	44.4	234.0	25.1	132.1
15	1739	570	2309	3004	695	552.8	719.1	149.9	195.0	81.2	105.7
16	0	570	570	3004	2434	124.0	653.8	30.8	162.5	16.0	84.6
17	0	570	570	3004	2434	112.8	594.3	25.7	135.4	12.8	67.6
18	0	570	570	3004	2434	102.5	540.3	21.4	112.8	10.3	54.1
19	0	570	570	3004	2434	93.2	491.2	17.8	94.0	8.2	43.3
20	1148	570	1718	3004	1286	255.4	446.5	44.8	78.4	19.8	34.6
21	0	570	570	3004	2434	77.0	405.9	12.4	65.3	5.3	27.7
22	0	570	570	3004	2434	70.0	369.0	10.3	54.4	4.2	22.2
23	0	570	570	3004	2434	63.7	335.5	8.6	45.3	3.4	17.7
24	0	570	570	3004	2434	57.9	305.0	7.2	37.8	2.7	14.2
25	0	570	570	3004	2434	52.6	277.3	6.0	31.5	2.2	11.3
26	0	570	570	3004	2434	47.8	252.1	5.0	26.2	1.7	9.1
27	0	570	570	3004	2434	43.5	229.1	4.1	21.9	1.4	7.3
28	0	570	570	3004	2434	39.5	208.3	3.5	18.2	1.1	5.8
29	0	570	570	3004	2434	35.9	189.4	2.9	15.2	0.9	4.6
30	2223	570	2793	3004	211	160.1	172.2	11.8	12.7	3.5	3.7
31	0	570	570	3004	2434	29.7	156.5	2.0	10.5	0.6	3.0
32	0	570	570	3004	2434	27.0	142.3	1.7	8.8	0.5	2.4
33	0	570	570	3004	2434	24.5	129.3	1.4	7.3	0.4	1.9
34	0	570	570	3004	2434	22.3	117.6	1.2	6.1	0.3	1.5
35	0	570	570	3004	2434	20.3	106.9	1.0	5.1	0.2	1.2
36	0	570	570	3004	2434	18.4	97.2	0.8	4.2	0.2	1.0
37	0	570	570	3004	2434	16.8	88.3	0.7	3.5	0.1	0.8
38	0	570	570	3004	2434	15.2	80.3	0.6	2.9	0.1	0.6
39	0	570	570	3004	2434	13.9	73.0	0.5	2.5	0.1	0.5
40	1148	570	1718	3004	1286	38.0	66.4	1.2	2.0	0.2	0.4
41	0	570	570	3004	2434	11.4	60.3	0.3	1.7	0.1	0.3
42	0	570	570	3004	2434	10.4	54.9	0.3	1.4	0.0	0.3
43	0	570	570	3004	2434	9.5	49.9	0.2	1.2	0.0	0.2
44	0	570	570	3004	2434	8.6	45.3	0.2	1.0	0.0	0.2
45	1739	570	2309	3004	695	31.7	41.2	0.6	0.8	0.1	0.1
46	0	570	570	3004	2434	7.1	37.5	0.1	0.7	0.0	0.1
47	0	570	570	3004	2434	6.5	34.1	0.1	0.6	0.0	0.1
48	0	570	570	3004	2434	5.9	31.0	0.1	0.5	0.0	0.1
49	0	570	570	3004	2434	5.3	28.1	0.1	0.4	0.0	0.1
50	484	570	1054	3004	1950	9.0	25.6	0.1	0.3	0.0	0.0
Total						19406.6	23625.3	15925.3	9921.4	15272.3	7325.3

