His Majesty's Government of Nepal
Department of Irrigation
Groundwater Resources Development Project

Reassessment of the Groundwater Development Strategy for Irrigation in the Terai

Volume 5
Economics

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Groundwater Development Consultants Ltd
Cambridge, United Kingdom

in association with

Hunting Technical Services Ltd
Hemel Hempstead, United Kingdom
EAST Consult (P) Ltd
Kathmandu, Nepal

The Report

Volume	Part	Title
1		Main Report
2	A	Land Resources
	B	Agriculture
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CHAPTER 1

INTRODUCTION

Information used in this volume is given and discussed in detail in the other report volumes; most notably Volume 2, Agriculture and Social Studies; Volume 3, Groundwater; and Volume 4, Engineering. These describe the sources of data used. They include the results of formal surveys carried out as part of this study that covered 60 shallow tubewells (STWs) and hand dug wells, 16 private sector STW drilling contractors, and selected deep tubewells (DTW) mainly in the Bhairahwa Lumbini Groundwater Project (BLGWP).

A wide range of other data, from formal sources and informal discussions with His Majesty's Government of Nepal (HMGN), Agricultural Development Bank of Nepal (ADBN) and other officials, as well as with farmers, are presented in the relevant report volumes. These other sources included the preliminary results of the 1991 Population Census and the 1990/91 National Sample Census of Agriculture available from the Central Bureau of Statistics (CBS).

This volume starts with some selected socio-economic background to the study area and an outline of the financial and economic analyses that have been carried out. Chapter 3 presents the derivation of financial prices and economic values used in the analyses. The following three chapters present the individual crop budgets for the different analysis strata and cases (Chapter 4) and the individual tubewell models and their benefits (Chapter 5, STW; Chapter 6, DTW) that form the basis for the analyses. Chapter 7 summarises the capital and operating costs that are given in detail in Volumes 3 and 4. Chapters 8 and 9 present the results of the financial and economic analyses for STWs (Chapter 8) and the larger, medium and deep tubewells (Chapter 9).

The viability of using tubewells in conjunction with surface irrigation is examined in Volume 1, Chapter 10.

The Study Area is shown on Figure 1.1.

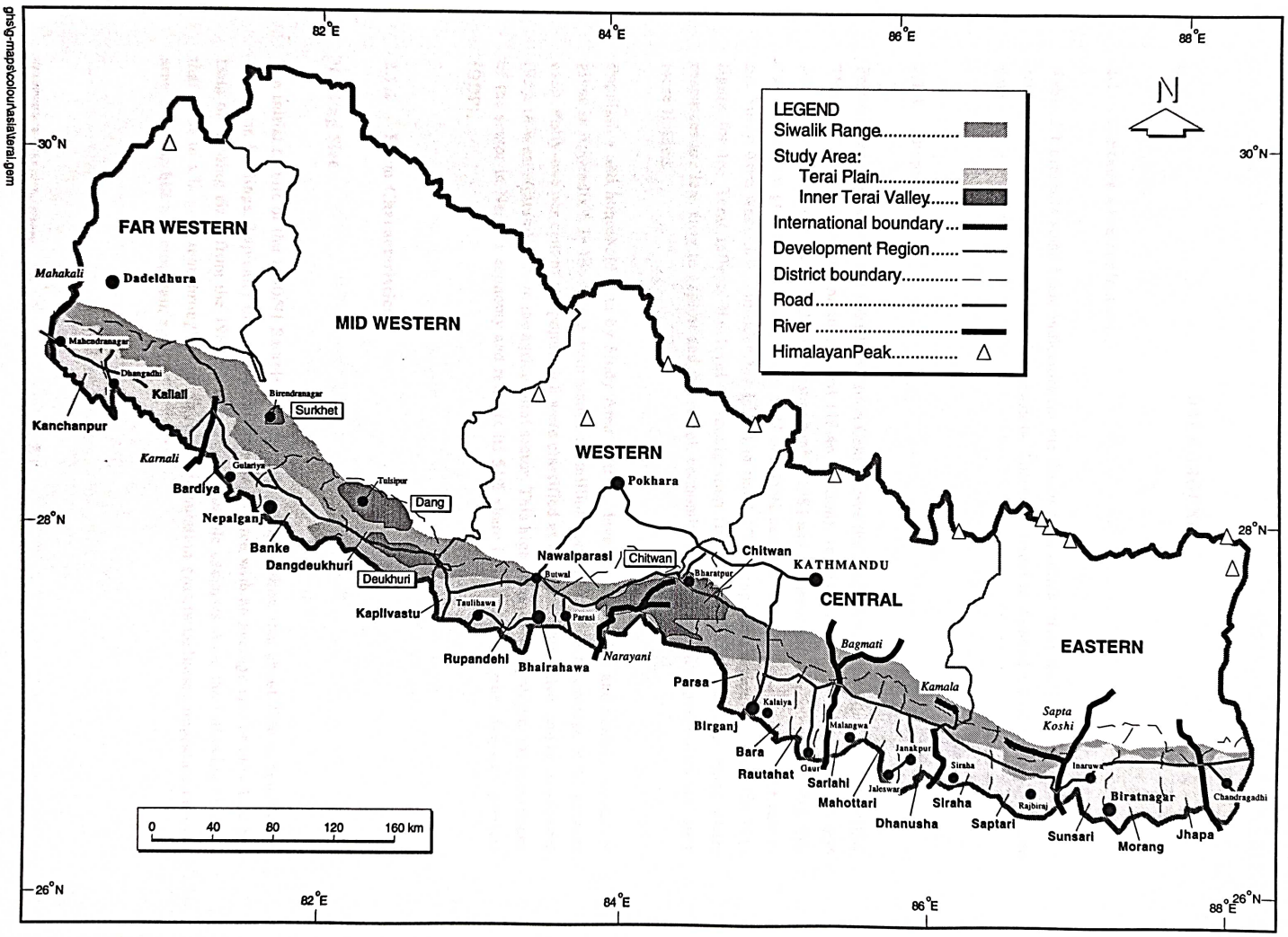


Figure 1.1
Study Area

CHAPTER 2

BACKGROUND

2.1 Study Area Indicators

Table 2.1 presents some basic indicators for the Study Area which cover the Terai and inner Terai ecological zones of 22 administrative districts. These are listed in Appendix I with the population data.

2.1.1 Population

Preliminary results from the 1991 Population Census give the Study Area population at 9.05 million. This is almost half of the national total (18.46 million), representing an overall density of 235 persons/km^2. This compares with 178 persons/km^2 in 1981 and 118 persons/km^2 recorded in 1971. The national annual growth rate between the 1981 and 1991 censuses was just under 2.1%. The rate in the Study Area was 2.8%, considerably less than the 4.3% during the previous decade. The high figure for the Terai reflects the level of immigration from the hill and mountain zones where resources are less easy to exploit and the social, economic and educational opportunities are much more limited.

Population and household data by Study Area district, development region and analysis strata are given in Appendix I. In 1991 there were almost 1.6 million households with an average of 5.7 persons each. Forty-one per cent of the population were classified as economically active, and of these, 84% (95% in West stratum) were in the agricultural sector. This high proportion highlights the importance of the sector in Nepal's economy and reflects its 54% share in the national gross domestic product (GDP).

2.1.2 Farm Characteristics

Holding Size

The initial results of the 1990/91 Sample Census of Agriculture show that about 70% of households have farm holdings. Typically these are small and fragmented with an average size of only 1.24 ha. Data on holding sizes from the 1980/81 and 1990/91 sample censuses show the following changes that arose to a large extent through the high rate of population growth including migration into the area from the hill and mountain zones.

TABLE 2.1

Selected Study Area Characteristics

Item	Analysis Stratum			Main Terai	Inner Terai	Study Area
	West	Central	East			
(a) Population 1991 *						
- '000 (Nr)	1 252.8	3 986	2 878.8	8 117.6	932.8	9 050.4
- % of Nepal population	6.8	21.6	15.6	44.0	5.0	49.0
- density (pers/km$^{2)}$	136	322	308	263	122	235
- growth 1981-1991 (%)	6.9	3.5	4.2	4.2	4.2	4.3
- growth 1981-91 (%/y)	4.2	2.6	2.4	2.8	3.0	2.8
(b) Households (HH) 1991						
- '000 (Nr)	191.5	693.5	535.1	1 420.1	161.9	1 582.0
- persons per HH (Nr)	6.54	5.75	5.38	5.72	5.76	5.72
- % econ. active in 1981	44	41	40	41	38	41
- % of these in agriculture	95	82	81	83	90	84
(c) Farm Holdings 1990/91						
- '000 ha	150.3	522.1	355.3	1 027.7	134.8	1 162.5
- % of which are:						
marginal (<1 ha)	47	62	55	57	68	58
small 1-3 ha	41	31	36	34	28	33
medium 3-5 ha	7	5	6	6	3	6
large >5 ha	4	3	3	3	1	3
- Average ha/HH	1.44	1.18	1.34	1.28	0.93	1.23
- Average pers/HH	7.0	6.3	6.1	6.3	6.3	6.3
(d) Agricultural area						
- cultivable '000 ha	595	918	614	2 127	251	2 378
- irrigable '000 ha	315	698	409	1 422	205	1 627
- percent of total area	53	76	67	67	82	68
- of which %: high suitability	61	63	72	65	59	64
- moderate suitability: for paddy	7	14	15	13	9	12
for other crops	32	23	13	22	32	24

Note: Populations are for the entire "Terai" districts and so include parts of the districts that are outside the Terai ecological zone.

Source: 1981 and 1991 Population Censuses, CBS;
1990/91 Sample Census of Agriculture, CBS;
LRMP Land System Report, 1988 Kenting Earth Science Ltd.

Holding size range (ha)	Holdings (%)		Area (%)		Area/holding (ha)	
	80/81	90/91	80/81	90/91	80/81	90/91
Marginal <1	58	58	9	19	0.24	0.41
Small 1-3	28	33	33	44	1.77	1.66
Medium 3-5	8	6	21	17	3.81	3.76
Large >5	6	3	37	19	9.94	8.41
All holdings					1.48	1.24

Apart from the marginal group (which surprisingly remains static), the figures, as expected with a rapidly rising population density, show a fall in average holding size, a decline in the number of larger holdings, and an increase in the number of small holdings. As illustrated in Table 2.1, farm holdings are smallest in the inner Terai (0.93 ha), and the largest in the West (1.44 ha).

Farm households in the Study Area averaged 6.3 persons each, and were larger than the average recorded for the nation (5.7 persons) in the 1991 Population Census. The number increased with holding size as illustrated below. Households were larger in the West than elsewhere: seven persons as compared to 6.1 to 6.3 persons.

Holding size range (ha)	Household size (pers)	10 - 64 years old	
		(Avg pers)	(%)
Marginal < 1	5.5	3.7	68
Small 1-3	7.0	4.9	70
Medium 3-5	8.9	6.2	69
Large > 5	10.0	7.1	71
All Holdings	6.3	4.3	69

About 70% of the people are in the economically active age group of 10 to 64 years of age. However, as shown in the individual crop budgets (Chapter 4), there seems to be a high propensity on many farms to hire labour under a variety of conditions, particularly in the medium and large categories, which include most of the present STW owners. More detail on holding size is given in Appendix I (Table I.4).

Fragmentation

A key factor in the utilisation of tubewells is the difficulty experienced in laying out distribution systems in circumstances where landholdings are commonly fragmented.

The 1990/91 Sample Census data on fragmentation are given in detail in Appendix I (Table I.5). As shown below, the average number of fragments or parcels for each holding was 3.8. This varied from 2.7 fragments on marginal farms (under 1 ha) to 8.6 fragments on large farms over 5 ha.

Holding size range (ha)	Fragmentation on each holding	
	Average (Nr)	percentage with only 1 parcel
Marginal < 1	2.7	32
Small 1-3	5.0	10
Medium 3-5	7.2	4
Large >5	8.6	8
All holdings	3.8	22

Significantly, almost one-third of marginal holdings had only one parcel of land. Because of the small size of such holdings, average 0.41 ha, individuals need to be part of a group to even acquire STWs. Nevertheless, having land in one parcel does reduce complications when laying out irrigation distribution systems.

Table 2.2 shows the differences among the four Study Area strata. As might be expected, fragmentation of holding is greater in the areas where population density is highest, in the Central and East strata.

TABLE 2.2

Fragmentation in the Terai All Strata

Stratum	Number parcels (Nr)					Avg Nr parcels per HH	Population density (pers/km^2)
	1	2-3	4-5	6-9	Over 10		
West	29	48	15	6	2	2.7	136
Central	11	41	21	16	11	4.8	322
East	29	40	15	10	6	3.4	308
Inner Terai	40	40	11	6	3	2.7	122
Study Area	22	41	17	12	7	3.8	235

Source: 1990/91 National Sample Census of Agriculture (preliminary)

Land Tenure

Data on land tenure is considered to be unreliable for a variety of reasons (See Volume 2C, Social Studies). The 1990/91 Sample Census of Agriculture preliminary results indicate that about 78% of holdings are owner operated, 19% owner-cum-tenant operated, and only 3% are tenant farmers. The latter is almost certainly a substantial underestimate arising from fears of any possible tightening of the various land reform measures taken in the past. The reported differences among the Study Area strata are:

Land tenure type	(Percentage)				
	West	Central	East	Inner Terai	Study Area
Operated owned	87	77	70	86	78
Owner-cum-tenant	11	22	22	12	19
Tenant only	2	1	8	2	3

(see Appendix I, Table I.6)

Tenancies may be for a fixed rent in cash or in kind or alternatively under share cropping arrangements (Volume 2C, Social Studies). The different forms of tenancy were found to be in the following proportions:

Forms of tenancy	Owner-cum-tenant (%)	Tenant only (%)
Fixed rent	24	33
Share crop	45	54
Other	31	13

The "other" category includes mortgage tenancies and other arrangements.

The data, though perhaps unreliable, do indicate the minimum extent to which share cropping and renting have to be taken into account in the final formulation of tubewell irrigation schemes. These will need to be flexible enough in terms of water and land use arrangements, that is water buying and selling and voluntary consolidation of plots or holdings, to enable farmers with different types of tenure to participate in this form of irrigation.

2.1.3 Irrigation Potential

The LRMP report at a reconnaissance level identified 16 720 km^2 as potentially irrigable. This is equivalent to 68% of the total cultivable area (23 720 km^2). Of this amount, 64% was considered to be of high potential, 12% moderate and suitable for paddy and 24% moderate but not suitable for paddy. Variations in these proportions in the four Study Area strata are shown in Table 2.1.

2.2 Stratification

To simplify the analyses and at the same time reflect major differences within the Study Area, four strata were identified:

Stratum	Development Region(s)
Main Terai	
- West	Far and Mid West
- Central	West and Central
- East	East
Inner Terai	Mid West, West and Central

The characteristics of each stratum are described in Volume 2B, Agriculture in terms of land resources and other physical conditions.

The stratification takes into account the main East-West variation in climate, in particular the nature of the monsoon rains. These start earlier and last longer in the east and decline in both aspects as one moves westwards. This together with the degree of development, especially of physical infrastructure gives rise to differences in cropping patterns, yields, settlement densities, etc.

The 1986 LRMP study data for the main Terai identified the following broad differences in cropping:

Predominant pattern	Study Area Stratum		
	West (%)	Central (%)	East (%)
Paddy based	57	84	73
Maize based	39	7	7
Other	4	9	20

Included in the other patterns in the East and Central strata, respectively, are those incorporating jute and sugar cane.

The stratification in broad terms also provides useful reflection of cost differences within the Study Area, especially in terms of transportation of inputs and outputs (Chapter 3).

2.3 Scope of the Study Analyses

2.3.1 Scope

The study analyses centre on the four strata described above and three types of tubewell: shallow (STW), medium (MTW) and deep (DTW). The characteristics of the four strata are described in Volume 2B, Agriculture, Chapter 4. The costs and their variants are described in Volume 3, Groundwater. There are two parts to the analyses. The first uses the tubewell as the unit, and the second illustrates the economic returns to a proposed tubewell development project based on existing HMGN Agricultural Service Centres. The proposed approach is described in Chapter 5 of Volume 2B, Agriculture, and in Volume 1, Chapter 12.

Two analysis levels have been applied to tubewells: full benefit/cost and least cost or partial analyses.

The scope of the benefit/cost analyses and the characteristics of the shallow and medium/deep tubewells adopted for them are summarised in Table 2.3. More detail is provided in Chapters 8 and 9.

A number of least cost comparisons have been made between tubewell types, power sources, distribution systems, etc., and these are set out in Table 2.4. They were carried out for a 13 l/s STW and a 60 l/s DTW sited in the Central Stratum. Also, MTWs and DTWs of varying capacity were also compared. Further detail is given in Chapter 7.

2.3.2 Benefit Cases

Three cases reflecting tubewell cropping performance were examined for STWs and two cases for larger tubewells. These are in addition to the without tubewell (without project) case that illustrates the returns from areas under rainfed conditions equivalent to individual tubewell commands. This is used to arrive at the incremental benefits of groundwater irrigation. The cases are as follows:

TABLE 2.3

Terai Groundwater Full Study Analyses Characteristics

	STW		M/DTW	
	Financial	Economic	Financial	Economic
Analysis unit				
Tubewell	*	*	*	*
Strata				
West	*	*	*	*
Central	*	*	*	*
East	*	*		
Inner Terai	*	*		
Benefit Cases				
Without tubewell	*	*	*	*
With tubewell				
- base	*	*	*	*
- improved	*	*	*	*
- high utilisation	*	*		
Land class				
2 mixed	*	*	*	*
2 upland			*	*
2R lowland			*	*
Power Source				
diesel	*	*	*	*
Distribution system				
unlined (earth)	*	*		
lined			*	*
Pumpset type				
suction	*	*		
force			*	*
Drilling Method				
manual	*	*		
machine drilled			*	*
Development method				
gravel pack			*	*
natural	*	*		
Capacity				
13 l/s	*	*		
60 l/s			*	*
Repayment capacity	*		*	
Sensitivity analysis	*	*	*	*

Source: GDC

TABLE 2.4

Terai Groundwater Partial Study Analyses

	STW		M/DTW	
	Financial	Economic	Financial	Economic
Analysis Base Unit				
Tubewell	P	P	P	P
Tubewell capacity (1)				
13 l/s	P	P		
60 l/s			P	P
Stratum				
Central	P	P	P	P
COMPARISONS				
Power Source				
diesel			P	P
electric			P	P
Distribution system				
earth lined	P	P	P	P
unlined	P	P	P	P
piped			P	P
Pumpset type				
suction			P	P
force			P	P
Drilling method				
machine	P	P		
manual	P	P		
hand dug	P	P		
Development type				
gravel pack	P	P	P	P
natural	P	P	P	P
Aquifer type				
D1			P	P
D2			P	P
D3			P	P
Well capacity				
15 l/s			P	P
30 l/s			P	P
45 l/s			P	P
60 l/s			P	P
90 l/s			P	P

Note: except for the well capacity comparison

Source: GDC

Base Case

The base case is applied to all three well types and illustrates the level of benefits already achieved when tubewells are installed. It takes into account the existing low level of support services, current availability of inputs and market conditions. The case can be considered to closely reflect the minimum well utilisation rates and crop production levels that can be achieved.

Improved Performance Case

The agricultural performance of tubewells, particularly STWs, has not fulfilled expectations. There are two main areas of underachievement: the area irrigated from the individual well, and the yield of crops grown.

The extent of these aspects is discussed in Chapters 4, 5 and 6, and in detail in Volume 2B, Agriculture, and 2C, Social Studies. Volume 2C, Social Studies, also assesses the improvements that can be reasonably anticipated if farmers are exposed to new ideas and given the necessary support.

The improved performance case can be considered the future with project position. It is adopted as such in the prefeasibility level project economic analysis. As discussed later, however, achievement does require a determined and effective effort to upgrade and target HMGN extension and research services and the support available from the Agricultural Development Bank of Nepal (ADBN) and the Agricultural Inputs Corporation (AIC) to farmers. The private sector can be expected to service groundwater irrigation but will also need encouragement and support from government and its related agencies, particularly in terms of credit and training. The proposed intensive programme described in Volume 1, Chapter 12 has been designed to achieve this.

STW High Utilisation Case

If water selling and buying and group ownership can be successfully established, then the average area irrigated by 15 l/s STWs could increase very significantly from about 2.5 ha to 4 to 6 ha. Ideas to encourage these two aspects of cooperation are put forward in Volume 2C, Social Studies.

2.3.3 Prices

Analyses have been carried out at present (1993) financial prices and projected (2005) economic values, in constant 1993 terms. Prices used are given in Chapter 3. Where enough detail is available and differences are considered significant, different prices and values are applied to each of the four Study Area strata.

2.3.4 Repayment Capacity

A key issue in the development of groundwater for irrigation is the ability of farmers, at very minimum, to cover all operating and maintenance costs. In addition, capital costs have to be met. The extent to which this is likely is covered in the analyses for those using each tubewell type (Chapters 8 and 9).

2.3.5 Other Analyses

The other analyses shown in Table 2.3 compare different aspects of well and distribution system construction and tubewell operation on a least cost basis, mainly in terms of the cost of water at the well head or to the field. The well types to which the individual analyses are applied are shown in the table. The specific aspects covered relate to power sources, type of well, type of distribution system, size of tubewell (from 15 l/s to 90 l/s) and for use of suction or force mode pumps. The main benefit/cost analyses have only been applied to the types of tubewell and distribution systems considered most appropriate to the Study Area conditions.

CHAPTER 3

PRICE ASSUMPTIONS

3.1 General

This chapter sets out the basis for the financial prices and economic values used in the study analyses. Financial prices are for early to mid-1993.

Economic values, wherever possible, are border parity values and are forecast for the year 2005 in terms of constant 1993 prices. They are derived from the World Bank's Price Prospects for Major Primary Commodities 1990-2005 published in May 1993 and from other sources which are noted where relevant. The World Bank's published prices have been adjusted to 1993 constant values by applying the Manufacturing Unit Value (MUV) index. This is commonly taken as an indicator of world market price inflation for primary commodities.

Table 3.1 summarises the recent past and forecast international market prices adopted for the Study. Where world prices were not available or were inappropriate, the values are based on internal Nepalese, 1993 prices. These include, in respect of production inputs, labour, agro-chemicals (excluding fertilisers), transportation and services, including those represented by marketing margins.

3.2 Exchange Rates

Mid-1993 currency exchange rates have been used:

Rs 49	=	US Dollar 1.00
Rs 160	=	Indian Rupee 100
Rs 73	=	Pound Sterling 1.00

3.3 Economic Conversion Factors

3.3.1 Standard Conversion Factor

A Standard Conversion Factor (SCF) of 0.9 has been adopted to convert financial prices to economic values. It allows for:

(a) the slight undervaluation of foreign exchange at official exchange rates; and

(b) the general level of taxes and duties relating to imported and exported goods; transfer costs within the national economy.

TABLE 3.1

World Commodity Prices (US$/t)

Commodity	(Constant 1993 US$) (1)								
	1988	1989	1990	1991	1992	Average 1988/92	1993	2000	2005
Rice	349	374	317	340	300	336	217	271	262
Wheat	208	235	172	155	178	190	105	176	143
Maize	124	130	120	116	109	120	89	112	91
Jute	429	435	451	409	332	411	340	355	346
Cotton	1625	1956	2012	1813	1348	1751	1290	1658	1603
Sugar	261	329	306	214	222	267	244	282	309
Soybean									
- grain	351	322	273	260	241	289	230	242	258
- oil	537	504	494	491	447	495	495	452	413
- meal	311	287	231	216	216	252	195	204	232
Groundnut									
- oil	684	905	1066	967	724	869	645	612	465
- meal	243	233	204	162	162	201	165	174	193
Tobacco	2251	2208	2171	2412	2044	2217	1975	1892	1868
Fertilisers									
- urea	180	155	174	186	148	169	156	187	176
- TSP	183	168	146	144	128	154	122	138	136
- DAP	228	202	189	187	150	191	140	164	160
- KCL	102	115	108	118	116	112	115	118	116
Petroleum (2)	15.8	19.0	23.4	18.8	15.4	18.5	17.4	19.9	18.8

Notes: (1) Published constant 1990 US$ price adjusted by the 1990-1993 MUV index change (x 1.1053)

(2) US$/BBL

Source: Price Prospects for Major Primary Commodities 1990-2005 World Bank, May 1993; Financial Times (London) and the Asian Wall Street Journal editions, June 1993.

The standard conversion factor (SCF) has been applied to internal marketing, handling and processing costs, including marketing margins.

3.3.2 Construction Conversion Factors

Composite Construction Conversion Factors (CCF) have been calculated for the analyses. They are derived from three components of construction costs which have the following conversion factors (CF) applied to them:

(a) Imported materials

This includes all imported equipment and material, i.e., pumpsets, well casing, finished steel products, etc. Customs duties and sales tax are applied to these imports, and a range of CFs have been used to adjust for these in the economic analyses. If items are imported from India or SAARC countries, there is some reduction in customs duty. The net saving is not very great, however, and the deduction has not been made in arriving at the conversion factors. The factors applied to the broad construction cost components into which costs have been divided are shown in Appendix VI in which the composite conversion factors are calculated.

(b) Local Materials

Sales taxes are levied on local materials. The rates vary but are most commonly 10% and a CF of 0.9 has been adopted. This has been applied to construction materials of local origin (cement, stone, brick, etc.) and to steelwork that has been substantially finished or fabricated within Nepal.

(c) Labour

Skilled labour has been included at its financial cost, a CF of 1.00. A CF of 0.75 has been used to adjust financial costs to the shadow wage rate of unskilled construction labour (see Section 3.8.2). This is the same as applied to agricultural labour.

(d) Transport

Where transport is a significant and identifiable cost component, a CF of 0.72 has been applied. This is discussed further in Section 3.7.

3.4 Duties and Taxes

As implied above, the values used in the economic analysis exclude customs duties and sales taxes that are levied on imports and local sales. They are included in the financial analyses.

3.5 Land Tax

Farmers are required to pay land tax to their local authorities. The tax is assessed at different rates depending upon the quality of the land. Four classes are defined separately for lowland and highland in the Terai and other regions. The definitions of the classes in the Terai are summarised in Table 3.2 and the rates levied in 1993/4 were:

Land class	Tax rate (Rs/ha)
Abbal	118
Doyum	107
Seem	89
Chahar	59

A high proportion of the areas expected to be selected for tubewell irrigation will fall into the Abbal and Doyum classes.

3.6 Updating Costs

Where necessary, costs have been updated using the national and Terai Zone Consumer Price Indices published by the Nepal Rastra Bank. The rates used are set out in Table 3.3.

3.7 Transport

Transport is a significant cost element in Nepal's economy, even in the flatter, more accessible Terai zone. Imports and exports (as well as internal Indian trade) all have to pass through India via Calcutta. While road conditions have improved during the past decade along the national east-west and north-south highways, internal access away from these is generally difficult. Farm to market roads are frequently poor, though travel is easier within the Study Area than elsewhere.

The East-West Highway or Mahendra Raj Marg and is paved and runs the length of the main Terai. There are a number of north-south links with the interior. The main ones are also paved, most notably the roads to Pokhara and Kathmandu. A series of north-south, mainly gravel, roads lead from the East-West Highway, providing access of variable quality within the Terai and penetrating into the hill zone in places. These roads also provide access for the marketing of inputs and exports to India.

TABLE 3.2

Definition of Land Tax Classes in the Terai (1990)

Land Class	Lowland Terai	Upland Terai
Abbal	- good loam soil with no stones - suitable for paddy - capable of 200% annual cropping intensity - irrigated	- good loam soil - suitable for paddy, wheat, maize and other crops
Doyum	- good loam soil with no stones - suitable for 200% annual cropping intensity - irrigable in monsoon season only	- good loam soil with no stones - suitable for maize, millet, oil seed, etc.
Seem	- stony, sandy soil - capable of only 100% annual cropping - rainfed only	- stony, sandy soils - suitable for cropping only every two years
Chahar	- sandy loam - suitable for crop only every few years - rainfed only	- stony, sandy soils - suitable for cropping only every few years - uneven topography

Source: Nepal Yen Sangraha (in Nepali), Khanda 7 (ka), 2047
Ministry of Law and Justice

TABLE 3.3

Consumer Price Indices 1988/89 to 1992/1993

Consumer price indices	1988 1989	1989 1990	1990 1991	1991 1992	1992 1993(1)
National					
- overall index	161.3	179.9	197.6	239.2	249.8
- transport	150.6	181.7	183.3	235.9	247.8
- non-food items and services	153.7	177.2	193.4	223.1	238.4
Terai					
- overall index	159.6	175.0	192.1	233.5	241.9
- transport	151.8	181.8	184.5	na	na
- non-food items and services	154.3	179.0	193.4	na	na

Note: (1) to January 1993

Source: Nepal Rastra Bank (base year 1983/84 = 100)

There are no significant links by river, but two short railways cross from India, from Birganj to Raxaul (6 km into Nepal) and Bizalpura to Jayanagar (51 km). The former link is almost abandoned and the latter is the main access route to India.

There are five main customs posts spread along the border at Biratnagar (Morang), Birganj (Parsa), Bhairahwa (Rupandehi), Nepalganj (Banke) and Mechi (Jhapa).

The calculations of the economic values of inputs and outputs allow for transport costs across the Study Area at the following rates:

Stratum	Financial (rounded) (Rs/t)	Economic (rounded) (Rs/t)
East	805	580
Central	1 170	842
West/Inner Terai	1 580	1 138

The financial rates are based on updated prices from the National Transport Corporation. The economic CF of 0.72 is that calculated in some detail for the 1988 Transport Investment and Maintenance Strategy Study (TecEcon with Scott Wilson Kirkpatrick & Partners and East Consult

for HMGN and ADBN). Financial transport prices for fertiliser are a little different. As shown later in Table 3.6, costs provided by the Agricultural Inputs Corporation (AIC) include transport at the average cost met by the corporation. The economic values are based on the figures given above for each study stratum (Table 3.7 for fertiliser).

Local, farm to market, transport is by bullock cart or head load. Field studies in early 1993 found that while costs varied, they were typically Rs 1.8/100 kg for each kilometre. The farmgate cost and price derivations assume a 10 km distance resulting in Rs 180/t. Other transport costs, where applicable, such as those borne by merchants in moving goods from AIC depots to local markets, assume motor transport to which a CF of 0.72 is applied to convert to the economic cost.

3.8 Labour

3.8.1 Skilled Labour

Skilled labour has been included in the financial analyses at its early 1993 cost. The shadow price of skilled private sector employees, i.e. drillers, masons, etc., has been taken to be the same as their financial cost. The rates paid are considered to reflect the full opportunity cost of such workers.

The same applies to HMGN and ADBN technical and professional staff that are included in the pre-feasibility project analysis. However, these public sector employees at the higher levels pay tax and the financial price has been adjusted by 0.85 to allow for this in the economic analyses. This adjustment has been applied to all those earning above Rs 40 000 a year, which is a simplification since tax starts at a lower salary at 10% and gradually increases to 25%.

3.8.2 Unskilled Labour

Unskilled labour for construction and agricultural work has been included at the 1993 daily rates which are discussed below. In the financial analyses, farm family labour has not been costed, though it has been included in the economic calculations.

Details of the cost and use of unskilled non-agricultural labour for drilling and construction are given in Volumes 3 and 4. Hiring of casual, daily paid workers by farmers is widespread. Permanent labour is also employed under varying conditions, including the system of bonded labour common in the West stratum of the Study Area.

It is common in all areas to provide cash and one or two meals each day. Wages are also often paid in kind. The 1993 Study survey showed 35% paid in kind. At harvest time, payment in kind is often in the form of a share of the crop harvested. At other times, payment is commonly in locally standard quantities of grain, varying from 4 to 7 kg/day.

Data are insufficient to arrive at definitive figures to distinguish between areas where wages are high and low. But they do vary among areas and for work in the peak (land preparation, paddy transplanting and harvesting) and off-peak (weeding, post-harvest) demand periods. Peak rates appear to be highest in the Central stratum and parts of the East stratum including Butwal and Bhairahwa and lowest in the West stratum where bonded labour is most common.

Financial Wage Rates

The financial analyses include the cost of hired labour at the average Study Area rate found during field studies in early 1993. The results of the limited survey of 61 tubewells are summarised in Table 3.4.

TABLE 3.4

Daily Paid Wage Rates 1993

Type of wage	Average value		Combined average
	(%)	(Rs/day)	(Rs/day)
Paid in cash only	40	34	}
Cash and food	25	44	} 38
			}
Kind only	11	23	}
Kind and food	24	34	} 31
			}
Total	100	-	35

Source: GDC field studies 1993

Most farmers (65%) paid in cash, or with cash and meals at an average cost of Rs 38/day. Payment in kind, with and without meals, was reported by 35% of respondents. Assuming an overall farmgate paddy price of Rs 4.8/kg (see Section 3.10) the average value paid in kind was Rs 31 a day. In both cases snacks and meals were valued respectively at Rs 5 and Rs 15 a day. The overall weighted cost was Rs 35/day.

For a number of reasons this figure may be rather on the high side. It does not take into account the possibly lower cost of bonded labour that is widely used in the West, and the proportion of those paying in kind appears to be low when compared to some other studies. Nevertheless, if the proportion was increased from 35% to 75%, the daily average cost would only fall to Rs 34/day, a very small difference. So taking into account the level of detail required of the study and the data limitations, the average rate of Rs 35/day has been adopted for all the study strata.

The main survey only considered average wage rates over the whole year. A separate study was carried out in the Butwal and Bhairahwa areas to determine the difference in peak and off-peak season payments. When demand was high, the reported rate was Rs 62/day which fell to Rs 37/day during the off-peak period. The difference of 68% was much larger than the 25% found in the 1987 GDC study and may not be typical of the whole area. It could reflect the greater demand for casual labour in the area where the data were collected. Nevertheless it is considered adequate for the following calculation of the economic conversion factor used to obtain the shadow price of labour for the economic analysis.

Using the Butwal - Bhairahwa data, the area's financial wage rate was calculated using the following assumptions:

(a) 65% paid on cash basis, 35% paid in kind;

(b) peak period four months, off-peak eight months;

(c) cash rates: peak Rs 62/day, off-peak Rs 37/day; and

(d) value in kind consisting paddy at Rs 4.8/kg, snack at Rs 5/day, and meals Rs 15/day, giving a total cost of Rs 31/day.

The resulting financial cost was Rs 41/day, which is higher than for the Study Area as a whole.

The same assumptions were used to calculate the economic value of labour, except that paddy was valued at Rs 5.9/kg, the projected average study value used in the economic analyses (see Section 3.11.2). In addition:

- the resulting peak rate of Rs 53/day is taken to be the opportunity cost of labour during this period; and

- the opportunity cost of off-peak labour is half the calculated rate of Rs 36/day, or Rs 18/day.

This reflects the greater difficulty in obtaining work at such times. Any lower rate would not have taken into account the fact that rice and wheat threshing and storage have their own labour demands during a part of the off-peak season, especially at present levels of mechanisation.

The overall shadow rate was Rs 30/day.

The factor to convert the financial cost to its economic value is therefore 0.75 (Rs 30 ÷ Rs 41). This conversion factor, when applied to the financial daily rate used in the study analyses (Rs 35), gives the shadow rate of Rs 26.

3.9 Agricultural Inputs

3.9.1 Seed

Almost all farmers plant seed from their previous crop or purchase locally from other farmers. Improved varieties are available from the Agricultural Inputs Corporation (AIC), and the use of high yield variety (HYV) paddy and particularly wheat is widespread, though often using seed purchased some years previously. Table 3.5 sets out the estimated price of such cereal seed.

The farmgate prices are based on AIC's 1992/93 procurement and other costs, official agents, commission and an element for transport from the dealer to the farm by bullock cart. Such seed is available from AIC depots and local Sajhas (government administered cooperatives).

TABLE 3.5

Financial Farmgate Value of Crop Seed Available from the Agricultural Inputs Corporation 1992/93 (Rs/t)

Item	Paddy	Wheat	Maize	Oil seed	Pulse
AIC procurement price plus direct expenditure	8 400	6 650	7 450	16 330	14 400
Losses (%)	(4.0)	(0.8)	(0.65)	(1.2)	(3.36)
(Rs)	336	53	48	198	484
Sub total	8 736	6 703	7 498	16 528	14 884
Promotion and administration costs (3%) plus contingencies (2%)	437	335	375	826	744
Total price at AIC depot	9 173	7 038	7 873	17 354	15 628
Dealer commission (10%)	917	704	787	1 735	1 563
Transport to farm	180	180	180	180	180
Farmgate price	10 270	7 922	8 840	19 269	17 371
Assumed price (Rs/kg)	10.3	7.9	8.8	19.3	17.4
Output value 1992/3	4.8	3.9	3.9	12.9	12.9
Ratio seed to output value at financial price	2.1	2.0	2.3	1.5	1.3

Source: GDC estimate based on 1993 AIC cost data

Table 3.5 also derives the cost of oil seed and pulses for planting if purchased through AIC. The ratio of seed cost in financial prices for farmers to output is shown at the bottom of the table. These have been applied to the economic farmgate output values to estimate seed prices in the economic analyses. For potato, the ratio assumed was 2.0.

3.9.2 Fertilisers

The financial farmgate prices of fertilisers are given in Table 3.6. The prices are based on 1993 AIC data.

TABLE 3.6

Fertilisers: Present Financial Prices 1993 (Rs/t)

Item	(Rs/t)			
	Urea	Compound	DAP	KCL
CIF Calcutta US$	163	203	211	160
Rs (1)	7 979	9 969	10 342	7 840
Charges/handling	60	75	78	59
Transport	1 675	1 675	1 675	1 675
Storage	32	32	32	32
Sub-total	9 746	11 751	12 127	9 606
Finance charges (2)	617	744	768	608
Administration	270	270	270	270
Losses (3)	24	29	30	24
Dealers commission (4)	196	350	438	298
Total price	10 854	13 144	13 633	10 806
Subsidy	5 254	3 144	1 133	2 306
Price ex-dealer	5 600	10 000	12 500	8 500
Local transport (5)	180	180	180	180
Farmgate price				
- Rs/t	5 780	10 180	12 680	8 680
- Rs/Kg	6	10	13	9

Notes: (1) Rs 49 = US$ 1.00
(2) 19% per annum for four months
(3) 0.25%
(4) 3.5% of dealer sale price
(5) 10 km x Rs 1.8/100 kg

Source: Agricultural Inputs Corporation, 1993

AIC is effectively still the sole importer of fertilisers, even though it is now legal for private concerns to do so. However, procedures are not yet clear enough to enable importers other than AIC to claim the subsidies that HMGN still provides through the Corporation. The extent of the subsidies is shown in Table 3.6. The subsidies are substantial, varying from 8% for DAP to 48% for urea. AIC depots in each district are wholesale outlets only. The final distribution is through cooperatives (*Sajhas*) and private dealers. There are 2 500 dealers in Nepal, of which 700 are cooperatives. Cooperatives now are reported to receive no preferential treatment except when supplies are very low, when they will be given priority at AIC depots.