EIRR = 13.98 %

B/C at 10%= 1.22

Calculation of EIRR-Banke-Case-2 (45 lit/sec) (Diesel Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	Present Worth Value by Discount Rate Int.= 0.10 Cost	Int.= 0.10 Benefit	Int.= 0.20 Cost	Int.= 0.20 Benefit	Int.= 0.25 Cost	Int.= 0.25 Benefit
1	15127	0	15127	0	-15127	15127.0	0.0	15127.0	0.0	15127.0	0.0
2	0	768	768	1352	584	634.7	1117.2	533.3	938.8	491.5	865.2
3	0	768	768	1802	1034	577.0	1354.2	444.4	1043.1	393.2	922.8
4	0	768	768	2253	1485	524.6	1538.8	370.4	1086.5	314.6	922.8
5	0	768	768	2493	1725	476.9	1548.2	308.6	1002.0	251.7	817.0
6	0	768	768	2704	1936	433.5	1526.1	257.2	905.4	201.3	708.7
7	0	768	768	2824	2056	394.1	1449.0	214.3	788.1	161.1	592.2
8	0	768	768	2914	2146	358.3	1359.3	178.6	677.7	128.8	488.9
9	0	768	768	2944	2176	325.7	1248.5	148.8	570.6	103.1	395.1
10	484	768	1252	3004	1752	482.7	1158.2	202.2	485.2	134.4	322.6
11	0	768	768	3004	2236	269.2	1052.9	103.4	404.3	66.0	258.0
12	0	768	768	3004	2236	244.7	957.2	86.1	336.9	52.8	206.4
13	0	768	768	3004	2236	222.5	870.2	71.8	280.8	42.2	165.1
14	0	768	768	3004	2236	202.2	791.0	59.8	234.0	33.8	132.1
15	2087	768	2855	3004	149	683.5	719.1	185.3	195.0	100.5	105.7
16	0	768	768	3004	2236	167.1	653.8	41.5	162.5	21.6	84.6
17	0	768	768	3004	2236	151.9	594.3	34.6	135.4	17.3	67.6
18	0	768	768	3004	2236	138.1	540.3	28.8	112.8	13.8	54.1
19	0	768	768	3004	2236	125.6	491.2	24.0	94.0	11.1	43.3
20	1561	768	2329	3004	675	346.2	446.5	60.7	78.4	26.9	34.6
21	0	768	768	3004	2236	103.8	405.9	16.7	65.3	7.1	27.7
22	0	768	768	3004	2236	94.3	369.0	13.9	54.4	5.7	22.2
23	0	768	768	3004	2236	85.8	335.5	11.6	45.3	4.5	17.7
24	0	768	768	3004	2236	78.0	305.0	9.7	37.8	3.6	14.2
25	0	768	768	3004	2236	70.9	277.3	8.1	31.5	2.9	11.3
26	0	768	768	3004	2236	64.4	252.1	6.7	26.2	2.3	9.1
27	0	768	768	3004	2236	58.6	229.1	5.6	21.9	1.9	7.3
28	0	768	768	3004	2236	53.3	208.3	4.7	18.2	1.5	5.8
29	0	768	768	3004	2236	48.4	189.4	3.9	15.2	1.2	4.6
30	2571	768	3339	3004	-335	191.4	172.2	14.1	12.7	4.1	3.7
31	0	768	768	3004	2236	40.0	156.5	2.7	10.5	0.8	3.0
32	0	768	768	3004	2236	36.4	142.3	2.2	8.8	0.6	2.4
33	0	768	768	3004	2236	33.1	129.3	1.9	7.3	0.5	1.9
34	0	768	768	3004	2236	30.1	117.6	1.6	6.1	0.4	1.5
35	0	768	768	3004	2236	27.3	106.9	1.3	5.1	0.3	1.2
36	0	768	768	3004	2236	24.8	97.2	1.1	4.2	0.2	1.0
37	0	768	768	3004	2236	22.6	88.3	0.9	3.5	0.2	0.8
38	0	768	768	3004	2236	20.5	80.3	0.8	2.9	0.2	0.6
39	0	768	768	3004	2236	18.7	73.0	0.6	2.5	0.1	0.5
40	1561	768	2329	3004	675	51.5	66.4	1.6	2.0	0.3	0.4
41	0	768	768	3004	2236	15.4	60.3	0.4	1.7	0.1	0.3
42	0	768	768	3004	2236	14.0	54.9	0.4	1.4	0.1	0.3
43	0	768	768	3004	2236	12.7	49.9	0.3	1.2	0.1	0.2
44	0	768	768	3004	2236	11.6	45.3	0.3	1.0	0.0	0.2
45	2087	768	2855	3004	149	39.2	41.2	0.8	0.8	0.1	0.1
46	0	768	768	3004	2236	9.6	37.5	0.2	0.7	0.0	0.1
47	0	768	768	3004	2236	8.7	34.1	0.1	0.6	0.0	0.1
48	0	768	768	3004	2236	7.9	31.0	0.1	0.5	0.0	0.1
49	0	768	768	3004	2236	7.2	28.1	0.1	0.4	0.0	0.1
50	484	768	1252	3004	1752	10.7	25.6	0.1	0.3	0.0	0.0
Total						23176.2	23625.3	18593.4	9921.4	17731.4	7325.3