Table 3.7 gives the derivation of the economic value of fertilisers. The world market prices are from the World Bank's forecasts of May 1993 (see Section 3.1), adjusted to constant 1993 prices. The breakdown of costs is based on AIC data. HMGN subsidies have been excluded and transport costs to each stratum have been included at the rates discussed in Section 3.7. The average 1993 economic values for the Study Area strata compare with the AIC based farmgate financial prices with and without the subsidies as shown below:

	Rs/kg			
	Urea	Compound	DAP	KCB
Financial				
with subsidy	5.8	10.2	12.7	8.7
without subsidy	10.9	13.1	13.6	10.8
Economic	10.7	12.8	13.3	10.5

As shown in Table 3.7, the economic values are derived from AIC's early 1993 procurement prices valued CIF Calcutta.

3.9.3 Draught Power

Throughout the Study Area, farmers typically use bullocks for land preparation and transport. Daily hire rates including labour vary considerably from Rs 50 to Rs 80 with an average rate of about Rs 55/day which has been used in both the financial and the economic analyses.

Typical work rates quoted by farmers were 0.1 ha/day for ploughing and 0.27 ha/day for puddling.

TABLE 3.7

Economic Value of Fertiliser (US$ then Rs @ Constant 1993 Prices)

Item	Urea		Compound		KCL		DAP		TSP	
	1993	2005	1993	2005	1993	2005	1993	2005	1993	2005
FOB port of origin (1)		176				116		160	122	136
Insurance/freight		30				50		85	85	85
CIF Calcutta US$	163	206	203	225	160	166	211	245	207	221
Nepal Rs (2)	7 987	10 094	9 947	11 025	7 840	8 134	10 339	12 005	10 143	10 829
Transport to border	370	370	370	370	370	370	370	370	370	370
Handling, letter of credit, etc.	53	53	66	66	52	52	69	69	69	69
Value Nepal border	8 410	10 517	10 383	11 461	8 262	8 556	10 778	12 444	10 582	11 268
Transport to AIC depot										
East	580	580	580	580	580	580	580	580	580	580
Central	842	842	842	842	842	842	842	842	842	842
West/Inner Terai	1 138	1 138	1 138	1 138	1 138	1 138	1 138	1 138	1 138	1 138
Storage	29	29	29	29	29	29	29	29	29	29
Other AIC costs	828	828	940	940	820	820	960	960	960	960
Value ex AIC depot										
East	9 846	11 953	11 931	13 009	9 690	9 984	12 346	14 012	12 150	12 836
Central	10 109	12 216	12 194	13 272	9 953	10 247	12 609	14 275	12 413	13 099
West/Inner Terai	10 404	12 511	12 489	13 567	10 248	10 542	12 904	14 570	12 708	13 394
Losses (0.25%)	25	31	31	33	25	26	32	36	31	33
Dealer commission (3)	355	429	428	466	350	360	443	501	436	460
Local transport (4)	180	180	180	180	180	180	180	180	180	180
Value at farmgate (Rs/kg)										
East	10	13	13	14	10	11	13	15	13	14
Central	11	13	13	14	11	11	13	15	13	14
West/Inner Terai	11	13	13	14	11	11	14	15	13	14

Notes: (1) Urea NW Europe, DAP and TSP US Gulf ports, KCL Vancouver, complex India
(2) Rs 49 = US$ 1.00
(3) 3.5% of final sale price
(4) 10 km x Rs 1.8/100 kg

Source:
Derived from Agricultural Input Corporation cost data including early 1993 CIF Nepal border acquisition prices and World Bank Commodity Price Forecasts, August 1992

3.9.4 Agro-chemicals

Herbicides are rarely, if ever, applied; but pesticide use, particularly on irrigated crops, has been increasing. Applications are typically still low and data for the Study Area on types and quantities applied are few. In the crop budgets, the cost of pesticides nevertheless has been included as values (costs) per hectare. The following are the financial costs applied to all four Study Area strata:

Crop	Cost of pesticides (Rs/ha)		
	Rainfed	Irrigated case	
		Base	Improved
Paddy	-	170	340
Wheat	-	70	140
Maize	-	80	160
Oil seed	-	-	70
Pulse	-	-	70
Potato	100	200	600

For maize, no application of agro-chemicals has been assumed for yields below 1 600 kg/ha. For yields of 1 600 to 2 000 kg/ha, Rs 80/ha has been assumed, for yields over 2 000 kg/ha, Rs 160/ha has been assumed. The economic value is derived using a standard conversion factor (SCF) of 0.9.

3.9.5 Containers

Most farmers use purchased containers only for that proportion of their crops that are marketed. Nevertheless, there are costs involved in home storage, and the crop budgets include an element for this. The cost is based on the use of sacks at Rs 24 each with a useful life of four years, resulting in an annual cost of Rs 6/80 kg sack.

The 80 kg sack will contain the following weight of each commodity:

Crop	Weight/sack
Paddy	80 kg
Wheat	60 kg
Maize	60 kg
Oilseed	70 kg
Pulses	60 kg
Potato	65 kg

The Rs 6/sack cost has been used in the financial budget and adjusted by the SCF to Rs 5.4/sack in the economic budget.

3.10 Financial Crop Prices

Farmgate financial prices for crops in each Study Area stratum have been derived from 1991/92 and 1992/93 wholesale market data published by the Ministry of Agriculture (MOA) Department of Agricultural Development. The basis is the average for the two years which offsets the unusually high prices in 1992/93 that resulted from poor cropping conditions caused by the unusually light and late monsoon rains throughout Nepal.

To determine farmgate prices, a set of factors was used. They were calculated from GDC's 1992/93 farmgate price information and the same year's MOA wholesale prices in the Central stratum of the Study Area. The factors were found to be:

Crop	Factor
Paddy	0.90
Wheat	0.76
Maize	0.86
Oil seed	0.81
Pulses	0.76
Potato	0.58

The two years' wholesale prices and the adopted farmgate prices are given for each stratum in Table 3.8.

TABLE 3.8

Wholesale and Farmgate Crop Prices in the Study Area (Rs/t)

Crop	Study area stratum				Wholesale farmgate factor (x)	GDC farmgate 1992/93 (1)
	West	Central	East	Inner Terai		
Paddy						
91/92	4 720	4 820	4 310	na		
92/93	5 710	6 380	5 740	5 330		5 750
Average	5 215	5 600	5 025	5 330		
Farmgate	4 700	5 047	4 529	4 804	0.90	
Wheat						
91/92	3 810	4 480	4 390	na		
92/93	5 550	6 210	6 330	5 250		4 700
Average	4 680	5 345	5 360	5 250		
Farmgate	3 542	4 045	4 057	3 973	0.76	
Maize						
91/92	3 650	5 100	4 790	na		
92/93	3 950	5 420	5 440	3 810		4 650
Average	3 800	5 260	5 115	3 810		
Farmgate	3 260	4 513	4 388	3 269	0.86	
Oilseeds						
91/92	16 440	17 530	16 770	na		
92/93	13 820	15 620	16 330	15 240		12 650
Average	15 130	16 575	16 550	15 240		
Farmgate	12 253	13 423	13 403	12 342	0.81	
Pulses						
91/92	20 000	19 440	19 680	na		
92/93	18 770	17 410	14 950	12 500		13 250
Average	19 385	18 425	17 315	12 500		
Farmgate	14 753	14 022	13 178	9 513	0.76	
Potato						
91/92	4 130	3 380	3 570			
92/93	5 010	5 310	4 560	na		3 100
Average	4 570	4 345	4 065	0		
Farmgate	2 668	2 537	2 373	0	0.58	

Note: (1) Field data from areas in the Central stratum. See text for derivation of wholesale - farmgate conversion factor.

Source: Agricultural Marketing Bulletin Special Issue 2049 (1991/92) MOA Agricultural Marketing Bulletin Special Issue 2050 (1992/93) MOA Report on Cost of Production for major crops in Nepal 1991/92 MOA GDC 1993 field studies.

3.11 Economic Crop Values

3.11.1 General

The basis for calculating the economic values of the Study Area's major crops is described in Section 3.1.

The following sections and tables set out the derivation of the farmgate values of each crop in each of the four analysis strata. The currency exchange rates, transport costs, economic conversion factors, etc., have all been discussed above. The status of the major crops in the Study Area is described in Volume 2B, Agriculture.

3.11.2 Cereals

In the Study Area, three main cereals have been used in the analyses: rice, wheat and maize. Each of the crops is grown to provide first for the household's annual subsistence needs, after which surpluses are traded but the majority of farmers only sell small quantities. The Terai is a surplus cereal production area despite its fast growing population. However, redistribution to the deficit hill and mountain zones is hard and expensive. Terai surpluses, mainly of rice, are often directed to India. Over the past decade, Nepal's officially recorded figures show that the country is a net exporter of rice and at times of maize and an importer of wheat. However, exports have been erratic and falling.

Nepal has a rapidly growing population which may rise to 23 million by the year 2000 and 27 million by 2010, almost 47% higher than the 1991 preliminary population census figure of 18.5 million. This, coupled with the limited area available for crop expansion throughout the country, including the Terai, means that Nepal can expect to become a net importer of rice as well as other cereals in the foreseeable future unless yields are rapidly increased. The bulk of imports may be reduced since there is scope for considerable increase in cereal yields. However, this is from a rather low level and is highly dependent upon significant improvements in cultural practices as well as expansion in the area irrigated. This is unlikely to be sufficiently rapid to enable the production of consistent surpluses for export. Indeed in recent years, yields of cereals, oil seeds and pulses have either remained static or have declined. The three cereal crops have therefore been valued at their import parity prices.

The calculations to derive the economic farmgate value of cereals are shown in Table 3.9 for paddy, Table 3.10 for wheat and Table 3.11 for maize. The following comments supplement the information in the tables.

TABLE 3.9

Economic Value of Paddy at 1993 Prices (per tonne)

Item		1993	2000
Thai milled white 5% brokens (1) FOB Bangkok US$		217	262
Quality adjustment 70%		152	183
Insurance & freight		35	35
Value CIF Calcutta		187	218
Transport/handling to Nepal border		29	32
Other importing costs and margins 10% (CIF) x SCF 0.9		17	20
Value Nepal border	US$	232	270
	Rs (2)	11 388	13 224
Merchants margins and costs 10% x SCF 0.9		1 025	1 190
Internal transport x SCF 0.72			
Strata	West/Inner Terai	1 138	1 138
	Central	842	842
	East	580	580
Value at wholesale market centre			
Strata	West/Inner Terai	9 226	10 897
	Central	9 521	11 192
	East	9 784	11 455
Milling costs		360	360
Net value at mill			
Strata	West/Inner Terai	8 866	10 537
	Central	9 161	10 832
	East	9 424	11 095
Paddy equivalent 62%			
Strata	West/Inner Terai	5 497	6 533
	Central	5 680	6 716
	East	5 843	6 879
Local trader's margin average 10%		567	671
Transport farm to mill x SCF 0.9		162	162
Farmgate Value			
Strata	West/Inner Terai	4 767	5 700
	Central	4 950	5 883
	East	5 113	6 046

Notes: (1) Derived from World Bank Commodity Price Forecasts 1990-2005 (May 1993)

(2) Rs 49 = US$ 1.00

Source GDC estimates

TABLE 3.10

Economic Value of Wheat at 1993 Prices (per tonne)

Item		1993	2000
Canadian # WRS at Canadian port (1)		105	143
Quality adjustment 70%		74	100
Insurance & freight		85	85
Value CIF Calcutta		159	185
Transport/handling to Nepal border		26	29
Other importing costs and margins 10% (CIF) x SCF 0.9		14	17
Value Nepal border	US$	199	230
	Rs (2)	9 761	11 277
Merchants margins and costs 10% x SCF 0.9		879	1 015
Internal transport x SCF 0.72			
- Strata	West/Inner Terai	1 138	1 138
-	Central	842	842
-	East	580	580
Value at wholesale market centre			
- Strata	West/Inner Terai	7 745	9 125
-	Central	8 040	9 420
-	East	8 303	9 683
Local trader's margin average 10%		803	941
Transport farm to mill x SCF 0.9		162	162
Farmgate Value			
- Strata	West/Inner Terai	6 780	8 022
-	Central	7 075	8 317
-	East	7 338	8 580

Notes: (1) Derived from World Bank Commodity Price Forecasts 1990 - 2005 (May 1993)

(2) Rs 49 = US$ 1.00

Source: GDC estimates

TABLE 3.11

Economic Value of Maize at 1993 Prices (per tonne)

Item		1993	2000
US maize #2 FOB Gulf Ports (1)		89	91
Quality adjustment 80%		71	73
Insurance & freight		85	85
Value CIF Calcutta		156	158
Transport/handling to Nepal border		26	26
Other importing costs and margins 10% (CIF) x SCF 0.9		14	14
Value Nepal border	US$	196	198
	Rs (2)	9 598	9 691
Merchants' margins and costs 10% x SCF 0.9		864	872
Internal transport x SCF 0.72			
Strata	West/Inner Terai	1 138	1 138
	Central	842	842
	East	580	580
Value at wholesale market centre			
Strata	West/Inner Terai	7 597	7 681
	Central	7 892	7 977
	East	8 155	8 239
Local trader's margin average 10%		788	797
Transport farm to mill x SCF 0.9		162	162
Farmgate Value			
Strata	West/Inner Terai	6 647	6 723
	Central	6 942	7 018
	East	7 205	7 281

Notes: (1) Derived from World Bank Commodity Price Forecasts 1990-2005 (May 1993)
(2) Rs 49 = US$ 1.00

Source: GDC estimates

Rice

Rice is the predominant cereal traded in the Study Area. Sales on the main markets occur mainly from August to October, at or shortly after harvest. Lesser quantities may be available until March, reflecting the ability of larger scale farmers and petty traders to store and sell when prices increase. The majority of farmers, however, dispose of surpluses immediately after harvest.

Paddy is typically sold by farmers to petty traders or local storekeepers at the nearest village market. Larger scale merchants bulk up the crop from the initial buyers and move it to the main market centres to sell to wholesale merchants and millers who then sell the crop on the domestic or export market in India. Figure 3.1 illustrates this structure for paddy marketing.

Locally grown, dried and processed rice is of low quality, usually 30% broken. The Food Marketing Corporation (FMC) standard for imports is 15% broken. The World Bank's commodity data are for Thai 5% broken quality with an adjustment factor of 0.7 applied as shown in Table 3.9. The calculation also provides for the cost of transport to the different Study Area strata. Local traders', wholesale merchants' and importing agencies' costs, losses and profit margins are included at 10% at each stage in the marketing channel. Typical financial milling costs are Rs 400/t, which has been adjusted by a 0.9 SCF to give an economic cost of Rs 360/t. A 62% milling% has been assumed.

Wheat

The import parity value of wheat at the farmgate was derived as illustrated in Table 3.10. Wheat and wheat flour are regularly imported, and local production is sold on the domestic market, apart from variable and usually unrecorded quantities exported to India in response to the two countries' border area price differentials.

Maize

Maize, much like rice, is exported, but in small and unpredictable quantities. Recent data on maize trade are very sparse, but it can be predicted that domestic demand will exceed supply and, as with rice, the crop's economic value will be derived in terms of it being an import substitute. Table 3.11 shows the derivation of the maize farmgate values used in the economic analyses.

The forecast for 2005 farmgate values for maize at 1993 constant prices of the three cereals used in the analyses are:

Crop (Rs/kg)	Stratum			
	West	Central	East	Inner Terai
Paddy	5.7	5.9	6.0	5.7
Wheat	8.0	8.3	8.6	8.0
Maize	6.7	7.0	7.3	6.7

3.11.3 Other Crops

As illustrated in Volume 2B, oil seeds, pulses and vegetables are widely grown in the Study Area and have been included in the study analyses.

Vegetables are grown in small quantities (mainly irrigated) and are represented by potatoes in the crop budgets. Oil seeds, mainly mustard; and pulses, mainly lentils and chickpeas; are widely grown but tend to be replaced by wheat and vegetables when irrigation is introduced.

All three types of crop are traded under free market conditions and prices can be expected to be close to their real value reflecting demand and supply on both sides of the Nepal-Indian border. In each case, therefore, their financial prices have been taken as their economic values. The prices adopted are:

Crop (Rs/kg)	Stratum			
	West	Central	East	Inner Terai
Oil seeds	12.3	13.4	13.4	12.3
Pulses	14.8	14.0	13.2	9.5
Potatoes	2.7	2.5	2.4	2.7

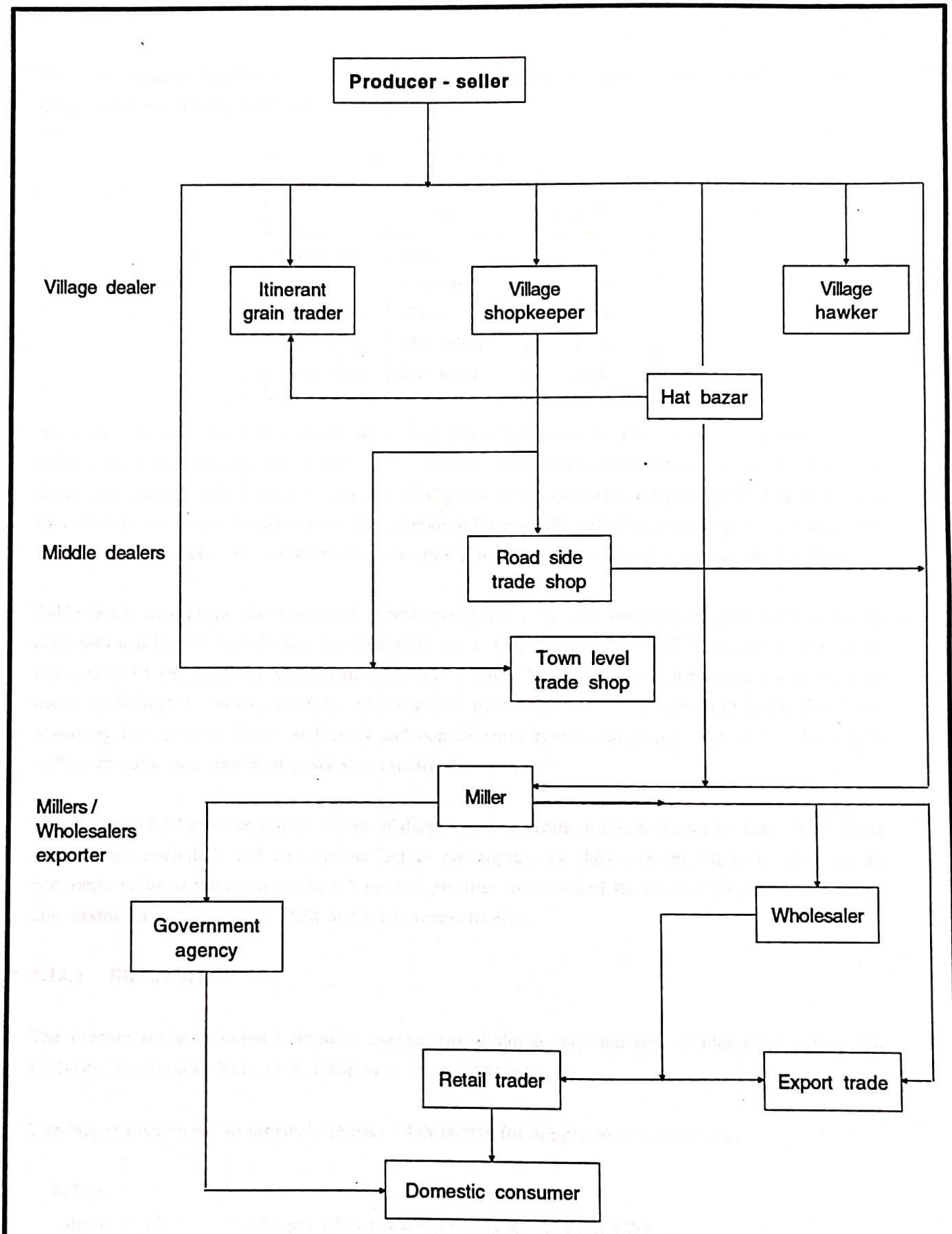
3.12 Energy

3.12.1 Introduction

Two sources of energy for pumping to be considered are diesel and electricity (which is available in some areas). They are compared at long term projected prices, expressed in constant 1993 values that exclude inflation.