EIRR = 11.21 %

Calculation of EIRR-Banke-Case-3(30 lit/sec) (Diesel Pump)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	Present Worth Value by Discount Rate					
						Int.= 0.10		Int.= 0.20		Int.= 0.25	
						Cost	Benefit	Cost	Benefit	Cost	Benefit
1	16907	0	16907	0	-16907	16907.0	0.0	16907.0	0.0	16907.0	0.0
2	0	896	896	1352	456	740.5	1117.2	622.2	938.8	573.4	865.2
3	0	896	896	1802	906	673.2	1354.2	518.5	1043.1	458.8	922.8
4	0	896	896	2253	1357	612.0	1538.8	432.1	1086.5	367.0	922.8
5	0	896	896	2493	1597	556.3	1548.2	360.1	1002.0	293.6	817.0
6	0	896	896	2704	1808	505.8	1526.1	300.1	905.4	234.9	708.7
7	0	896	896	2824	1928	459.8	1449.0	250.1	788.1	187.9	592.2
8	0	896	896	2914	2018	418.0	1359.3	208.4	677.7	150.3	488.9
9	0	896	896	2944	2048	380.0	1248.5	173.7	570.6	120.3	395.1
10	484	896	1380	3004	1624	532.0	1158.2	222.9	485.2	148.2	322.6
11	0	896	896	3004	2108	314.0	1052.9	120.6	404.3	77.0	258.0
12	0	896	896	3004	2108	285.5	957.2	100.5	336.9	61.6	206.4
13	0	896	896	3004	2108	259.5	870.2	83.7	280.8	49.3	165.1
14	0	896	896	3004	2108	235.9	791.0	69.8	234.0	39.4	132.1
15	2087	896	2983	3004	21	714.1	719.1	193.6	195.0	105.0	105.7
16	0	896	896	3004	2108	195.0	653.8	48.5	162.5	25.2	84.6
17	0	896	896	3004	2108	177.3	594.3	40.4	135.4	20.2	67.6
18	0	896	896	3004	2108	161.2	540.3	33.7	112.8	16.1	54.1
19	0	896	896	3004	2108	146.5	491.2	28.0	94.0	12.9	43.3
20	2099	896	2995	3004	9	445.2	446.5	78.1	78.4	34.5	34.6
21	0	896	896	3004	2108	121.1	405.9	19.5	65.3	8.3	27.7
22	0	896	896	3004	2108	110.1	369.0	16.2	54.4	6.6	22.2
23	0	896	896	3004	2108	100.1	335.5	13.5	45.3	5.3	17.7
24	0	896	896	3004	2108	91.0	305.0	11.3	37.8	4.2	14.2
25	0	896	896	3004	2108	82.7	277.3	9.4	31.5	3.4	11.3
26	0	896	896	3004	2108	75.2	252.1	7.8	26.2	2.7	9.1
27	0	896	896	3004	2108	68.3	229.1	6.5	21.9	2.2	7.3
28	0	896	896	3004	2108	62.1	208.3	5.4	18.2	1.7	5.8
29	0	896	896	3004	2108	56.5	189.4	4.5	15.2	1.4	4.6
30	2571	896	3467	3004	-463	198.7	172.2	14.6	12.7	4.3	3.7
31	0	896	896	3004	2108	46.7	156.5	3.1	10.5	0.9	3.0
32	0	896	896	3004	2108	42.4	142.3	2.6	8.8	0.7	2.4
33	0	896	896	3004	2108	38.6	129.3	2.2	7.3	0.6	1.9
34	0	896	896	3004	2108	35.1	117.6	1.8	6.1	0.5	1.5
35	0	896	896	3004	2108	31.9	106.9	1.5	5.1	0.4	1.2
36	0	896	896	3004	2108	29.0	97.2	1.3	4.2	0.3	1.0
37	0	896	896	3004	2108	26.3	88.3	1.1	3.5	0.2	0.8
38	0	896	896	3004	2108	24.0	80.3	0.9	2.9	0.2	0.6
39	0	896	896	3004	2108	21.8	73.0	0.7	2.5	0.1	0.5
40	2099	896	2995	3004	9	66.2	66.4	2.0	2.0	0.4	0.4
41	0	896	896	3004	2108	18.0	60.3	0.5	1.7	0.1	0.3
42	0	896	896	3004	2108	16.4	54.9	0.4	1.4	0.1	0.3
43	0	896	896	3004	2108	14.9	49.9	0.4	1.2	0.1	0.2
44	0	896	896	3004	2108	13.5	45.3	0.3	1.0	0.0	0.2
45	2087	896	2983	3004	21	40.9	41.2	0.8	0.8	0.1	0.1
46	0	896	896	3004	2108	11.2	37.5	0.2	0.7	0.0	0.1
47	0	896	896	3004	2108	10.2	34.1	0.2	0.6	0.0	0.1
48	0	896	896	3004	2108	9.2	31.0	0.1	0.5	0.0	0.1
49	0	896	896	3004	2108	8.4	28.1	0.1	0.4	0.0	0.1
50	484	896	1380	3004	1624	11.8	25.6	0.2	0.3	0.0	0.0
Total						26200.8	23625.3	20921.1	9921.4	19927.3	7325.3