Figure 3.1

Marketing Channels for Paddy in the Terai



Source : Factors affecting the Terai paddy market: Pricing policy implications. Manohar Sharma Planning paper series No 3 1986. SICFASN Project.

3.12.2 Diesel

The pump price of diesel varies throughout the Study Area as the figures below from the Nepal Oil Corporation (NOC) for mid-1993 illustrate:

Town	Development region	Retail price (Rs/litre)
Biratnagar	East	11.3
Birganj	Central	11.3
Bhairahwa	West	11.5
Nepalganj	Mid West	11.8
Dhangadhi	Far West	11.9

As to be expected, there is a slight increase in price from east to west reflecting transport costs. Other data from NOC, set out in Table 3.12, indicate that there is an element of cross-subsidisation across the country. The cost build up from NOC given in the table also reflects the cost of delivering fuel from east to west. In the Eastern Development Region, the calculated pump price in early 1993 was Rs 10.9 per litre. From region to region this price rose to Rs 12.5 per litre in the Far West.

Table 3.12 also gives the projected future pump price on the assumption that NOC's border acquisition price changes in the same ratio as the World Bank's May 1993 forecast for petroleum between 1993 and 2005; by a factor of 1.080 (ref Table 3.1). The expected long term price would be about 6.5% higher, varying from Rs 11.6 per litre in the East to Rs 13.3 per litre in the Far West, assuming the level of duties and taxes and commissions remain unaltered, and in the absence of sufficient data, that transport costs also remain the same.

The present and future economic value of diesel in each strata are also shown in Table 3.12. Duty and tax are excluded, and conversion factors are applied as shown in the table to arrive at the economic value at the pump of Rs 9.1 to 10.6 per litre in 1993 and Rs 9.8 to 11.4 per litre in 2005; conversion factors (CFs) are 0.84 and 0.85, respectively.

3.12.3 Electricity

The present study included a detailed assessment of the supply and cost of electrical power. The findings are given in Volume 4, Chapter 6, Power Engineering.

The Nepal Electricity Authority's (NEA) 1993 tariffs for supply to irrigation was:

400 V:
- up to 10 kVA, Rs 10 per kVA per month plus Rs 1.15 per kWh
- over 10 kVA, Rs 15 per kVA per month plus Rs 1.50 per kWh

11 kV Rs 20 per kVA per month plus Rs 1.40 per kWh

TABLE 3.12

Retail Diesel Fuel Prices for 1993 and 2005 (Rs/l)

Item	Conversion factor	Far West	Mid West	West	Central	East
Financial 1993						
Import price		9.651	9.200	9.000	8.869	8.650
Transport		0.663	0.680	0.280	0.138	0.125
Shrinkage 1%		0.097	0.092	0.090	0.089	0.087
Dealers' commission 3%		0.373	0.360	0.341	0.333	0.326
Customs duty		1.155	1.155	1.155	1.155	1.155
Sales tax		0.514	0.514	0.514	0.514	0.514
Total		12.452	12.001	11.380	11.097	10.856
Financial 2005 *						
Import price		10.423	9.936	9.720	9.579	9.342
Transport		0.663	0.680	0.280	0.138	0.125
Shrinkage 1%		0.104	0.099	0.097	0.096	0.093
Dealers' commission 3%		0.397	0.382	0.363	0.354	0.347
Customs duty		1.155	1.155	1.155	1.155	1.155
Sales tax		0.514	0.514	0.514	0.514	0.514
Total		13.256	12.766	12.129	11.835	11.576
Economic 1993						
Import price		9.651	9.200	9.000	8.869	8.650
Transport	0.72	0.477	0.490	0.202	0.099	0.090
Shrinkage 1%		0.097	0.092	0.090	0.089	0.087
Dealers' commission 3'	0.90	0.336	0.324	0.307	0.300	0.293
Total		10.561	10.106	9.599	9.357	9.120
Economic 2005	(1)					
Import price		10.423	9.936	9.720	9.579	9.342
Transport	0.72	0.477	0.490	0.202	0.099	0.090
Shrinkage 1%		0.104	0.099	0.097	0.096	0.093
Dealers' commission 3'	0.90	0.357	0.344	0.327	0.319	0.312
Total		11.362	10.869	10.346	10.092	9.838

Note: * import price adjusted by ratio 2005 to 1993 world market prices from World Bank Commodity Pric Projections for petroleum (Table 3.1) x 1.080

Source: derived from Nepal Oil Corporation data

Only pumps operating less than 50 hours per month will pay enough through the demand charge to cover the cost of supply. While this may be applicable in some STW operations, the tariff contains a subsidy for most DTWs and some STWs.

The NEA has only outline plans for expansion to meet additional demand during the period before their major additional generation capacity Arun III, is installed in 2002 or 2003. In these circumstances, the NEA has not been able to provide any long range marginal cost (LRMC) for electrical power.

From the present until when Arun III is operational in 1992, the Electricity Sub-sector Management Assistance Programme of the World Bank (ESMAP) proposed the installation of 25 MW gas turbine generators as a stop-gap measure. Their figures for the LRMC of energy at the various supply voltages were Rs 3 430/MWh at 33 kV, Rs 4 263/MWh at 11 kV, and Rs 5 880/MWh at 400 V. The Rs 5 880/MWh for 400 V supply includes a substantial allowance for the so-called non-technical losses, (a euphemism for theft), and should be substantially reduced. It is not the fault of the paying customers that the NEA is unable to collect the revenue due on all the electricity delivered.

For economic analysis, the figure of Rs 4 263/MWh, Rs 4.263/kWh, is recommended since all DTWs will be connected directly to a transformer for the exclusive use of the well operation.

3.13 Summary of Financial Prices and Economic Values

Table 3.13 lists the financial prices and corresponding economic values of crops and crop inputs adopted for the study analyses. The present 1993 financial prices and the future 2005 economic values are used in the analyses. The 1993 estimated economic values are included for comparison.

TABLE 3.13

Summary of Crop and Crop Input Financial and Economic Prices by Stratum (Rs)

Item	Unit	Financial 1993				Economic 1993				Economic 2005			
		West	Central	East	Inner Terai	West	Central	East	Inner Terai	West	Central	East	Inner Terai
Crops	kg												
paddy		4.7	5.1	4.5	4.8	4.8	5.0	5.1	4.8	5.7	5.9	6.0	5.7
wheat		3.5	4.0	4.1	4.0	6.8	7.1	7.3	6.8	8.0	8.3	8.6	8.0
maize		3.3	4.5	4.4	3.3	6.6	6.9	7.2	6.6	6.7	7.0	7.3	6.7
oil seed		12.3	13.4	13.4	12.3	12.3	13.4	13.4	12.3	12.3	13.4	13.4	12.3
pulse		14.8	14.0	13.2	9.5	14.8	14.0	13.2	9.5	14.8	14.0	13.2	9.5
potato		2.7	2.5	2.4	2.7	2.7	2.5	2.4	2.7	2.7	2.5	2.4	2.7
Crop inputs													
Fertilisers	kg												
urea		5.8	5.8	5.8	5.8	11.0	10.7	10.4	11.0	13.2	12.9	12.6	13.2
compound		10.2	10.2	10.2	10.2	13.1	12.6	12.8	13.1	14.2	14.0	13.7	14.2
DAP		12.7	12.7	12.7	12.7	13.6	13.3	13.0	13.6	15.3	15.0	14.7	15.3
KCL		8.7	8.7	8.7	8.7	10.8	10.5	10.2	10.8	11.1	10.8	10.5	11.1
manure/compost		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Seeds	ratio to crop price												
paddy		2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
wheat		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
maize		2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
oil seed		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
pulse		1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
potato		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Draught power	day	55	55	55	55	55	55	55	55	55	55	55	55
Labour	day	35	35	35	35	26	26	26	26	26	26	26	26
Energy													
diesel	Rs/l	12.2	11.2	10.9	12.2	10.3	9.5	9.1	10.3	13.0	12.0	11.6	13.0
electricity	Rs/kWh		(1)			0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43

Note: See Section 3.12.3

Source : GDC estimates

CHAPTER 4

CROP BUDGETS

4.1 General

Four sets of crop gross margin budgets have been calculated. They illustrate the expected gross margins relevant to the three analysis cases described in Section 2.3.2. In each instance, the budgets have been prepared for the four Study Area strata to reflect differences found in yields and inputs described in Volume 2B, Agriculture, and the prices discussed in Chapter 3 of this volume. The sets of gross margins represent:

- present rainfed production;
- future rainfed production assuming that over a period of, say 12 to 15 years, HMGN and other support services do improve and enable changes in cultivation practices that raise yields to be adopted by the majority of farmers;
- existing practices and yields where year-round irrigation is available. This is equivalent to the base case referred to in Section 2.3.2. It is the minimum benefit from each crop that can be expected; and
- finally, the projected levels of production using groundwater when growers take up the range of better practices described in Volume 2, including good tubewell and in-field water management.

As implied above, it is clear that the agricultural performance of existing tubewells has not fulfilled expectations. There are two main areas of underachievement:

- the crop area irrigated from the individual STW (which is discussed in the next chapter); and
- the yield of crops grown under irrigation.

4.2 Yields

The provision of water alone will immediately and without any other major inputs raise yields. This is the result of the farmers' ability to prepare land and transplant paddy at the most appropriate time, to harvest paddy and plant the following winter crop on time and to overcome any possible mid-season water deficits.

Yields of cereal crops have been shown to increase to the extent shown in Table 4.1 if given the provision of water but no other substantial outside advice or assistance.

TABLE 4.1

Present Crop Yield Changes with Tubewell Irrigation (t/ha)

Crop (t/ha)	Before TW	After TW	Increase %
Paddy	1.84	2.72	48
Wheat	1.12	1.70	52
Maize	1.19	1.42	19
Pulses	0.46	0.46	-
Oil seeds	0.50	0.56	12
Potato	5.27	10.12	92

Source: GDC 1993.

Paddy and wheat yields have increased about 50% and maize yields have increased almost 20% with the availability of year-round water. Oil seeds and pulses generally do not exhibit the same response to irrigation; although vegetables, including potatoes, will show very substantial increases of up to 100%.

The yield changes in Table 4.1 do not imply that farmers installing tubewells at present do not use more fertiliser or change cultivation practices. Rather, the changes they do institute are limited by their existing knowledge and unchanged circumstances. To realise more fully the potential of irrigation and increase yields further, farmers need to be exposed to new ideas: improved crop varieties, better cultivation methods including in-field water control and appropriate fertiliser applications, improved storage for surpluses, as well as access to recommended physical inputs, credit and markets.

If these conditions are met, yields of paddy and wheat, for example, can be expected to rise further to, say 3.5 to 4 t/ha and 2.5 to 3 t/ha, respectively. However, if this is to happen, additional investment and effort will be needed to make HMGN and other advisory and support services a great deal more accessible and effective. Such changes will take time to arrange, and under normal conditions there will be some delay before this second boost to yields can be expected to begin.

The requirements, both institutional and technical, for achieving such yields, as well as to improve tubewell performance in the respects discussed in Chapter 5, are detailed in Volume 2B, Agriculture.

During the development or project period used for the study analyses, there will be some improvement in rainfed (without project) crop yields. This will result from an expected gradual

improvement in HMGN and other support services and pressures on the farming community as population grows within the limited cultivable area in the Terai.

The yield assumptions adopted for the analyses are summarised in Table 4.2 for both the with and without project cases. Figure 4.1 illustrates diagrammatically the anticipated pattern of yield changes expected for a group of tubewells and farmers within tubewell command area.

The yield figures shown are those in Table 4.2 for paddy in the West stratum. In the figure:

A-B is the immediate increase with irrigation and negligible changes in other conditions (1.70 t/ha to 2.80 t/ha);

B-C is the period immediately following the installation;

B-C2 represents some yield improvement as the irrigator gains experience (2.80 to 2.95 t/ha);

B-C1 shows that without a project development there may be improvements in rainfed (- TW or minus project) crop yields brought about by the existing support services (1.70 to 1.80 t/ha);

C-D once the recommended support services are organised, trained and put into operation (during B-C), further crop yield increases can be expected;

C-D2 from farmers' exposure to new ideas from the support services and easier access to inputs and markets from the service sector (2.95 to 4.00 t/ha); and

C-D1 during the same period, rainfed crop yields may also rise as a result of some general improvement in support services to the rainfed sector (1.80 to 2.15 t/ha).

In Figure 4.1, then, A-C1-D1 illustrates the without project (- TW) and A-C2-D2 the with project (+ TW) changes used in the analyses. The difference between D2 and D1, 1.85 t/ha paddy in the West stratum illustrated, represents the incremental yield benefit over a project period of, say 12 to 15 years. Full yields are given in Table 4.3.

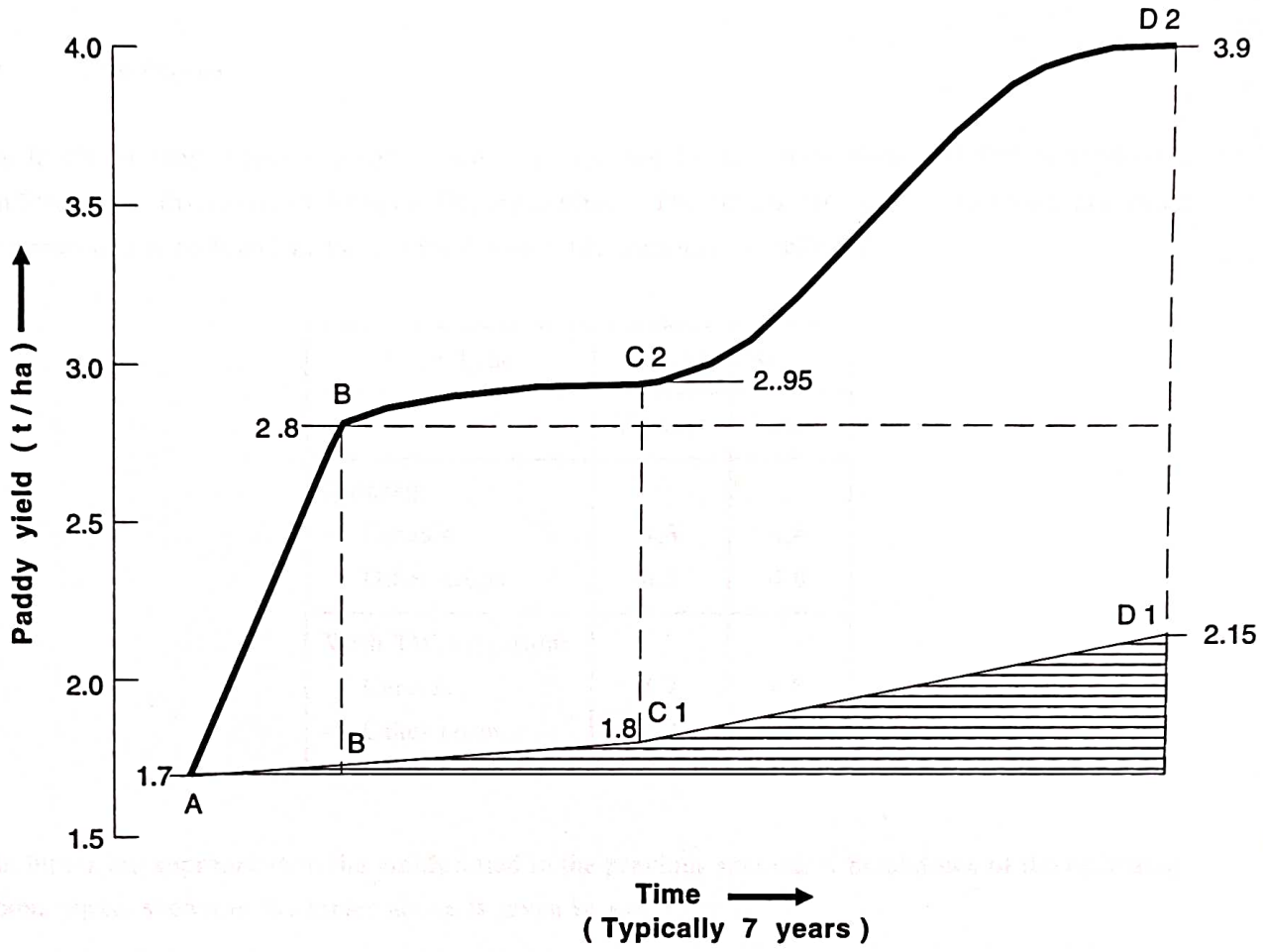
TABLE 4.2

Crop Yield Assumptions by Stratum (t/ha)

Crop	West	Central	East	Inner Terai
Paddy				
- TW present	1.70	1.80	1.80	1.90
future	2.15	2.25	2.25	2.35
+ TW present	2.80	2.80	2.80	2.90
future	4.00	4.00	4.00	4.50
Wheat				
- TW present	1.00	1.20	1.50	0.80
future	1.45	1.65	1.95	1.10
+ TW present	1.60	1.60	2.00	1.60
future	2.80	2.80	3.20	2.80
Maize				
- TW present	1.00	1.40	1.50	1.00
future	1.45	1.85	1.95	1.25
+ TW present	1.60	1.80	2.00	1.10
future	2.80	3.00	3.20	1.50
Oilseeds				
- TW present	0.50	0.50	0.50	0.50
future	0.50	0.50	0.50	0.50
+ TW present	0.57	0.56	0.56	0.57
future	0.70	0.70	0.70	0.70
Pulses				
- TW present	0.46	0.46	0.46	0.46
future	0.46	0.46	0.46	0.46
+ TW present	0.46	0.46	0.46	0.46
future	0.70	0.70	0.70	0.70
Potato				
- TW present	5.00	5.00	5.00	5.00
future	6.00	6.00	6.00	6.00
+ TW present	10.00	10.00	10.00	10.00
future	13.00	13.00	13.00	13.00

Source: GDC estimates (Volume 2B, Agriculture)

Figure 4.1
Diagrammatic Illustration of Yield Benefit Build up with Irrigation



A - B = Increase with water only
B - C = Slight increase as farmers gain experience
C - D = Second phase increase resulting from improved extension advice and availability of required inputs

The improvements from A to C2 can be expected with an intensified development project. This is the period during which institutional improvements required to give better supporting and advisory services are put in place but before they become effective in the field.

Possible increase without irrigation (pre-tubewell yield = 1.70 t/ha)

Note: Indicative paddy yields taken for 'West' Stratum - see Volume 2, Part B, Tables 4.8, 4.9, 4.12 & 4.13.

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There are other factors, of course, which will influence benefits to irrigation, particularly the annual cropping intensity and area irrigated from each well. These are discussed in the chapters on tubewell models.

4.3 Crop Inputs

The levels of crop inputs presently used and expected in the future under rainfed and irrigated conditions are discussed in Volume 2B, Agriculture. The inputs are summarised here and more information can be found in the Tables 4.3 to 4.10, presented as follows:

Crop Type	Table Nr	
	Present	Future
Rainfed:		
- Cereals	4.3	4.4
- Other crops	4.5	4.6
With TW irrigation:		
- Cereals	4.7	4.8
- Other crops	4.9	4.10

The inputs are appropriate to the yields noted in the previous section. A breakdown of the estimated labour inputs shown in the tables above is given in Appendix II.

4.4 Crop Budgets

Tables 4.11 and 4.12 summarise the financial and economic crop gross margin budgets adopted for the analyses.

The financial budgets included only the proportion of labour and the draught bullock work hired; the farmers' family's inputs are not included. The proportions of these two components that are hired are shown in the physical input tables in the previous section. These estimates are from the GDC 1987 field studies. The budgets at economic prices included all labour and bullock draught work.

The full budgets are set out in Appendix III.

TABLE 4.3

Crop Yields and Inputs: Cereals Without Irrigation Present by Stratum

Item	Unit	West			Central			East			Inner Terai		
		Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize
Yield	kg	1 700	1 000	1 000	1 800	1 200	1 400	1 800	1 500	1 500	1 900	800	1 000
Input													
Seed	kg	70	100	25	70	100	25	70	100	25	70	100	25
Fertiliser - urea	kg	20	10	0	50	30	0	20	10	0	20	10	0
Pesticides	Rs	0	0	0	0	0	0	0	0	0	0	0	0
Bullock total of which hired	pair day % pair day	25 45 11	23 20 5	23 5 1	30 35 11	33 10 3	23 15 3	33 24 8	21 14 3	15 15 2	25 45 11	23 20 5	23 5 1
Labour total of which hired	day % day	118 44 52	30 11 3	53 14 7	120 45 54	30 12 4	67 14 9	120 46 55	33 12 4	71 14 10	121 45 54	27 12 3	53 14 7
Containers	Nr	21	17	17	23	20	23	23	25	25	24	13	17

Source: GDC estimates (ref Volume 2B, Agriculture).

TABLE 4.4

Crop Yields and Inputs: Cereals Without Irrigation Future

Item	Unit	West			Central			East			Inner Terai		
		Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize
Yield	kg	2 150	1 450	1 450	2 250	1 650	1 850	2 250	1 950	1 950	2 350	1 100	1 250
Input													
Seed	kg	70	100	25	70	100	25	70	100	25	70	100	25
Fertiliser urea	kg	50	50	30	80	60	50	50	50	50	50	50	30
Pesticides	Rs	0	0	0	0	0	0	0	0	0	0	0	0
Bullocks total	pair day	25	23	23	30	33	23	33	21	15	25	23	23
of which hired	%	45	20	5	35	10	15	24	14	15	45	20	5
	pair day	11	5	1	11	3	3	8	3	2	11	5	1
Labour total	day	135	38	74	137	40	87	138	43	91	138	37	67
of which hired	%	44	11	14	45	12	14	46	12	14	45	12	14
	day	59	4	10	62	5	12	63	5	13	62	4	9
Containers	Nr	27	24	24	28	28	31	28	33	33	29	18	21

Source: GDC estimate (ref Volume 2B, Agriculture).

TABLE 4.5

Crop Yields and Inputs: Other Crops Without Irrigation - Present

Item	Unit	All strata		
		Oil seed	Pulse	Potato
Yield	kg	500	460	5 000
Input				
Seed	kg	15	15	500
Fertiliser				
- urea	kg	0	0	50
- manure/compost	kg	0	0	1 000
Pesticides	Rs	0	0	100
Bullock total	pair day	23	23	40
of which hired	%	0	0	25
	pair day	0	0	10
Labour total	day	16	14	141
of which hired	%	7	9	25
	day	1	1	35
Containers	Nr	7	8	77

Source: GDC estimates (ref Volume 2B, Agriculture)

TABLE 4.6

Crop Yields and Inputs: Other Crops Without Irrigation - Future

Item	Unit	All strata		
		Oil seed	Pulse	Potato
Yield	kg	500	460	6 000
Input				
Seed	kg	15	15	600
Fertiliser				
- urea	kg	0	0	50
- manure/compost	kg	0	0	1 000
Pesticides	Rs	0	0	100
Bullocks total	pair day	23	23	40
of which hired	%	0	0	25
	pair day	0	0	10
Labour total	day	16	14	162
of which hired	%	7	9	25
	day	1	1	41
Containers	Nr	7	8	92

Source: GDC estimates (ref Volume 2B, Agriculture)

TABLE 4.7

Crop Yields and Inputs: Cereals with Irrigation Base Case (1)

Item	Unit	West			Central			East			Inner Terai		
		Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize
Yield	kg	2 800	1 600	1 600	2 800	1 600	1 800	2 800	2 000	2 000	2 900	1 600	1 100
Input													
Seed	kg	70	100	25	70	100	25	70	100	25	70	100	25
Fertiliser													
- urea	kg	100	100	50	100	100	50	100	100	50	100	100	50
Pesticides	Rs	170	70	0	170	70	80	170	70	80	170	70	0
Bullocks total	pair day	33	28	27	37	36	27	23	26	26	33	21	27
of which hired	%	45	20	5	35	10	15	25	15	15	45	20	5
	pair day	15	6	1	13	4	4	6	4	4	15	4	1
Labour total	day	153	48	83	153	48	89	153	51	96	153	48	67
of which hired	%	45	25	25	45	25	25	45	25	25	45	25	25
	day	69	12	21	69	12	22	69	13	24	69	12	17
Containers	Nr	35	27	27	35	27	30	35	33	33	36	27	18

Note: (1) Base Case - Present performance

Source: GDC estimate (ref Volume 2B, Agriculture)

TABLE 4.8

Crop Yields and Inputs: Cereals with Irrigation Improved Performance Case (1)

Item	Unit	West			Central			East			Inner Terai		
		Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize
Yield	kg	3 900	2 800	2 800	4 000	2 800	3 000	4 000	3 200	3 200	4 500	2 800	1 500
Input													
Seed	kg	70	100	25	70	100	25	70	100	25	70	100	25
Fertiliser													
- urea	kg	100	100	75	100	100	75	100	100	75	100	100	50
Pesticides	Rs	340	140	160	340	140	160	340	140	160	340	140	0
Bullock total	pair day	33	28	27	37	36	27	23	26	26	33	21	27
of which hired	%	45	20	5	35	10	15	25	15	15	45	20	5
	pair day	15	6	1	13	4	4	6	4	4	15	4	1
Labour total	day	167	60	120	168	60	126	168	64	132	173	60	81
of which hired	%	45	25	25	45	25	25	45	25	25	45	25	25
	day	75	15	30	76	15	32	76	16	33	78	15	20
Containers	Nr	49	47	47	50	47	50	50	53	53	56	47	25

Note: (1) Improved Performance Case - Future Case

Source: GDC estimates (Ref Volume 2B, Agriculture).

TABLE 4.9

Crop Yields and Inputs: Other Crops with Irrigation Base Case (1)

Item	Unit	All strata		
		Oil seed	Pulse	Potato
Yield	kg	560	460	10 000
Input				
Seed	kg	15	15	900
Fertiliser				
- urea	kg	0	0	100
- manure/compost	kg	0	0	2 000
Pesticides	Rs	0	0	200
Bullock total	pair day	0	0	40
of which hired	%	0	0	25
	pair day	0	0	10
Labour total	day	27	14	188
of which hired	%	25	25	40
	day	7	4	75
Containers	Nr	8	8	154

Note: (1) Base Case - Present performance

Source: GDC estimates (ref Volume 2B, Agriculture)

TABLE 4.10

Crop Yields and Inputs: Other Crops With Irrigation Improved Performance Case

Item	Unit	All strata		
		Oil seed	Pulse	Potato
Yield	kg	700	700	13 000
Input				
Seed	kg	15	15	1 100
Fertiliser				
- urea	kg			
- manure/compost	kg	0	0	3 000
Pesticides	Rs	70	70	600
Bullocks total	pair day	0	0	40
of which hired	%	0	0	25
	pair day	0	0	10
labour total	day	36	33	222
of which hired	%	25	25	40
	day	9	8	89
Containers	Nr	10	12	200

Note: (1) Improved Performance Case - Future case.

Source: GDC estimates (ref Volume 2B, Agriculture)

TABLE 4.11

Summary of Crop Gross Margins 1993 Financial Prices by Stratum (Rs/ha)

Crop	West	Central	East	Inner Terai
Paddy				
- TW present	4 697	5 578	4 883	5 716
future	6 318	7 413	6 403	7 374
+ TW present	8 352	9 518	8 322	8 617
future	13 076	15 171	13 255	16 207
Wheat				
- TW present	2 302	3 475	4 893	1 706
future	3 589	4 992	6 009	2 944
+ TW present	3 415	4 225	5 935	3 984
future	7 359	8 769	10 591	8 345
Maize				
- TW present	2 746	5 478	5 814	2 746
future	3 898	7 036	6 903	3 481
+ TW present	3 893	6 349	6 989	2 706
future	7 143	11 120	11 648	3 587
Oilseeds				
- TW present	5 813	6 338	6 338	5 813
future	5 813	6 338	6 338	5 813
+ TW present	6 343	6 934	6 934	6 343
future	7 908	8 653	8 653	7 908
Pulses				
- TW present	6 452	6 100	5 748	4 118
future	6 452	6 100	5 748	4 118
+ TW present	6 366	6 014	5 661	4 031
future	9 666	9 121	8 577	6 058
Potato				
- TW present	8 195	7 395	6 995	8 195
future	9 931	8 971	8 491	9 931
+ TW present	17 160	15 520	14 700	17 160
future	22 628	20 468	19 388	22 628

Source: GDC.

TABLE 4.12

Summary of Crop Gross Margin Constant 1993 Economic Values by Stratum (Rs/ha)

Crop	West	Central	East	Inner Terai
Paddy				
- TW present	4 030	4 216	4 610	5 079
future	5 727	6 012	6 433	6 775
+ TW present	7 667	8 008	9 073	7 687
future	13 346	14 464	15 649	16 569
Wheat				
- TW present	4 133	5 210	8 906	2 629
future	6 957	8 258	11 121	4 478
+ TW present	6 885	6 895	11 221	7 270
future	16 002	16 372	21 032	15 841
Maize				
- TW present	3 582	6 265	7 724	3 582
future	5 614	8 209	9 098	4 870
+ TW present	5 888	7 520	8 372	3 659
future	12 384	14 455	16 701	5 279
Oilseeds				
- TW present	4 154	4 679	4 679	4 154
future	4 154	4 679	4 679	4 154
+ TW present	5 866	6 457	6 457	5 866
future	7 280	8 026	8 026	7 280
Pulses				
- TW present	4 849	4 497	4 144	2 514
future	4 849	4 497	4 144	2 514
+ TW present	6 114	5 762	5 408	3 779
future	9 087	8 543	7 999	5 481
Potato				
- TW present	3 569	2 784	2 399	3 569
future	5 010	4 065	3 600	5 010
+ TW present	12 321	10 711	9 921	12 321
future	16 988	14 873	13 838	16 988

Source: GDC

CHAPTER 5

SHALLOW TUBEWELL BENEFITS

5.1 STW Models

As outlined in Section 2.3.2 three STW models were examined:

- Base Case (BC) represents the present achievement by farmers with STWs. In this the area served by the model is low and cultural practices do not achieve the reasonable optimum levels that can be expected with reliable year-round irrigation water;

- Improved Performance Case (IPC) illustrating the future potential levels of production when growers have access to new ideas and necessary inputs; and

- High Utilisation Case (HUC) which assumes that 4 ha are irrigated from a STW. This implies that farmers have to group together to jointly own or sell and buy water from a STW in order to give irrigation access to something nearer a well's potential command area. It also assumes that individuals in such a STW users group cooperate closely in respect of water allocation and scheduling. The HUC is applied in the analyses to both the Base and Improved Performance Cases to illustrate the effect of larger command areas at present and in the future.

In addition, the benefits from the equivalent area of land as the tubewell model have been calculated to arrive at the incremental crop benefits for the analyses.

5.2 Tubewell Coverage

Three tubewell surveys carried out since the early 1980s (APROSC 1983; GDC 1987; GDC 1993) illustrate the continuing low utilisation of STWs in terms of area covered. As shown in Table 5.1 all three surveys found command areas of less than 2.5 ha, and only 1.89 ha in the West and Mid West Regions in 1993. Table 5.1 does, however, indicate that there may have been an improvement in annual cropping intensities since the mid to late 1980s. With STWs, these have increased from 156% (1983) to 142% (1987) to a range (1993) between 168% in the inner Terai and 214% (in the East and Central strata) where spring paddy and/or maize were included in the observed cropping patterns. The latest study does therefore indicate some improvement in STW utilisation, but the low areas commanded (i.e., irrigated) from the great majority of wells remains poor.

TABLE 5.1

Shallow Tubewell Performance 1983, 1987 and 1993

Year	Average STW owners holdings (ha)	STW command area (ha)	Annual cropping intensities (%)	
			Before	After
1983	6.6	2.57	139	156
1987	6.9	2.45	127	142
1993				
West		1.89	143	197
Central		2.30	171	204
East		2.26	131	214
Inner Terai		2.54	90	168

Note: Intensities of over 200% indicate spring paddy

Source: APROSC 1983, GDC 1987, GDC 1993.

Base Case

Using the 1993 data in Table 5.1 as a guide, the STW models for the Base Case assume:

Stratum	Command area (ha)	Annual cropping intensity (%)
West	1.9	197
Central	2.3	204
East	2.3	214
Inner Terai	2.5	168

Improved Performance Case

In each stratum, the Improved Performance Case assumes the same command areas with an annual cropping intensity of 200% and, of course, the higher yields and inputs discussed in the previous section.

High Utilisation Case

High Utilisation Case is also based on 200% annual intensity but with a larger, 4 ha command area.

It is apparent from the field studies and observations that the cropping intensities found include a proportion of land that does not receive irrigation in the winter season except when crops are under particular stress. This is common for oil seeds and pulses which typically continue to be grown using residual moisture conditions even when water is available. To simplify the crop models and to enable a direct comparison of with and without tubewell benefits, this factor has been allowed for in the oil seed and pulse crop gross margins shown earlier.

Table 5.2 sets out the annual cropping patterns that arise from these assumptions.

5.3 Incremental Benefits

The estimated incremental benefits are summarised in Table 5.3 at financial farmgate prices and in Table 5.4 at economic values. A detailed breakdown of the benefits with and without groundwater is given in Appendix IV.

5.4 Benefit Development

The analyses of STW under the different cases assume that farmers rapidly reach the Base Case cropping intensities shown in Table 5.2. The increase in cropping is fairly modest and the rate of build up assumed has been 60% for year one and 100 for year two.

More time will be required to achieve the High Utilisation and Improved Performance Cases. In both cases, the achievement will depend largely on the support services becoming a great deal more effective in conveying to farmers the benefits of group tubewell ownership or water buying and selling for the high intensity case and the improved cultural practices outlined in Section 4.2 for the improved performance case. Experience in Nepal has shown that neither of these occur automatically but will require a concerted effort by HMGN and others (refer to Volumes 2B and 2C). Therefore the STW analyses are confined to examining the effect of the wells under each of the conditions individually.

TABLE 5.2

Cropping Patterns and Intensities: With and Without STWs by Stratum

Item	Without STW		With STW			
	Present & future		Present		Future	
	(%)	(ha)	(%)	(ha)	(%)	(ha)
West						
Command area		1.90		1.90		4.00
paddy	66	1.26	85	1.62	100	4.00
wheat	15	0.28	60	1.14	54	2.16
maize	28	0.54	19	0.36	16	0.64
oil seeds	17	0.33	11	0.21	10	0.40
pulses	15	0.29	18	0.35	17	0.68
vegetables	1	0.01	3	0.06	3	0.13
Intensity/total	143	2.71	197	3.74	200	8.01
Central						
Command area		2.30		2.30		4.00
paddy	92	2.12	107	2.45	104	4.18
wheat	32	0.74	36	0.83	35	1.42
maize	19	0.43	21	0.49	21	0.84
oil seeds	13	0.31	21	0.48	20	0.82
pulses	12	0.27	11	0.25	11	0.43
vegetables	3	0.07	8	0.19	8	0.32
Intensity/total	171	3.94	204	4.69	200	8.00
East						
Command area		2.30		2.30		4.00
paddy	96	2.20	98	2.26	100	4.00
wheat	17	0.39	54	1.25	51	2.04
maize	12	0.27	22	0.51	21	0.84
oil seeds	3	0.07	8	0.18	8	0.32
pulses	1	0.02	6	0.14	6	0.24
vegetables	0	0.01	16	0.37	14	0.56
Intensity/total	129	2.96	205	4.71	200	8.00
Inner Terai						
Command area		2.50		2.50		4.00
paddy	42	1.06	98	2.46	100	4.00
wheat	8	0.20	35	0.87	48	1.92
maize	17	0.42	12	0.29	17	0.68
oil seeds	17	0.42	17	0.42	24	0.96
pulses	7	0.18	4	0.11	6	0.24
vegetables	0	0.00	4	0.11	5	0.20
Intensity/total	91	2.28	170	4.26	200	8.00

Source: GDC estimates (Volume 2B, Agriculture).

TABLE 5.3

Summary of Financial STW Incremental Benefits (at 1993 prices)

Stratum		(Rs/TW)	(Rs/ha)
West			
(a)	Present		
	Base	11 498	6 051
	High intensity (HI)	27 221	6 805
(b)	Future		
	Improved performance (IP)	23 586	12 414
	High intensity and improved performance (HI+IP)	53 859	13 465
Central			
(a)	Present		
	Base	16 836	7 320
	High intensity (HI)	27 885	6 971
(b)	Future		
	Improved performance (IP)	33 544	14 584
	High intensity and improved performance (HI +IP)	56 179	14 045
East			
(a)	Present		
	Base	22 421	9 748
	High intensity (HI)	37 251	9 313
(b)	Future		
	Improved performance (IP)	40 130	17 448
	High intensity and improved performance (HI+IP)	67 160	16 790
Inner Terai			
(a)	Present		
	Base	19 708	7 883
	High intensity (HI)	37 268	9 317
(b)	Future	41 596	
	Improved performance (IP)		16 639
	High intensity and improved performance (HI+IP)	75 981	18 995

Source: GDC estimates (Ref Appendix IV).

TABLE 5.4

Summary of Economic STW Incremental Benefits
(at constant 1993 prices)

Stratum		(Rs/TW)	(Rs/ha)
West			
(a)	Present Base High intensity (HI)	15 518 34 232	8 167 8 558
(b)	Future Improved performance (IP) **High intensity and improved performance (HI+IP)**	35 055 75 515	18 450 18 879
Central			
(a)	Present Base High intensity (HI)	17 255 28 766	7 502 7 192
(b)	Future Improved performance (IP) **High intensity and improved performance (HI+IP)**	39 587 66 654	17 212 16 663
East			
(a)	Present Base High intensity (HI)	28 131 46 870	12 231 11 717
(b)	Future Improved performance (IP) **High intensity and improved performance (HI+IP)**	56 392 94 451	24 518 23 613
Inner Terai			
(a)	Present Base High intensity (HI)	20 920 40 819	8 368 10 205
(b)	Future Improved performance (IP) **High intensity and improved performance (HI+IP)**	53 782 99 599	21 513 24 900

Source: GDC estimates (ref Appendix D).

CHAPTER 6

MEDIUM AND DEEP TUBEWELL BENEFITS

6.1 Tubewell Models

A number of medium (MTW) and deep (DTW) tubewell models have been evaluated. The different capacities and command areas of these are:

Item	Capacity (l/s)	Command area (ha)
DTW	90 60	90 60
MTW with distribution system - piped - open channel - open channel	 45 45 30	 45 36 20

One set of cropping patterns that are related to land type has been adopted for MTW and DTW analysis. Table 6.1 sets out the cropping patterns for three types of land.

The Land System 2 (mixed)

This model will be the most common in any DTW programme. At the MTW and DTW command area scale of 30 to 90 ha there will be varying proportions, according to tubewell siting, of medium and upland areas within Land System 2. Table 6.1 shows that the proportions assumed for the study analyses are about 90% medium land and 10% upland, lowland areas would be avoided entirely. As described earlier, in Volume 2, upland areas are not suitable for paddy and have a maize/wheat based cropping pattern in contrast to paddy/wheat on medium land.