EIRR = 9.37 %

B/C at 10%= 0.90

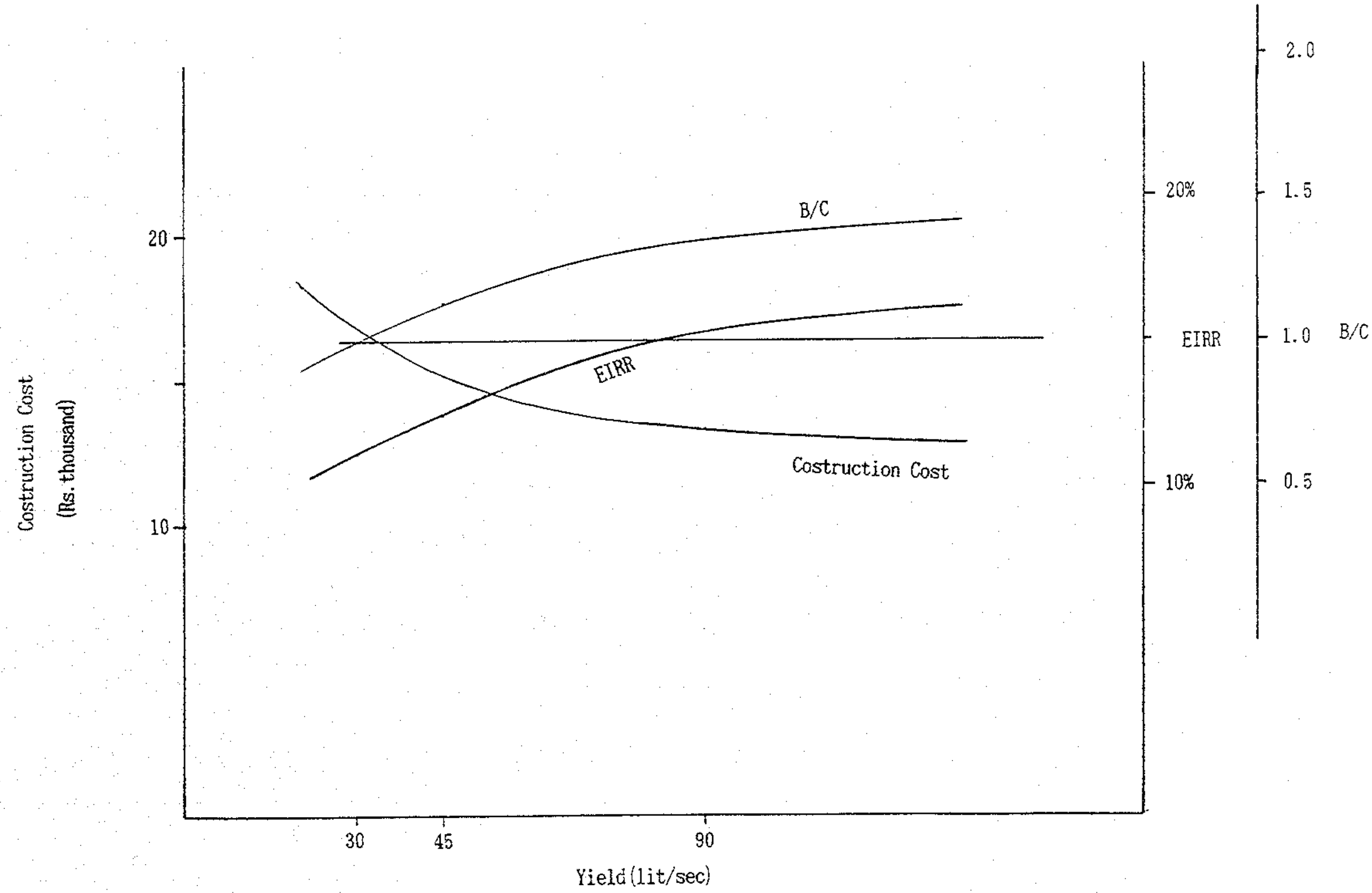


Figure 9.2.2 (1) LCFA and LFWY (Diesel Pump) Jhapa

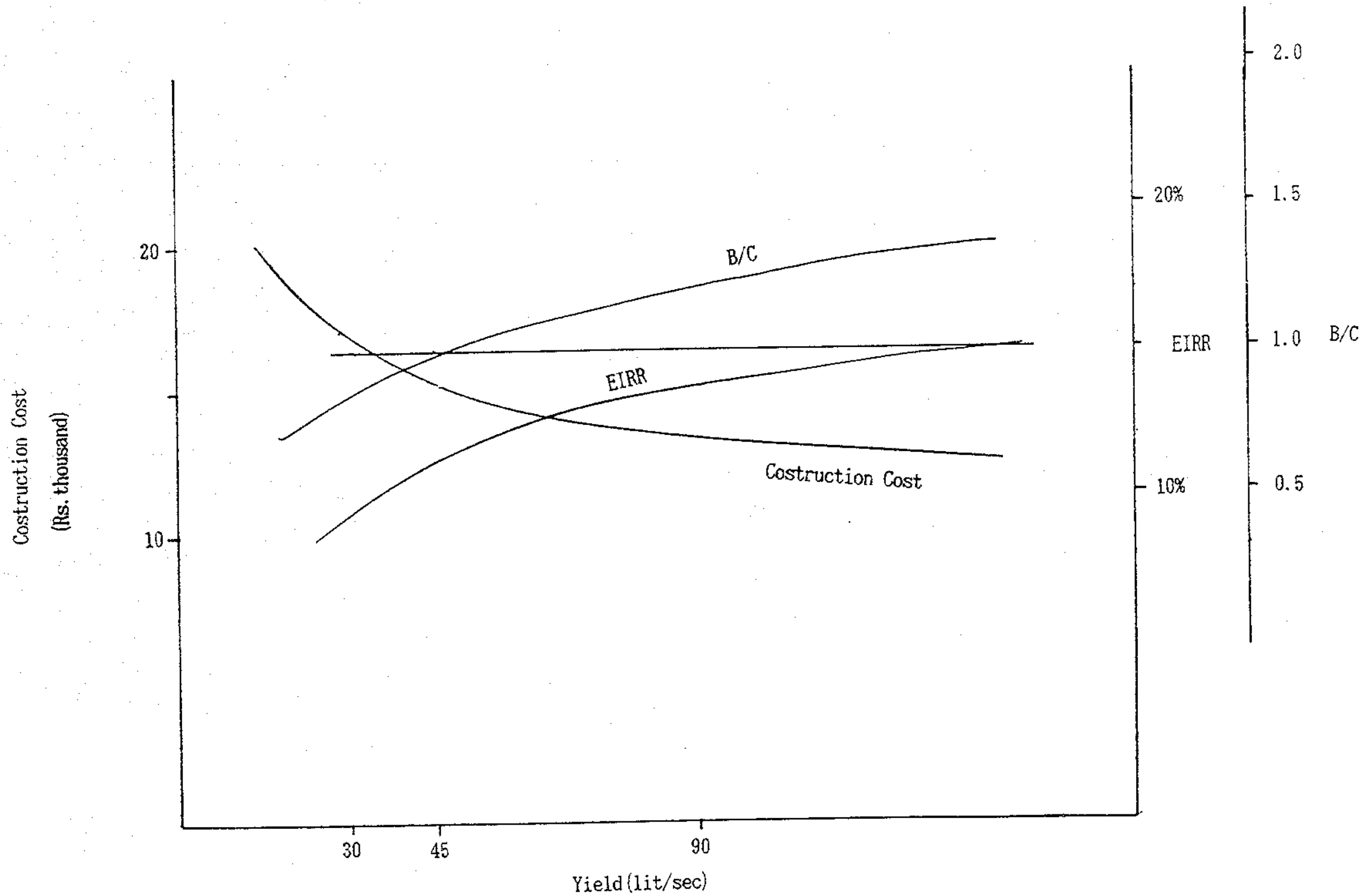


Figure 9.2.2 (2) LCFA and LFWY (Diesel Pump) Mahottari

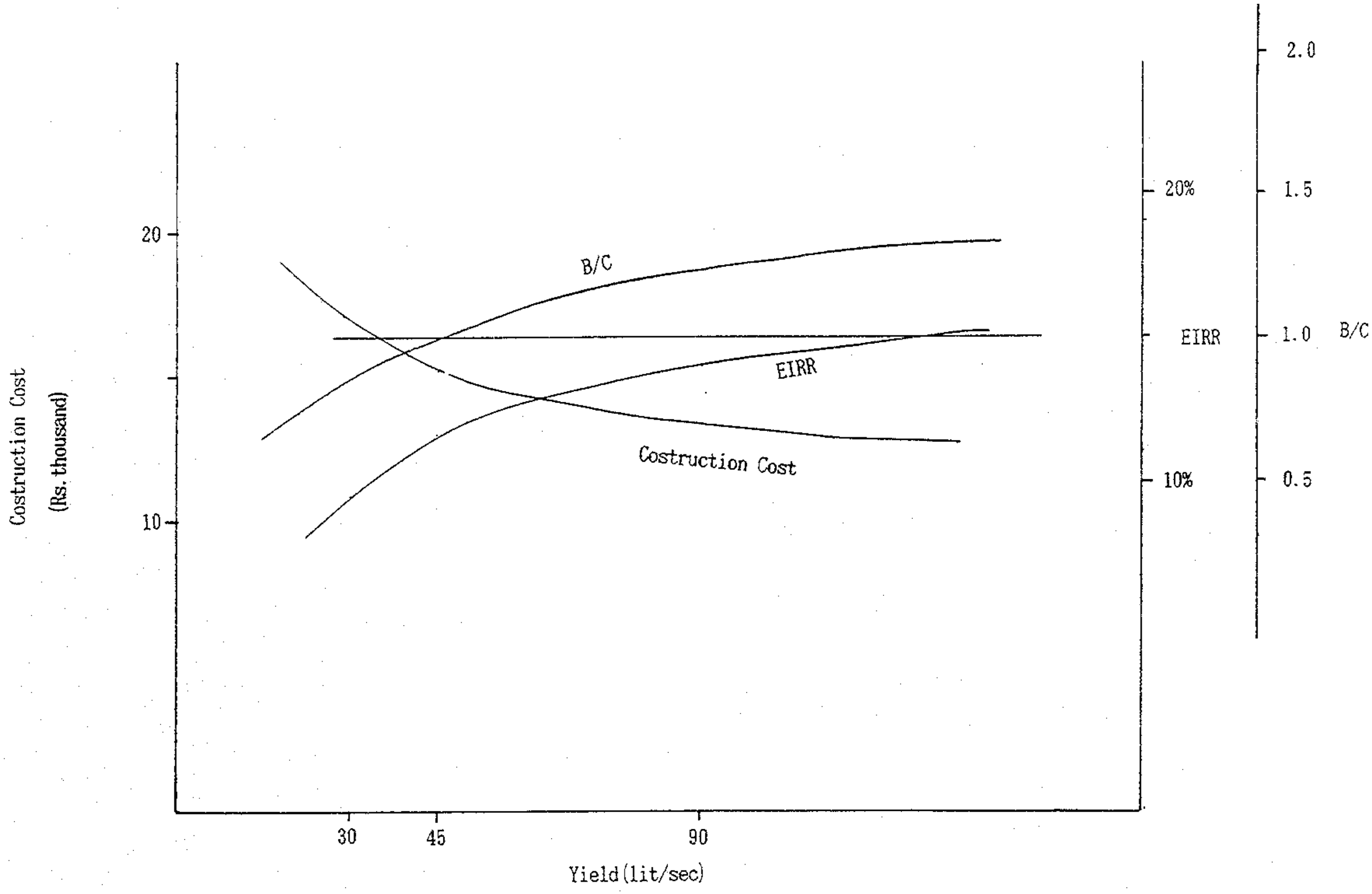


Figure 9.2.2 (3) LCFA and LFWY (Diesel Pump) Banke

9.3. Evaluation of Aquifer Potential

The evaluation of aquifer potential is of particular importance to the groundwater irrigation project. The first consideration is to interpret the lithologic well logs and data of borehole loggings in order to establish the hydrogeological units. Particular attention should be paid to the presence of the Churia Group in shallow depths, based on the regional geological studies. In general, the Terai Plain is underlain by a thin series of alternating clay and sand and gravel beds, and possible yields are estimated at 60 to 120 l/s. Potential problems may arise in certain areas where the consolidated Churia Formation with finer materials underlies the shallow parts. For instance, north of Nepalganj, a formation underlies the central part of the alluvial plain; it is composed of a thick series of alternating fine sand and silt, with many siltstone fragments, and it has been established in previous studies as alluvial. The composition rate of the permeable