Two cropping patterns have been adopted to illustrate returns in Land System 2 (mixed) areas; one for the main Terai and another for the Inner Terai where cropping intensities are lower (refer to Volume 2C, Social Studies, Table 5.2). The patterns with and without tubewells are summarised in Table 6.1.

TABLE 6.1

Cropping Patterns and Intensities: Deep and Medium Tubewells

Crop	Land System 2 (mixed)				Class 2-Upland		Class 2R Lowland	
	w/o TW (%)	w/TW (%)	w/o TW (%)	w/TW (%)	w/o TW (%)	w/TW (%)	w/o TW (%) (1)	w/TW (%)(2)
Paddy	85	90	42	88	0	0	99	146
Wheat	20	65	8	61	0	50	0	0
Maize	20	15	17	17	80	100	0	0
Oil seeds	10	10	17	17	40	15	0	0
Pulses	10	10	7	7	10	10	1	0
Vegetables	1	5	0	5	0	5	0	4
Intensity/total	146	195	91	195	130	180	100	150

Notes: (1) spring paddy 18%
(2) spring paddy 46%

Source: GDC estimates

Main Terai

The without tubewell cropping pattern and annual intensity of 146% was derived from data in Table 5.2 for the four Study Area strata. When a tubewell is installed, the cropping intensity can be expected to rise to 195% and the proportion of paddy, wheat and vegetables will increase. Maize cropping will decrease in the winter, but because it is grown on upland areas its cropping pattern will remain unchanged in the monsoon season. Oil seed and pulse proportions are unlikely to change.

Inner Terai

With irrigation, the cropping intensity can be expected to increase significantly from the low 90%, rainfed levels observed during the present study, to 195% (refer to Table 5.2 and Volume 2B, Agriculture). As shown in Table 6.1, the major increase will be in paddy, wheat and vegetables. The proportion of maize in each season is unlikely to alter.

Two further cropping patterns have been examined for areas which are much less likely to be developed with MTWs and DTWs. Each has been applied to all four Study Area strata.

The Class 2 uplands only model is also given for areas where medium land is scarce.

The Class 2R lowland model is for areas which are poorly drained and suitable only for rice.

The systems are described in Volume 2A, Land Resources.

Table 6.2 gives the crop areas assumed for the MTW and DTW analyses based on the patterns in Table 6.1. Spring paddy is grown only on Class 2R land where drainage is very poor. While the crop is grown without irrigation, in the lower lying parts of such land, the availability of year-round water should enable farmers to increase the area under crop from under 20% to about 45% of the land available.

6.2 Incremental Benefits

The increase in benefits for the three land classes is summarised in Table 6.3.

The incremental benefits are given in terms of annual gross margins, each hectare at 1993 financial prices and forecast economic values (at constant 1993 prices). They apply to all five tubewell capacities. The figures are for the Central Stratum and have been calculated for the comparison of net benefits given later in this volume. The relative differences will be very similar for the other three strata. A full breakdown of the gross margins by crop showing the total gross margins for each tubewell is provided in Appendix V.

The incremental gross margins are calculated as follows:

Present the Base Case and Improved Performance Case, less the gross margin from the equivalent area of present rainfed cropping that they replace; and

Future the Improved Performance Case, less the projected rainfed production levels that were discussed in Chapter 4, Crop Budgets.

6.3 Benefit Development

As with STWs, the build up of benefits has been separately assessed for the Base and the Improved Performance Cases.

TABLE 6.2

Cropping Patterns and Intensities: Deep and Medium Tubewells

Well type	Command area (ha)	Land system 2 (mixed)				Class 2 - Upland		Class 2R - Lowland	
		Main Terai		Inner Terai					
		Without TW (ha)	With TW (ha)	Without TW (ha)	With TW (ha)	Without TW (ha)	With TW (ha)	Without TW (ha)*	With TW (ha)**
DTW 90 l/s* **	90								
paddy		76.5	81.0	37.8	79.2	0.0	0.0	89.1	131.4
wheat		18.0	58.5	7.2	54.9	0.0	45.0	0.0	0.0
maize		18.0	13.5	15.3	15.3	72.0	90.0	0.0	0.0
oil seeds		9.0	9.0	15.3	15.3	36.0	13.5	0.0	0.0
pulses		9.0	9.0	6.3	6.3	9.0	9.0	0.9	0.0
vegetables		0.9	4.5	0.0	4.5	0.0	4.5	0.0	3.6
Intensity/total		131.4	175.5	81.9	175.5	117.0	162.0	90.0	135.0
DTW 60 l/s* **	60								
paddy		51.0	54.0	25.2	52.8	0.0	0.0	59.4	87.6
wheat		12.0	39.0	4.8	36.6	0.0	30.0	0.0	0.0
maize		12.0	9.0	10.2	10.2	48.0	60.0	0.0	0.0
oil seeds		6.0	6.0	10.2	10.2	24.0	9.0	0.0	0.0
pulses		6.0	6.0	4.2	4.2	6.0	6.0	0.6	0.0
vegetables		0.6	3.0	0.0	3.0	0.0	3.0	0.0	2.4
Intensity/total		87.6	117.0	54.6	117.0	78.0	108.0	60.0	90.0
MTW 45 l/s* **	45								
paddy		38.3	40.5	18.9	39.6	0.0	0.0	44.6	65.7
wheat		9.0	29.3	3.6	27.5	0.0	22.5	0.0	0.0
maize		9.0	6.8	7.7	7.7	36.0	45.0	0.0	0.0
oil seeds		4.5	4.5	7.7	7.7	18.0	6.8	0.0	0.0
pulses		4.5	4.5	3.2	3.2	4.5	4.5	0.5	0.0
vegetables		0.5	2.3	0.0	2.3	0.0	2.3	0.0	1.8
Intensity/total		65.7	87.8	41.0	87.8	58.5	81.0	45.0	67.5
MTW 45 l/s** **	36								
paddy		30.6	32.4	15.1	31.7	0.0	0.0	35.6	52.6
wheat		7.2	23.4	2.9	22.0	0.0	18.0	0.0	0.0
maize		7.2	5.4	6.1	6.1	28.8	36.0	0.0	0.0
oil seeds		3.6	3.6	6.1	6.1	14.4	5.4	0.0	0.0
pulses		3.6	3.6	2.5	2.5	3.6	3.6	0.4	0.0
vegetables		0.4	1.8	0.0	1.8	0.0	1.8	0.0	1.4
Intensity/total		52.6	70.2	32.8	70.2	46.8	64.8	36.0	54.0
MTW 30 l/s** **	24								
paddy		20.4	21.6	10.1	21.1	0.0	0.0	23.8	35.0
wheat		4.8	15.6	1.9	14.6	0.0	12.0	0.0	0.0
maize		4.8	3.6	4.1	4.1	19.2	24.0	0.0	0.0
oil seeds		2.4	2.4	4.1	4.1	9.6	3.6	0.0	0.0
pulses		2.4	2.4	1.7	1.7	2.4	2.4	0.2	0.0
vegetables		0.2	1.2	0.0	1.2	0.0	1.2	0.0	1.0
Intensity/total		35.0	46.8	21.8	46.8	31.2	43.2	24.0	36.0

Notes:

* spring paddy 19%; ** spring paddy 46%

*** piped distribution systems (1.00 l/s per ha); **** lined open channel distribution systems (1.25 l/s per ha)

Source: GDC estimates (Volume 2B, Agriculture)

TABLE 6.3

Summary of Medium and Deep Tubewell Incremental Gross Margins
Central Region 1993 Prices (Rs/ha)(1)

Land System Tubewell type	Financial			Economic		
	BC	PIF	FIP	BC	PIF	FIP
Main Terai						
- Class 2 mixed	6 490	15 970	13 780	7 810	21 400	18 870
- Class 2 upland	3 350	11 210	9 960	5 760	18 110	16 550
- Class 2R lowland	8 930	17 390	15 570	7 900	17 490	15 710
Inner Terai						
- Class 2 mixed	8 330	18 580	17 660	9 860	23 780	22 700

Notes: 1 Figures rounded to nearest Rs 10/ha see Appendix V

2 BC = base case; PIF = present improved performance;
FIP = future improved performance.

Source: GDC estimates

Base Case

The need for a large group of farmers to work together in MTWs and DTWs is expected to result in a rather slower build up of benefits compared to the two years (60% and 100%) for STWs (Section 5.4). A four year build up is assumed at the following rate:

Year	1	2	3	4
Percentage of full incremental benefit	40	70	90	100

This takes into account both the increase in yields and cropping intensities, the latter are likely to be more slowly achieved.

Improved Performance Case

It is expected that the installation of the larger tubewells will always attract a greater degree of HMGN assistance than STWs. It is likely, therefore, that the improved performance levels of production will be reached quickly compared to STWs, and more quickly than rainfed cropping can be expected to improve to the future rainfed position described in earlier chapters. For MTWs and DTWs to achieve the incremental benefits shown in Columns 3 and 6 of Table 6.3 could take six years at the rate below:

Year	1	2	3	4	5	6
Percentage of full incremental benefit	15	30	55	80	95	100

The Base Case can be considered to represent performance with rather little outside support, though more than STWs have been getting. The improved performance case assumes that the tubewell groups receive good support from the beginning.

CHAPTER 7

TUBEWELL COSTS

7.1 Introduction

The expected benefits from shallow, medium and deep tubewells given in the two previous chapters are for before the deduction of fixed production overhead costs. The cost of providing irrigation water is the major fixed cost and is presented in this chapter. The background to the technical possibilities for the three tubewell types and the detailed breakdown of capital and recurrent costs for the tubewells are given in Volume 3, Groundwater, and for distribution systems in Volume 4, Engineering. The costs for the tubewell variants considered most appropriate to the range of analyses described in Chapter 2 (Tables 2.3 and 2.4) are summarised in this chapter.

Financial and economic prices are presented using the economic conversion factors for each of the major well cost components for each of the major wells. Cost components are discussed in Chapter 3.

7.2 Shallow Tubewells

7.2.1 Capital Costs

(a) Well and Pumpset

Three types of well were considered: mechanically drilled as provided under the ILC programme, manually drilled as generally supplied with ADBN financing and the smaller capacity hand dug well found in areas with shallow aquifers and suitable soil conditions. In each case, suction mode diesel powered pumpsets are included. The cost of both gravel packed and natural development of the mechanically drilled boreholes were also considered.

The pumpset capacities adopted were 13 l/s for the ILC and ADBN type wells and 10 l/s for hand dug wells.

The costs are broken down in Table 7.1 for machine drilled wells; in Table 7.2 for manually drilled wells and in Table 7.3 for hand dug wells. Each table sets out the main cost components and conversion factors used.

The costs are summarised to more clearly show the foreign exchange (FE) element in Table 7.4.

TABLE 7.1

Capital Costs of Shallow Tubewells, 15 l/s Diesel, Machine Drilled, Suction Mode

Well Type	Local materials	Transport (est)	Imported Materials			Skilled labour	Unskilled labour	Total Cost
			Pumpset diesel	Other	Total			
Gravel pack								
a) Drilling								
Financial Rs	115 825	2 800	0	55 625	55 625	13 325	7 295	194 870
CF	0.90	0.72	0.70	0.80	0.80	1.00	0.75	0.87
Economic Rs	104 243	2 016	0	44 500	44 500	13 325	5 471	169 555
b) pumpset								
Financial Rs	32 800	0	24 000	0	24 000	4 870	5 330	67 000
CF	0.90	0.72	0.70	0.80	0.70	1.00	0.75	0.82
Economic Rs	29 520	0	16 800	0	16 800	4 870	3 998	55 188
Total								
Financial Rs	148 625	2 800	24 000	55 625	79 625	18 195	12 625	261 870
Economic Rs	133 763	2 016	16 800	44 500	61 300	18 195	9 469	224 742
CF								0.86
Natural development								
a) Drilling								
Financial Rs	96 350	2 300	0	57 100	57 100	18 745	6 875	181 370
CF	0.90	0.72	0.70	0.80	0.80	1.00	0.75	0.87
Economic Rs	86 715	1 656	0	45 680	45 680	18 745	5 156	157 952
b) pumpset								
Financial Rs	32 800	0	24 000	0	24 000	4 870	5 330	67 000
CF	0.90	0.72	0.70	0.80	0.70	1.00	0.75	0.82
Economic Rs	29 520	0	16 800	0	16 800	4 870	3 998	55 188
Total								
Financial Rs	129 150	2 300	24 000	57 100	81 100	23 615	12 205	248 370
Economic Rs	116 235	1 656	16 800	45 680	62 480	23 615	9 154	213 140
CF								0.86

Source: Consultants' estimates (Volume 3, Groundwater)

TABLE 7.2

Capital Costs Tubewells, STW 13 l/s Diesel, Manually Drilled, Suction Mode

Item	Local materials	Transport (est)	Imported Materials			Skilled labour	Unskilled labour	Total Cost
			Pumpset	Other	Total			
Drilling								
Financial Rs	420	0	0	11 800	11 800	3 605	1 575	17 400
CF	0.90	0.72	0.70	0.80	0.80	1.00	0.75	0.84
Economic Rs	378	0	0	9 440	9 440	3 605	1 181	14 604
Pumpset (8hp)								
Financial Rs	6 800	0	24 000	1 000	25 000	1 490	910	34 200
CF	0.90	0.72	0.70	0.80	0.70	1.00	0.75	0.76
Economic Rs	6 120	0	16 800	800	17 600	1 490	683	25 893
Total								
Financial Rs	7 220	0	24 000	12 800	36 800	5 095	2 485	51 600
Economic Rs	6 498	0	16 800	10 240	27 040	5 095	1 864	40 497
CF								0.78

Source: GDC estimates

TABLE 7.3

Capital Costs of 10 l/s Diesel, Suction Mode, Hand Dug Wells

Item	Local materials	Transport (est)	Imported Materials			Skilled labour	Unskilled labour	Total Cost
			Pumpset	Other	Total			
Drilling								
Financial Rs	5 100	0	0	0	0	100	10 900	16 100
CF	0.90	0.72	0.70	0.80	0.80	1.00	0.75	0.84
Economic Rs	4 590	0	0	0	0	100	8 175	12 865
Pumpset (5.5 hp)								
Financial Rs	1 600	0	20 000	0	20 000	140	260	22 000
CF	0.90	0.72	0.70	0.80	0.70	1.00	0.75	0.76
Economic Rs	1 440	0	14 000	0	14 000	140	195	15 775
Total								
Financial Rs	6 700	0	20 000	0	20 000	240	11 160	38 100
Economic Rs	6 030	0	14 000	0	14 000	240	8 370	28 640
CF								0.75

Source: GDC estmates

TABLE 7.4

Summary of Shallow Tubewell Costs at 1993 Prices (Rs '000)

TW type	Financial				Economic			
	Foreign exchange	Local costs	Unskilled labour	Total	Foreign exchange	Local costs	Unskilled labour	Total
Diesel/suction mode/ manually installed								
- hand drilled	36.80	12.32	2.48	51.60	27.04	11.59	1.86	40.49
- hand dug (10 l/s)	20.00	6.94	11.16	38.10	14.00	6.27	8.37	28.64
Electric/suction mode*				141.60				114.33
Diesel/suction mode/ machine drilled development								
- natural	81.10	155.07	12.20	248.37	62.48	141.51	9.15	213.14
- gravel pack	79.63	169.62	12.63	261.87	61.30	153.97	9.47	224.74

Notes: * including electrical connection costs of Rs 76 000 (Rs 63 080 economic) assuming one 11 kV/400 V transformer shared between 4 STWs.

Source: GDC estimates (Appendix F and Volume 3, Groundwater)

The total costs and FE proportion are:

Pricing	Machine drilled		Manually drilled natural development	Hand dug
	Gravel pack	Natural development		
Financial (Rs'000)	261.87	248.37	51.60	38.10
FE (%)	33	36	71	53
Economic (Rs'000	224.74	213.14	40.50	28.64
FE (%)	30	32	68	49

The costs include borehole, pumpset and pumphouse of the standard commonly found with the type of tubewell costed. Details of these are given in Volume 4 and the costs are shown in Tables 7.1 to 7.3.

While innumerable variations of STW could be compared, only two comparisons have been made: between the three methods of drilling and between gravel packed and naturally developed machine drilled STWs.

Drilling Methods

The capital and discounted costs of the different STW drilling methods are summarised below:

Item	Initial cost (Rs '000)		NPV at 12% - 20 years (Rs '000)	
	Financial	Economic	Financial	Economic
Hand dug drilled	38.10	28.64	50.50	38.19
Natural development				
- Manual	51.60	40.50	65.84	51.51
- Machine	248.37	213.14	258.44	220.66
Gravel pack machine	261.87	224.74	272.32	232.58

The calculations use the following assumptions:

Item	Life period (years)
Pump	10
Motor	8
Well	
- hand dug	8
- manually drilled	10
- machine drilled	15
Pumphouse	20

Annual maintenance costs have also been included for hand dug wells at 5% of the well cost. No similar cost would be incurred for the bore holes. The residual values of the pumps, motors and wells are also allowed for in year 20 based on the proportion of expected component life remaining at that time.

The costs are compared for each unit area of land irrigated in Table 7.5.

TABLE 7.5

Comparison of Diesel Driven Shallow Tubewell Costs (Rs '000/ha)

Drilling method	Capital cost		NPV (12%-20 years)	
	Financial	Economic	Financial	Economic
Hand dug	12.7	9.6	16.8	12.7
Drilled				
Manually drilled	12.9	10.1	16.5	12.9
Machine drilled				
- natural development	62.1	53.3	64.6	55.2
- gravel pack	65.5	56.2	68.1	58.1

Source: GDC estimates

Both the ILC (machine) and ADBN (manual) type STWs have the same capacity and with reasonable management could serve 4 ha. The smaller hand dug wells can be expected to irrigate 3 ha and the smaller command area served by hand dug wells and their shorter life reduces their apparent slight cost advantage over the ADBN type naturally developed, manually drilled wells. Over 20 years there is a negligible difference in cost between the hand dug and manually drilled STWs.

The ADBN type STW is substantially cheaper for each hectare command area over a 20 year period than machine drilled wells:

Type of development	Manual natural (ADBN)	Machine (natural development)	Machine (gravel pack) (ILC)	Hand dug
Financial (%)	100	392	412	102
Economic (%)	100	428	450	99

(NPV 12% and 20 years comparison)

Clearly where circumstances permit, the manually drilled, naturally developed STW should be favoured.

Method of Borehole Development

The figures given indicate that there is a slight (5 to 6%) cost advantage when boreholes are naturally developed (Table 7.1) rather than gravel packed.

(b) Distribution Systems

Open channel distribution systems are appropriate to STWs. Table 7.6 summarises the costs of lined and unlined earth systems described in Volume 4, Engineering. The ILC programme uses the more expensive lined system while ADBN and privately funded STWs typically have earth channels, which exhibit greater water losses on most soil types.

It has been assumed for the unlined channels that the STW owner's family or group carry out the construction. Therefore, no cost was included in the financial analyses. In the economic analysis, the opportunity cost of labour need for construction has been used and the CF of 0.75 (refer to Section 3.8.2) for unskilled labour has been applied to the financial seasonal wage rates applied to local construction costs (Volume 4). No structures are included in typical unlined distribution systems.

TABLE 7.6

Capital Cost of Shallow Tubewell Open Channel Systems (Rs/ha)

System type	Local materials	Imported materials	Skilled labour	Unskilled labour (1)	Total Cost
Lined channels					
Cost factor	0.48	0.32	0.07	0.13	1.00
Financial	9 826	6 550	1 433	2 661	20 470
CF	0.90	0.80	1.00	0.75	0.86
Economic	8 843	5 240	1 433	1 996	17 512
Structures					
Cost factor	0.17	0.59	0.11	0.13	1.00
Financial	2 485	8 626	1 608	1 901	14 620
CF	0.90	0.80	1.00	0.75	0.83
Economic	2 237	6 901	1 608	1 425	12 171
Total					
Financial	12 311	15 176	3041	4 561	35 090
CF	0.90	0.80	1.00	0.75	0.85
Economic	11 080	12 141	3 041	3 421	29 683
Unlined Channels (2)					
Cost factor	0.00	0.00	0.00	1.00	1.00
Financial	0	0	0	3 355	3 355
CF	0.90	0.80	1.00	0.75	0.75
Economic	0	0	0	2 516	2 516

Notes: (1) Costs in this table are given at the prevailing seasonal wage; see text for cost of unskilled labour used in the financial analyses.

(2) no permanent structures built on ADBN type STWs.

Source: GDC estimates

Single brick width lined channels with the appropriate structures described in Volume 4 are expected to be constructed using 50% hired labour, the cost of which has been included in the financial analyses, and 50% farmer's family labour which has been excluded though included in the economic analysis at its shadow price.

The figures used in the analyses, after making these adjustments to those in Table 7.6 are:

	Unlined (Rs/ha)	Lined (Rs/ha)
Financial	-	32 810
Economic	2 520	29 680

7.2.2 Recurrent Costs

(a) Pumping

The cost of diesel and electric STW pumping has been discussed in Volume 3, Groundwater. The prices of diesel fuel and electrical energy were presented in Section 3.12 of this volume. Diesel cost varies across the Study Area and the differences are taken into account in the annual operating costs presented in Table 7.7. The table sets out the annual energy costs for one hectare assuming the pumping hours necessary with lined and unlined open channels, for the main and inner Terai conditions, and on the basis of the base crop cropping patterns described in Section 5.2. The total pumpset operating costs shown in Table 7.7 include an element of minor repairs and regular maintenance at 10% of the initial pump capital cost a year spread over the actual irrigated area.

The hours pumped will vary not only between the main and Inner Terai but also as crop performance and well utilisation improves. Tables 7.8 and 7.9 show the extent of the variations for each Study Area stratum for the improved performance and high utilisation cases (Section 5.2), respectively. The differences between the three cropping cases are illustrated in Table 7.10 for the Central (main Terai) and Inner Terai strata.

Dug well pumping hours have been increased by 50% over the STW levels for unlined channels to compensate for the reduction to 10 l/s and associated drop in system efficiency.

TABLE 7.7

Pumping Costs STW and Hand Dug Wells, Base Case Cropping

Item	Stratum	Diesel (Rs/l)	Consumption (l/kWh)	Cost (Rs/kWh)	Energy use (kW/h)	Annual pumping (h/ha)	Energy cost (Rs/ha/yr)	Other costs * (Rs/ha/yr)	Total costs (Rs/ha/yr)
Financial:									
Lined System	West	12.2	0.31	3.78	6	112	2 542	600	3 142
	Central	11.2	0.31	3.47	6	112	2 333	600	2 933
	East	10.9	0.31	3.38	6	112	2 271	600	2 871
	Inner Terai	12.2	0.31	3.78	6	75	1 702	600	2 302
Unlined System	West	12.2	0.31	3.78	6	147	3 336	1 263	4 599
	Central	11.2	0.31	3.47	6	147	3 062	1 043	4 105
	East	10.9	0.31	3.38	6	147	2 980	1 043	4 023
	Inner Terai	12.2	0.31	3.78	6	100	2 269	960	3 229
Hand Dug	West	12.2	0.31	3.78	4	220	3 328	1 000	4 328
	Central	11.2	0.31	3.47	4	220	3 056	1 000	4 056
	East	10.9	0.31	3.38	4	220	2 974	1 000	3 974
	Inner Terai	12.2	0.31	3.78	4	150	2 270	1 000	3 270
Economic:									
Lined System	West	13	0.31	4.03	6	112	2 708	420	3 128
	Central	12.0	0.31	3.72	6	112	2 500	420	2 920
	East	11.6	0.31	3.60	6	112	2 417	420	2 837
	Inner Terai	13.0	0.31	4.03	6	75	1 814	420	2 234
Unlined System	West	13	0.31	4.03	6	147	3 554	884	4 438
	Central	12.0	0.31	3.72	6	147	3 281	730	4 011
	East	11.6	0.31	3.60	6	147	3 172	730	3 902
	Inner Terai	13.0	0.31	4.03	6	100	2 418	672	3 090
Hand Dug	West	13	0.31	4.03	4	220	3 547	700	4 247
	Central	12.0	0.31	3.72	4	220	3 273	700	3 973
	East	11.6	0.31	3.60	4	220	3 164	700	3 864
	Inner Terai	13.0	0.31	4.03	4	150	2 418	700	3 118

Note: * at 10% of pump capital cost over irrigated area

Source: GDC estimates

TABLE 7.8

Pumping Costs for STWs and Hand Dug Wells, Improved Performance Case Cropping

Well type	Stratum	Diesel (Rs/l)	Consumption (l/kWh)	Cost (Rs/kWh)	Energy use (kW/h)	Annual pumping (h/ha)	Energy cost (Rs/ha/yr)	Other costs * (Rs/ha/yr)	Total costs (Rs/ha/yr)
Financial:									
Lined system STW	West	12.2	0.31	3.78	6	132	2 995	600	3 595
	Central	11.2	0.31	3.47	6	132	2 750	600	3 350
	East	10.9	0.31	3.38	6	132	2 676	600	3 276
	Inner Terai	12.2	0.31	3.78	6	90	2 042	960	3 002
Unlined system STW	West	12.2	0.31	3.78	6	154	3 495	1 263	4 758
	Central	11.2	0.31	3.47	6	154	3 208	1 043	4 251
	East	10.9	0.31	3.38	6	154	3 122	1 043	4 165
	Inner Terai	12.2	0.31	3.78	6	100	2 269	960	3 229
Hand dug	West	12.2	0.31	3.78	4	230	3 480	1 000	4 480
	Central	11.2	0.31	3.47	4	230	3 195	1 000	4 195
	East	10.9	0.31	3.38	4	230	3 108	1 000	4 108
	Inner Terai	12.2	0.31	3.78	4	150	2 260	1 000	3 260
Economic:									
Lined system STW	West	13	0.31	4.03	6	132	3 192	420	3 612
	Central	12.0	0.31	3.72	6	132	2 946	420	3 366
	East	11.6	0.31	3.60	6	132	2 848	420	3 268
	Inner Terai	13.0	0.31	4.03	6	90	2 176	420	2 596
Unlined system STW	West	13	0.31	4.03	6	154	3 724	884	4 608
	Central	12.0	0.31	3.72	6	154	3 437	730	4 167
	East	11.6	0.31	3.60	6	154	3 323	730	4 053
	Inner Terai	13.0	0.31	4.03	6	100	2 418	672	3 090
Hand dug	West	13	0.31	4.03	4	230	3 707	700	4 407
	Central	12.0	0.31	3.72	4	230	3 423	700	4 123
	East	11.6	0.31	3.60	4	230	3 308	700	4 008
	Inner Terai	13.0	0.31	4.03	4	150	2 408	700	3 108

Note: * at 10% of pumpset capital cost over irrigated area

Source: GDC estimates

TABLE 7.9

Pumping Costs for STWs and Hand Dug Wells, High Utilisation Cropping

Well type	Stratum	Diesel (Rs/l)	Consumption (l/kWh)	Cost (Rs/kWh)	Energy use (kW/h)	Annual pumping (h/ha)	Energy cost (Rs/ha/yr)	Other costs * (Rs/ha/yr)	Total costs (Rs/ha/yr)
Financial:									
Lined system STW	West	12.2	0.31	3.78	6	138	3131	343	3474
	Central	11.2	0.31	3.47	6	138	2875	343	3218
	East	10.9	0.31	3.38	6	138	2798	343	3141
	Inner Terai	12.2	0.31	3.78	6	101	2292	343	2635
Unlined system STW	West	12.2	0.31	3.78	6	147	3336	600	3936
	Central	11.2	0.31	3.47	6	147	3062	600	3662
	East	10.9	0.31	3.38	6	147	2980	600	3580
	Inner Terai	12.2	0.31	3.78	6	100	2269	600	2869
Hand dug	West	12.2	0.31	3.78	4	220	3328	667	3995
	Central	11.2	0.31	3.47	4	220	3056	667	3723
	East	10.9	0.31	3.38	4	220	2974	667	3641
	Inner Terai	12.2	0.31	3.78	4	150	2270	667	2937
Economic:									
Lined system STW	West	13	0.31	4.03	6	138	3337	240	3577
	Central	12.0	0.31	3.72	6	138	3080	240	3320
	East	11.6	0.31	3.60	6	138	2977	240	3217
	Inner Terai	13.0	0.31	4.03	6	101	2442	240	2682
Unlined system STW	West	13	0.31	4.03	6	147	3554	420	3974
	Central	12.0	0.31	3.72	6	147	3281	420	3701
	East	11.6	0.31	3.60	6	147	3172	420	3592
	Inner Terai	13.0	0.31	4.03	6	100	2418	420	2838
Hand dug	West	13	0.31	4.03	4	220	3547	467	4014
	Central	12.0	0.31	3.72	4	220	3273	467	3740
	East	11.6	0.31	3.60	4	220	3164	467	3631
	Inner Terai	13.0	0.31	4.03	4	150	2418	467	2885

Note: * at 10% of pumpset capital cost over irrigated area (7.0 ha for lined systems, 4.0 ha for unlined channels; 3.0 ha for hand dug wells)

Source: GDC estimates

TABLE 7.10

Comparision of STW and Hand Dug Well Pumping Costs in the Central and Inner Terai (Rs/ha per year)

Stratum	STW lined system cropping case			STW unlined system cropping case			Hand dug well cropping case		
	Base	Improved	High utilisation	Base	Improved	High utlisation	Base	Improved	High utilisation
Financial									
Central	2 930	3 350	3 220	4 110	4 250	3 660	4 060	4 200	3 720
Inner Terai	2 300	3 000	2 630	3 220	3 230	2 870	3 270	3 260	2 940
Economic									
Cenral	2 920	3 370	3 320	4 010	4 170	3 700	3 970	4 120	3 740
Inner Terai	2 230	2 600	2 680	3 090	3 090	2 840	3 120	3 110	2 890

Source: GDC estimates

(b) Distribution Systems

Unlined earth channels can be maintained by unskilled family labour and therefore, no cost is shown in the financial analyses. In the economic analyses, it is expected that one-fifth of the system will require repairs and maintenance. This amounts to approximately 60 m/ha, equivalent to three days work at 10 m a day. At the shadow wage rate of Rs 26/day, the annual cost included is Rs 80/ha (Rs 78 rounded).

Lined systems require some financial expense even though repairs are likely to be carried out by family or group members since materials are needed for structures and channel linings. Maintenance costs, therefore, have been estimated at 3% of capital costs excluding unskilled labour each year, equivalent to Rs 915/ha (refer to Table 7.6). Based on the economic costs given in Table 7.6, the annual amount allowed at economic values is Rs 788/ha each year.

(c) Other Recurrent Costs

Land tax is included at Rs 118/ha year. This represents payment for Abbal land which is irrigable the year round (Section 3.5).

Miscellaneous costs to cover farm tools, crop processing and storage, and other minor fixed overheads are allowed for at the rate of 5% of the variable costs of crop production derived from the base case cropping pattern in the Central Stratum. As shown below, this is almost Rs 175/ha a year.

Crop	Financial cost			Annual fixed costs (Rs/ha)
	Average all strata		Proportion factor	
	Total (Rs/ha)	5% (Rs/ha)		
Rice	4 670	234	0.53	124
Wheat	2 110	106	0.17	18
Maize	1 470	74	0.10	7
Oil seed	560	28	0.10	3
Pulse	410	21	0.05	1
Potato	9 620	481	0.04	19
Total			1.00	172

These costs are financial. The economic cost has been derived using the SFC of 0.9, Rs 158/ha.

7.3 Medium and Deep Tubewells

7.3.1 Introduction

Detailed specifications and costings for medium and deep tubewells with capacities ranging from 15 h/s to 90 h/s are given in Volume 3, Groundwater. Their capital and recurrent costs at 1993 financial and economic prices are summarised in the next two sections. Section 7.3.4 presents the results of face-level cost comparisons in terms of the unit cost of water at the wellhead. The comparisons are:

(1) diesel versus electric pumping;
(2) gravel pack versus natural borehole development;
(3) siting in D1, D2, or D3 aquifers.

The three comparisons are summarised as shown in Table 7.11.

TABLE 7.11

Medium and Deep Tubewell Least Cost Comparisons

Comparison	Pumpset power	Type of well completion	Aquifer class	Pumpset mode	Tubewell capacity				
					90 l/s	60 l/s	45 l/s	30 l/s	15 l/s
Diesel v electric	diesel electric	gravel pack	D2	force	* *	* *	* *	* *	* *
Well completion	diesel	gravel pack natural dev	D2	force	* *	* *	* *	* *	* *
Aquifer class	diesel	gravel pack	D1 D2 D3	force	* * *	* * *	* * *	* * *	 * *

The tubewell sizes and basic specifications and aquifer classes for which each comparison is made are set out in the tables.

Section 7.3.5 provides the cost of, and comparison of two types of water distribution systems suitable for MTWs and DTWs: lined open channels and piped systems.

The main financial and economic analyses combining costs and benefits are provided in Chapter 9.

7.3.2 Capital Costs

Table 7.12 summarises the financial and economic capital costs for MTW and DTW boreholes, force mode pumpsets and pumphouses for wells of the capacity 90, 60, 45, 30 and 15 l/s in D2 aquifers. In each case the cost of diesel and electric versions and for gravel packed and naturally developed boreholes are shown. Electrically powered tubewell costs include provision for equipment, and power lines from 11 kV transmission lines as described in Volume 4, Engineering.

The cost of installing the different capacity diesel powered, gravel packed force mode MTWs and DTWs in D1, D2, and D3 class aquifers is summarised in Table 7.13.

Well costs are based on current construction practices and do not reflect the economies in construction of lower capacity wells thought to be attainable by using cheaper materials.

Miscellaneous costs of 10% representing engineering costs have been added to both Tables 7.12 and 7.13.

TABLE 7.12

Capital Costs of Medium/Deep Tubewells; Aquifer D2, Diesel and Electric - Gravel Pack and Natural Development Completion (Rs'000 @ 1993 Financial and Economic Prices)

Item	Gravel pack completion				Natural development completion			
Energy Source	Diesel		Electric		Diesel		Electric	
	Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic
Deep TW 90 l/s								
Well	1 029	892	1 029	892	790	680	790	680
Pumpset**	471	356	286	236	471	356	286	236
Connection	0	0	1 465	1 216	0	0	1 465	1 216
Miscellaneous	150	125	278	234	126	104	254	213
Total	1 650	1 373	3 059	2 579	1 387	1 139	2 795	2 345
Irrig area ha	72							
Rs/ha	22 923	19 067	42 482	35 817	19 264	15 818	38 823	32 568
Deep TW 60 l/s								
Well	663	576	663	576	567	491	567	491
Pumpset**	379	291	242	201	379	291	242	201
Connection	0	0	965 *	801	0	0	965	801
Miscellaneous	104	87	187	158	95	78	177	149
Total	1 146	954	2 057	1 736	1 041	861	1 952	1 642
Irrig area ha	48							
Rs/ha	23 883	19 882	42 862	36 165	21 683	17 932	40 662	34 215
Medium TW 45 l/s								
Well	547	476	547	476	435	376	435	376
Pumpset**	338	262	217	181	338	262	217	181
Connection	0	0	737	612	0	0	737	612
Miscellaneous	88	74	150	127	77	64	139	117
Total	973	813	1 651	1 396	850	703	1 528	1 286
Irrig area ha	36							
Rs/ha	27 036	22 575	45 873	38 775	23 598	19 520	42 436	35 720
Medium TW 30 l/s								
Well	392	345	392	345	319	280	319	280
Pumpset**	262	205	178	148	262	205	178	148
Connection	0	0	150	125	0	0	150	125
Miscellaneous	65	55	72	62	58	48	65	55
Total	720	605	793	680	639	533	712	608
Irrig area ha	24							
Rs/ha	30 003	25 192	33 028	28 321	26 634	22 196	29 659	25 325
Medium TW 15 l/s								
Well	225	198	225	198	186	163	186	163
Pumpset**	180	141	119	99	180	141	119	99
Connection	0	0	145	120	0	0	145	120
Miscellaneous	41	34	49	42	37	30	45	38
Total	446	373	538	459	403	335	496	421
Irrig area ha	12							
Rs/ha	37 160	31 068	44 869	38 256	33 585	27 882	41 294	35 069

Notes:

* with lined channel distribution systems @ 1.25 l/s per hectare

** including pump house and installation
BUT excluding the costs of discharge box and distribution systems

Source: Consultants' estimates Volume 3, Groundwater

TABLE 7.13

Capital Costs: Medium and Deep Tubewells, Diesel,Gravel Pack: Aquifers D1, D2 and D3 at Financial and Economic Prices (1993 prices) (Rs'000)

Well type	Aquifer D1		Aquifer D2		Aquifer D3	
	Financial	Economic	Financial	Economic	Financial	Economic
Deep TW 90 l/s						
- well	879	762	1 029	892	1 390	1 205
- pumpset**	443	356	471	356	543	406
- miscellaneous (10%)	132	112	150	125	193	161
Total	1 454	1 229	1 650	1 373	2 126	1 771
Irrig area (ha)*	72					
Unit area cost (Rs/ha)	20 191	17 075	22 923	19 067	29 524	24 601
Deep TW 60 l/s						
- well	589	512	678	576	Not	Not
- pumpset**	361	279	379	291	calculated	calculated
- miscellaneous (10%)	95	79	106	87		
Total	1 045	870	1 163	954		
Irrig area (ha)*	48					
Unit area cost (Rs/ha)	21 776	18 129	24 222	19 882		
Medium TW 45 l/s						
- well	469	409	547	476	Not	Not
- pumpset**	323	252	338	262	calculated	calculated
- miscellaneous (10%)	79	66	88	74		
Total	872	728	973	813		
Irrig area (ha)*	36					
Unit area cost (Rs/ha)	24 222	20 217	27 036	22 575		
Medium TW 30 l/s						
- well	363	320	392	345	Not	Not
- pumpset**	252	198	262	205	calculated	calculated
- miscellaneous (10%)	62	52	65	55		
Total	677	569	720	605		
Irrig area (ha)*	24					
Unit area cost (Rs/ha)	28 206	23 723	30 003	25 192		
Medium TW 15 l/s						
- well	206	181	225	198	Not	Not
- pumpset**	178	140	181	142	calculated	calculated
- miscellaneous (10%)	38	32	41	34		
Total	423	353	447	374		
Irrig area (ha)*	12					
Unit area cost (Rs/ha)	35 228	29 445	37 242	31 160		

Notes:
* with lined channel distribution systems at 1.25 l/s per hectare
** including pump house and installation
BUT excluding the costs of discharge box and distribution systems

Source: GDC estimates

7.3.3 Pumping Costs

Tables 7.14 and 7.15 set out the hourly diesel and electric pumping costs. These were derived from the energy prices discussed in Section 3.12 and consumption rates given in Volume 3, Groundwater, for the different tubewell sizes. Regular repair and maintenance costs have been included at 10% of original capital cost on an hourly basis. the annual operating hours shown in Table 7.14 are based on usage in the main Terai with land open channel distribution systems and providing for the Improved Performance cropping pattern presented in Chapter 6.