beds and the transmissivity in this formation are less than 15% and 200 m2/day, respectively, which are much smaller compared with neighboring alluvial formations. Therefore, the Study Team believes this to be the Churia Formation. The regional geology, in particular, the presence of the Churia Hills just east of the Rapti, as well as the low groundwater potential compared with other alluvium, support this idea. Furthermore, this can be easily confirmed through a study of the regional geology and a careful interpretation of the lithologic logs and aerial photographs.

9.4. Construction of Production Well

9.4.1. Design of Production Well

(1) Depth and Diameter

Well design is the process of specifying physical materials, dimensions, and water requirements for a well. The possible yield can be determined by the specific capacity and/or transmissivity in relation to the screenable length of the aquifers. It is essential to construct production wells using proper drilling techniques and optimal location of the well screen.

The diameter must be chosen to satisfy the water requirement. For this connection, the entrance velocity of the water into the screen is calculated based on a 120 l/s yield with different well diameters. Results indicate that the velocity in well diameters of 150 mm, 200 mm, and 250 mm are 3.4 cm/s, 2.5 cm/,s and 2.0 cm/s, respectively. It has been proposed based on field experience and laboratory tests that the average entrance velocity of water moving into the screen should not exceed 3.0 cm/s (Driscoll,1987). As a result of the above, it can be stated that a well with a 150 mm diameter is not adequate to yield a 120 l/s discharge and that a 200 mm diameter also seems to be critical to regulate moving formation material.

Taking these results into consideration, the necessary screen length is calculated as follows.

Table 9.4.1 Length of Screen and Entrance Velocity by Yields

Well Yield (l/s)	Necessary Length of Screen		Required Velocity (cm/sec)
	Velocity=2.0 cm/s	Velocity=3.0 cm/s	
60	15.6	10.2	1.0
80	20.7	13.6	1.4
100	25.9	17.0	1.7
120	31.1	20.3	2.0

Remarks: Required velocity is based on a 30 m screen length.
Screen opening is 25%.

The optimum length of screen for four different yields in Jhapa, Mahottari, and Bank can be calculated by using the optimum screen velocity derived from the representative transmissivity (Walton, 1962). The actual depth of well is the sum of the lengths of housing (=50 m), the total length of beds including permeable and impermeable beds, several clearances for seasonal fluctuation (=10 m), and others. Results are tabulated in Table 9.4.2.

Table 9.4.2 Calculation of Necessary Well Depth

District/Area	T(m^2/d) /k(m/d)	Cal. S.L. Yield(l/s) 60 80 100 120	Rate of Sand & Grav(%)	F.L. Yield(l/s) 60 80 100 120	Total W.L. (m)
Jhapa					
North Alv.	1,130/ 49	13 18 20 26	61	21 30 33 43	98
Kankai Alv.	1,740/ 76	10 14 17 20	76	13 18 22 26	81
Gangetic Alv.	2,490/108	9 11 14 17	77	12 14 18 22	77
Terrace	1,000/ 43	16 21 26 31	66	24 32 40 50	105
Mahottari					
Bhabar	4,800/218	6 7 9 11	60	10 12 15 18	73
Gangetic Alv.	520/ 24	20 27 34 41	52	38 52 65 79	134
Banke					
Bhabar	700/ 90	9 13 16 19	30	30 43 53 63	118
Central Alv.	210/ 27	18 24 29 35	15	120 160 193 233	288
South Alv.	1,010/129	8 10 13 15	50	16 20 26 30	85

Remarks: T=transmissivity k=permeability, derived by T with aquifer lengths of 23 m in Jhapa, 22 m in Mahottari, and 7.8 m in Banke
Cal.S.L.=calculated screen length F.L.=length of necessary beds
Total W.L.=necessary total well length

The table shows that most of the wells in the alluvial plain require less than 100 m depth for a 120 l/s discharge. Further depth of about 150 m is necessary in the terrace terrain in Jhapa, in southern Terai in Mahottari, and in the Bhabar Zone in Banke. An exception among the three areas is the central part of alluvial plain in Banke, where the Churia Formation underlies close to the surface and the well depth required is more than 280 m. The above results lead to the conclusion that, in general, the depth of production wells in the Terai Plain requires approximately 120 m to satisfy a 120 l/s discharge.

9.4.2. Completion of Production Well

(1) Well Drilling Method

Selection of the drilling method depends on the geologic conditions. The percussion drilling method is the proper technique in the Bhabar Zone where the stratum is composed mainly of large gravel; the rotary drilling method is more efficient in the southern Terai because the sand and gravel size decreases southward. Taking regional geological conditions into consideration, the most economical method should be adopted for the project drilling.

(2) Density of Drilling Fluid

Selection and maintenance of the proper drilling fluid density will prevent the collapse or the flow of water into a borehole. Water-based drilling fluids include (1) clean, fresh water, (2) water with clay additives, (3) water with polymeric additives and (4) water with clay and polymeric additives. Water-based drilling fluid systems with clay or polymeric additives are typically used in unconsolidated formations, therefore items (2) and (4) are recommended drilling fluids for the Terai Plain.

Control of the drilling fluid density is a fundamental factor in successful water well drilling. To maintain an open hole, the pressure exerted by the drilling fluid column must exceed the pore pressure in the aquifer. Typically, a minimum excess pressure of 34.5 kPa is desirable, though the pressure requirement may be higher when pressure from confined formations is encountered.

Ordinarily, the water pressure within a freshwater aquifer is 9.8 kPa/m, unless the total dissolved solids are abnormally high. Therefore, at a depth of 10 m the pressure is 98 kPa. Under confined conditions, the potentiometric surface is above the top of the aquifer, therefore, the pore pressure at any thickness always exceeds the normal hydraulic pressure of 9.8 kPa of aquifer thickness.
A simple equation for determining the hydrostatic pressure exerted by the drilling fluid in a borehole is as follows:

Hydrostatic pressure(g/cm2)
= fluid density (g/cm3) x height of fluid column (cm)

To control the flow of water into the borehole, it is necessary to increase the density of the drilling fluid before reaching the confined formation. The additional drilling fluid density required to equalize the confined pressure is determined by the follow:

Additional drilling fluid density
= weight of water x (height of water above ground level/depth to top of confined aquifer)

The calculated additional density at site EX-8 in Jhapa is 0.45 where the height of the artesian pressure and the depth to the top of aquifer are 9 m and 60 m, respectively. Based on the above formula, the required density of drilling fluid is calculated as shown below.

Table 9.4.3 Required density of Drilling Fluid

Aquifer	S.W.L. (mags)	Pore Pressure (kPa)	Excess P. (kPa)	Total P. (kPa)	Add. Density	Total F. Density
Unconfined	0	60 x 9.8 = 96.6	34.5	131	-	1.3
Confined	9	60 x 9.8 = 96.6	34.5	131	0.45	1.75

Remark: S.W.L.=static water level Excess P.=excess pressure Total P. =total pressure
Add. Density=additional density F.Density=fluid density

It is not necessary to increase the fluid density for unconfined aquifers because the weight of ordinal bentonite is estimated at 1,320 kg/m3; however, drilling in confined aquifers requires the control of the fluid density. An excessive increase in the density can affect the drilling and well completion process in the following ways:

- Large volumes of drilling fluid and cuttings can be forced into the aquifer during drilling. Removal of the drilling fluid and cuttings during development can be extremely difficult, especially if clay additives are used.
- Material cost increase due to high fluid losses.
- Rate of penetration is reduced.
- Sample collection is more difficult and less reliable as cuttings do not separate from the drilling fluid at the surface.

Polymers are ordinarily used to control viscosity. Even the addition of small volumes of polymers to the drilling fluid can have significant effects on viscosity. In general, high-viscosity drilling fluids are required to lift coarse sand or gravel, whereas lower viscosity drilling fluids are adequate to lift fine sand and silt. In most cases, continuous monitoring of the drilling fluid is necessary to achieve the best results.

(3) Casing and Screen

a) Casing

Standard design procedures involve choosing the casing diameter and material, estimating well depth, selecting the length, diameter, and material for the screen, determining the screen slot size, and choosing the completion method. In regard to the material for the casing and screen, an assessment of the water quality is essential to prevent corrosion and incrustation. A general idea of the chemical combinations and the limit of concentrations which cause corrosion and incrustation are listed in Table 9.4.4

Table 9.4.4 Quality Limitation for Corrosion and Incrusting in mg/l

	pH	CO2	Fe	Mn	Hard's	DO	TDS	Cl
Corrosion	7.0>	50<	-	-	-	2.0<	1,000<	500<
Incrusting	7.5<	-	0.5<	0.2<	300<	-	-	-

The table shows that there are no problems related to quality in the exploratory wells in Jhapa, except in the Kankai alluvial plain. It is advisable to use stainless if Fe and Mn concentrations exceed the limit.

b) Screen

A type of continuous slot wire-wound screen is adequate for irrigation purposes because of its large slot opening. The required opening must be greater than 25%, as stated in sub-chapter (1).

Three factors, including water quality and strength requirements, govern the choice of materials used to fabricate well screens. High concentrations of Fe and Mn should also be taken into consideration for Terai groundwater.

The three loads, or forces, imposed on a screen include the column load (vertical compression), tensile load (extending forces), and collapse pressure (horizontal force). While a borehole is open during the installation of the screen and pipe, a screen attached directly to the casing may have to support the entire weight of the pipe. This burden exerts a column load on the screen. A tensile load is exerted on the screen when long screen and casing sections are installed. After the borehole material sloughs against the screen, the earth pressure exerts a horizontal stress on the screen, especially during development. The screen must have adequate collapse resistance to withstand both the earth and hydraulic pressures. The screen's resistance to both column and tensile loading is directly proportional to the yield strength of the material used to fabricate the screen, whereas the collapse resistance is proportional to the material's modulus of elasticity.

The necessary resistance is calculated using the following standard well:

Housing

Diameter: 400 mm Length: 50 m Material: steel (w=80 kg/m)

Casing

Diameter: 250 mm Material: stainless steel (w=45 kg/m)

Location: 70-140 mbgs (total 70 m)

Screen

Type:continuous slot wire Material=stainless steel (w=30 kg/m)

Location: 60-70, 140-150 mbgs (total 20 m)

Fresh water in the borehole

Load exerts to screen under above conditions

Tensile load : (450kg x 70m)+(10kg x 30m)=3,450 kg ....67 kg/cm^2

Column load : (80kg x 50m)+((10kg x 10m)+(45kg x 70m)=7,250 kg ... 40 kg/cm^2

Max collapse load : k x g x H .... 0.5 x 2.0 x 150 m=150 t/m2 ....15 kg/cm^2

k = coefficient of earth pressure at rest

g = unit weight of sand and gravel

H = depth to bottom of screen

Some degree of safety should be considered in selection of screen material, for example, 150% to 200% of the calculated load.

Table 9.4.5 Required Strength of Casing

Casing	Dia. (mm)	Thick. (mm)	Tensile (kg/cm2)	Column (kg/cm2)	Collapse (kg/cm2)
Required Strength	250	6.6	134	280	30
Tested Strength	250	6.6	2,000	-	40

Table 9.4.6 Required Strength of Screen

Screen	Dia. (mm)	Opening (%)	Slot size (mm)	Tensile (t)	Collapse (kg/cm2)
Required Strength	250	-	-	7	15
Tested Strength	250				
Ordinal		39	1.5	50	19.6
Reinforced by					
Ring base		39	1.5	28	50.5
Wire base		-	1.5	22	25.4

Remarks: ordinal = continuous slot wire-wound screen

The table shows that the strength of the casing is within the required limits; however, the strength of the screen, especially the collapse, indicates a critical value to the required strength. Therefore, it is strongly recommended that reinforced screens be used if the well depth exceeds 100 m.

JICA