7.3.4 Tubewell Comparisons

The three comparisons summarised in Table 7.11 have a numbers of assumptions in common. These include the following replacement periods (years):

	Diesel				Electric			
	Gravel pack		Natural development		Gravel pack		Natural development	
Borehole	20		20		20		20	
Pump	10	)	10	)	10	)	10	)
		) 8*		) 12*		) 12*		) 12*
Motor	7	)	7	)	15	)	15	)
Pumphouse	20		20		0		20	

Note: * aggregate 8 year replacement period

These periods are before replacement or a major refit. The comparisons are each made in terms of water pumped at the wellhead areas discounted over a 20 year period using the pumping costs given in the previous section for each well size and type.

In the year of installation, it has been assumed that the well operates for half the full year's annual hours.

Diesel versus electric power

The cost of water at the wellhead for the five different size MTWs and DTWs is shown in Table 7.16. The costs shown are the NPV (12%) of one cubic metre of water over a 20 year period.

TABLE 7.14

Medium and Deep Tubewell Diesel Pumping Costs; Central Stratum D2 Aquifer

Well type	Diesel Cost (Rs/l)	Diesel Consumption (l/kWh)	Diesel Cost (Rs/kWh)	Energy Use (kW/h)	Energy Cost (Rs/hour)	Other costs* (Rs/hour)	Total costs (Rs/hour)	Annual cost (Rs'000)
Financial								
90 l/s	11.2	0.31	3.47	25.6	88.9	24.6	113.5	153.2
60 l/s	11.2	0.31	3.47	16.1	55.9	17.4	73.3	101.1
45 l/s	11.2	0.31	3.47	12.0	41.7	14.2	55.9	78.0
30 l/s	11.2	0.31	3.47	7.4	25.7	10.8	36.5	50.4
15 l/s	11.2	0.31	3.47	3.2	11.1	7.3	18.4	25.4
Economic								
90 l/s	12.0	0.31	3.72	25.6	95.2	17.2	112.4	151.8
60 l/s	12.0	0.31	3.72	16.1	59.9	12.2	72.1	99.4
45 l/s	12.0	0.31	3.72	12.0	44.6	10.0	54.6	76.2
30 l/s	12.0	0.31	3.72	7.4	27.5	7.6	35.1	48.4
15 l/s	12.0	0.31	3.72	3.2	11.9	5.1	17.0	23.5

Note: * 10% capital cost of pumpset

Source: GDC estimates

TABLE 7.15

Medium and Deep Tubewell Electrical Pumping Costs Central Stratum; D2 Aquifer; Piped System

Well type	Energy use (kW/h)	Annual pumping hours	Annual fixed charge (Rs/kW)	Annual fixed charge Equivalent (Rs/hour)	Unit charge (Rs/kWh)	Hourly cost (Rs/kWh)	Total cost (Rs/hour)	Other costs* (Rs/hour)	Total costs (Rs/hour)	Annual cost (Rs'000)
Financial										
90 l/s	23.4	1 350	240	4.2	1.40	32.8	36.9	15.1	52.0	70.2
60 l/s	14.8	1 380	240	2.6	1.40	20.7	23.3	11.6	34.9	48.1
45 l/s	11.0	1 395	240	1.9	1.40	15.4	17.3	9.7	27.0	37.6
30 l/s	6.8	1 380	150	0.7	1.50	10.2	10.9	8.0	18.9	26.1
15 l/s	3.0	1 380	120	0.3	1.15	3.4	3.7	5.5	9.2	12.7
Economic										
90 l/s	23.4	1 350	0	0.0	4.26	99.8	99.8	12.1	111.8	151.0
60 l/s	14.8	1 380	0	0.0	4.26	63.1	63.1	9.3	72.4	99.9
45 l/s	11.0	1 395	0	0.0	4.26	46.9	46.9	7.7	54.6	76.2
30 l/s	6.8	1 380	0	0.0	4.26	29.0	29.0	6.4	35.4	48.8
15 l/s	3.0	1 380	0	0.0	4.26	12.8	12.8	4.4	17.2	23.7

Note: * 10% capital cost of pumpset

Source: GDC estimates

TABLE 7.16

Comparison of Diesel and Electric DTW/MTW Water Costs (Rs/m^3)

MTW/DTW	Diesel	Electric
Financial		
- 90 l/s	0.318	0.383
- 60 l/s	0.319	0.380
- 45 l/s	0.344	0.401
- 30 l/s	0.369	0.313
- 15 l/s	0.431	0.409
Economic		
- 90 l/s	0.282	0.398
- 60 l/s	0.276	0.392
- 45 l/s	0.302	0.409
- 30 l/s	0.321	0.333
- 15 l/s	0.365	0.405

Note: Gravel packed wells in D2 aquifer with force mode pumps

Source: GDC estimates

At present financial prices, the unit cost of water varies from Rs 0.318 to Rs 0.431/m^3 from the 90 l/s to the small 15 l/s wells and the cost as might be expected falls as well size increases. Electric pumpsets, because of different connection and equipment requirements, do not show the same pattern. At the subsidised NEA rates discussed in Volume 3, Groundwater, the cost of water varies from Rs 0.401/m^3 for 45 l/s MTWs to Rs 0.313/m^3 for the 30 l/s MTW. Costs are higher than diesel by 17 to 20% or more for tubewells of 45 l/s but in contrast, cheaper for the smaller tubewells; 15% less in the case of 30 l/s tubewells and 5% less for the small 15 l/s example.

The analyses using economic values that exclude subsidies show that water is more expensive for all MTW and DTW sizes if delivered using electric pumpsets. This reflects the impact of charging the full well connection cost. The cost advantage to diesel varies as shown in Table 7.16 from 41% for 90 l/s DTWs to only 4% for the 30 l/s model. Generally the cost advantage decreases with well capacity as illustrated in the table.

Borehole Development

Gravel pack and naturally developed boreholes have a similar life and well maintenance costs are minimal in both cases. At both financial prices and economic values, gravel pack boreholes are a lot more costly over a 20 year period. Water costs are 7% (15 l/s and 30 l/s MTW) to 9% (90 l/s DTW) more expensive with gravel pack wells.

As shown in Table 7.17, there is, therefore, a slight but not very significant advantage in the natural development of MTWs and DTWs whatever their capacity.

TABLE 7.17

Comparison of Water Costs from Gravel Pack and Natural Well Development (Rs/m³)

MTW/DTW size	Gravel pack	Natural development
Financial		
- 90 l/s	0.318	0.292
- 60 l/s	0.319	0.302
- 45 l/s	0.344	0.319
- 30 l/s	0.369	0.344
- 15 l/s	0.431	0.404
Economic		
- 90 l/s	0.282	0.258
- 60 l/s	0.276	0.262
- 45 l/s	0.302	0.280
- 30 l/s	0.321	0.299
- 15 l/s	0.365	0.342

Note: Gravel packed wells in D2 aquifer with force mode pumps

Source: GDC estimates

Aquifer Class

The cost of water extraction for the three aquifer classes; D1, D2 and the deepest D3; are given in Table 7.18.

TABLE 7.18

Comparison between DTW/MTW Water Costs from Aquifer Classes D1, D2 and D3 (Rs/m³)

MTW/DTW size	D1	D2	D3
Financial			
- 90 l/s	0.289	0.318	**0.368**
- 60 l/s	0.303	0.319	
- 45 l/s	0.323	0.344	
- 30 l/s	0.355	0.369	
- 15 l/s	0.414	0.431	
Economic			
- 90 l/s	0.259	0.282	0.324
- 60 l/s	0.263	0.276	
- 45 l/s	0.285	0.302	
- 30 l/s	0.310	0.321	
- 15 l/s	0.351	0.365	

Note: Gravel packed wells with diesel driven pumps

Source: GDC estimates

The main analysis has been based on MTWs and DTWs sunk in D2 aquifers. However as shown in the table, and to be expected the cost of water extracted from more productive D1 aquifers is 4 to 9% lower at financial prices. The difference as shown below is greatest in the case of the largest DTWs:

Difference in cost (financial)	DTW capacity (l/s)				
	90	60	45	30	15
D1	91	95	94	96	96
D2	100	100	100	100	100
D3	116	-	-	-	-

Only the 90 l/s DTW was analysed for the D3 aquifer case and the cost of water rises from Rs 0.318/m³ to Rs 0.368/m³ making it 16% more expensive. In practical terms, we would not recommend siting wells in D3 aquifers; certainly not for the larger capacity wells which would attract heavy pumping cost penalties.

The pattern and size of the cost differences are the same at economic values. The results in Table 7.18 depict the classical view that water costs increase with decreasing pump size. If more innovative (and cost saving) well design is championed, this view might change (with water from cheaper low capacity wells becoming more financially and economically attractive).

7.3.5 Distribution Systems

Three types of distribution system for MTWs and DTWs are discussed in Volume 4, Engineering; unlined and lined open channels, and buried pipes. The unit area costs for lined channels and buried pipes are given in Table 7.19. The piped systems are about 38% less expensive to install than lined channels. They are easy to maintain and provide water "on tap" which makes for easier water management provided that the design is sound and the recipient farmers cooperate with each other. Unlined earth channels are not normally considered in the context of MTWs/DTWs.

TABLE 7.19

Capital Costs of DTW/MTW Distribution Systems (Rs/ha)

System type	Local materials	Imported materials	Skilled labour	Unskilled labour (2)	Total cost
(a) Piped systems (1)					
Cost factor	0.15	0.73	0.06	0.06	1.00
Financial cost	3 330	16 206	1 332	1 332	22 200
CF	0.90	0.80	1.00	0.75	0.82
Economic cost	2 997	12 965	1 332	999	18 293
(b) Lined open channels					
Financial cost	12 311	15 176	3 041	4 561	35 090
CF	0.90	0.80	1.00	0.75	0.85
Economic cost	11 080	12 141	3 041	3 421	29 682

Notes: 1. Average for ring main and radial systems.
2. See Table 7.6

Source: GDC estimates

The costs compare as shown below:

Item	Financial		Economic
	(Rs '000/ha)	(FE %)	(Rs '000/ha)
Lined open channels	35.09	43	29.68
Piped systems	22.20	73	18.29

Piped systems do however have a much higher foreign exchange component; 73% against 43%. Piped systems when reasonably operated also reduce water losses and reduce pumping requirements by about one quarter.

A simple analysis was performed to compare the net present value (NPV) of costs of the distribution systems, annual maintenance (taken as 3% of the capital cost for both piped systems and lined open channels) and the annual pumping costs discounted at 12% per annum over a period of 20 years. When expressed as an annual cost per hectare over the 20 year period the results averaged:

Pricing	NPV (12%) (Rs '000/ha per year)		Ratio of lined/piped
	Lined channels	Buried pipes	
Financial	1.91	1.20	1.59
Economic	1.62	1.00	1.62

The life of both lined channel and piped systems was taken as 20 years. Pumping costs for the piped systems were increased by a nominal 15% to allow for higher delivery head at the pump.

CHAPTER 8

SHALLOW TUBEWELL ANALYSES

8.1 Scope

Two sets of analyses were carried out. The first presented in the following section is to compare machine and manually drilled shallow tubewells and hand dug wells. The second is to examine the differences in financial returns to the farmers and the economic benefits from the most widely used manually drilled, diesel powered STWs in the four different Study Area strata.

8.2 Well Type Comparison

8.2.1 Introduction

The two STWs included in this comparison can be viewed as the ILC and ADBN models. The ILC model is machine drilled, gravel packed and with a lined water distribution system. It typically serves 4 ha, though with good water management and larger group ownership, this could practically be raised to an average 7 ha. In contrast, the ADBN manually drilled, naturally developed type that has an unlined, earth distribution system has been found to irrigate between 1.9 ha (West stratum) and 2.5 ha (Inner Terai). With improved water management, this can be increased to at least 4 ha. Throughout the Study Area where aquifers are shallow, there are hand dug wells that may irrigate 2 to 3 ha via unlined systems.

The comparison made is for conditions (pricing, cropping, etc.) in the Central Stratum that were described in an earlier chapter. In each case, suction mode diesel pumpsets are assumed.

Three comparisons are presented:

Base Case (BC)

The Base Case represents average performance and crop cultural practices as found at present (Volume 3, Groundwater; Volume 2B, Agriculture) and described in Chapter 5 of this volume.

Improved Performance (IP)

The Improved Performance Case represents the cultural and water management practices that could be practised given existing knowledge provided that farmers were made aware of it and had access to the necessary crop inputs. The IP case, however, assumes that the formation of larger owners' or users' groups remains a problem and the present level of well coverage remains as in the BC.

High Utilisation (HU)

Finally, the High Utilisation case, which illustrates benefits from the IP case over a larger, but nevertheless, realistic command area. This may be viewed as a future case where support services are strengthened and more active in the field of water management and irrigated crop cultivation (Volume 2C, Social Studies) and where the benefits of group well ownership or water buying/selling are more widely accepted than at present.

The comparison between the three well types is presented in the form of internal rates of return (IRR), net present values (NPV) and benefit/cost ratios (B/C) over a 20 year period. The results are given at both 1993 financial prices and forecast (2005) economic values at constant 1993 prices. These were discussed in Chapter 3. Returns to farmers are shown in more detail in Chapter 8 in which the benefits to the ADBN type STW in each of the four Study Area strata are compared. A 12% discount rate was used in the analyses.

The major characteristics of the three wells are summarised in Table 8.1.

TABLE 8.1

STW and Hand Dug Well Characteristics, Central Stratum, Diesel Powered, Suction Mode

Well type	Borehole development	Distribution system	Depth (m)	Command area (ha)	
				BC/IP*	HU
Drilled - machine (ILC) - manual (ADBN)	 Gravel pack Natural	 Lined Unlined	 60 20	 4.0 2.3	 7 4
Hand dug	**	Unlined	10	2.0	3

Notes: * BC = Base Case; IP = Improved Performance; HU = High Utilisation (See text)
** Lined with concrete rings

Source: GDC estimates

8.2.2 Well Costs

The financial and economic capital costs are set out in Table 8.2. Details are provided in Volume 3, Groundwater, and Chapter 7. Table 8.3 summarises the annual recurrent costs for pumping and fixed overheads that covers distribution system maintenance, land tax and the miscellaneous items noted in Chapter 7.

TABLE 8.2

Summary of STW and Dug Well Capital Costs; Central Stratum, Suction Mode, Diesel Powered (Rs '000)

Well Type	Well and pumpset	Distribution system		Total		Unit area cost (Rs 000/ha)	
		BC/IP	HU	BC/IP	HU	BC/IP	HU
Financial							
Shallow TW (diesel)							
- machine drilled (1)	261.9	131.2	229.7	393.1	491.6	98.3	70.2
- manually drilled (2)	51.6	0.0	0.0	51.6	51.6	22.4	12.9
Shallow TW (Electric)*							
- manually drilled (2)	141.6	0.0	0.0	141.6	141.6	61.6	35.4
Hand dug (diesel)	38.1	0.0	0.0	38.1	38.1	19.1	12.7
Economic							
Shallow TW (diesel)							
- machine drilled (1)	224.7	118.7	207.8	343.4	432.5	85.9	61.8
- manually drilled (2)	40.5	5.8	10.1	46.3	50.6	20.1	12.6
Shallow TW (Electric)*							
- manually drilled	114.3	5.8	10.1	120.1	124.4	52.2	31.1
Hand dug (diesel)	28.6	5.0	7.6	33.7	36.2	16.8	12.1

Notes: * including cost of electrical connection of Rs 76 000 (Rs 63 100 economic) assuming the cost of 11 kV/400 transformers can be shared between 4 STWs

(1) gravel pack development; (2) natural development

Source: GDC estimates

8.2.3 Benefits

The derivation of the incremental crop benefits, expressed as gross margins, has been given in Chapter 5 and Appendix D. The benefits in the Central Stratum for various cases compared are summarised in Table 8.4. The unit area gross margins net of the returns from an equivalent area of rainfed crops are:

Case	Financial (Rs/ha)	Economic (Rs/ha)
Base case	7 320	7 500
Improved performance	14 580	17 210
High intensity	14 050	16 660

TABLE 8.3

Summary of STW and Hand Dug Well Annual Recurrent Costs
Central Stratum, Suction Mode, Diesel Powered (Rs)

Cropping case	Well Type	Area (ha)	Pumping	Distribution system	Land tax (Rs/year)	Other costs	Total (Rs)
Base	**Financial**						
	Shallow TW						
	Machine drilled + lined channels	4.0	11 732	3 660	472	700	16 564
	Manually drilled + unlined channels	2.3	9 442	0	271	402	10 116
	Hand dug + unlined channels	2.0	8 112	0	236	350	8 698
	Economic						
	Shallow TW						
	Machine drilled + lined channels	4.0	11 680	3 152	0	632	15 464
	Manually drilled + unlined channels	2.3	9 225	184	0	363	9 772
	Hand dug + unlined channels	2.0	7 946	160	0	316	8 422
Improved Performance	**Financial**						
	Shallow TW						
	Machine drilled + lined channels	4.0	13 400	3 660	472	700	18 232
	Manually drilled + unlined channels	2.3	9 777	0	271	402	10 451
	Hand dug + unlined channels	2.0	8 390	0	236	350	8 976
	Economic						
	Shallow TW						
	Machine drilled + lined channels	4.0	13 464	3 152	0	632	17 248
	Manually drilled + unlined channels	2.3	9 584	184	0	363	10 131
	Hand dug + unlined channels	2.0	8 246	160	0	316	8 722
High Utilisation	**Financial**						
	Shallow TW						
	Machine drilled + lined channels	7.0	22 526	6 405	826	1 225	30 982
	Manually drilled + unlined channels	4.0	14 640	0	472	700	15 812
	Hand dug + unlined channels	3.0	11 169	0	354	525	12 048
	Economic						
	Shallow TW						
	Machine drilled + lined channels	7.0	23 240	5 516	0	1 106	29 862
	Manually drilled + unlined channels	4.0	14 800	320	0	632	15 752
	Hand dug + unlined channels	3.0	11 220	240	0	474	11 934

Source: GDC estimates

TABLE 8.4

Summary of Annual Crop Benefits to Shallow Tubewells
Central Stratum, Suction Mode, Diesel Powered

Cropping Case	Well type	Area (ha)	Gross margin (Rs/ha)	Gross margin (Rs/well)	Year 1	2	3	4	5	6	7
Base	Proportion x				0.60	1.00	1.00	1.00	1.00	1.00	1.00
Financial	Shallow TW										
	Machine drilled + lined channels	4.0	7 320	29 280	17 568	29 280	29 280	29 280	29 280	29 280	29 280
	Manually drilled + unlined channels	2.3	7 320	16 836	10 102	16 836	16 836	16 836	16 836	16 836	16 836
	Hand dug + unlined channels	2.0	7 320	14 640	8 784	14 640	14 640	14 640	14 640	14 640	14 640
Economic	Shallow TW										
	Machine drilled + lined channels	4.0	7 500	30 000	18 000	30 000	30 000	30 000	30 000	30 000	30 000
	Manually drilled + unlined channels	2.3	7 500	17 250	10 350	17 250	17 250	17 250	17 250	17 250	17 250
	Hand dug + unlined channels	2.0	7 500	15 000	9 000	15 000	15 000	15 000	15 000	15 000	15 000
Improved	Proportion x				0.50	0.55	0.65	0.70	0.85	0.90	1.00
Financial	Shallow TW										
	Machine drilled + lined channels	4.0	14 580	58 320	29 160	32 076	37 908	40 824	49 572	52 488	58 320
	Manually drilled + unlined channels	2.3	14 580	33 534	16 767	18 444	21 797	23 474	28 504	30 181	33 534
	Hand dug + unlined channels	2.0	14 580	29 160	14 580	16 038	18 954	20 412	24 786	26 244	29 160
Economic	Shallow TW										
	Machine drilled + lined channels	4.0	17 210	68 840	34 420	37 862	44 746	48 188	58 514	61 956	68 840
	Manually drilled + unlined channels	2.3	17 210	39 583	19 792	21 771	25 729	27 708	33 646	35 625	39 583
	Hand dug + unlined channels	2.0	17 210	34 420	17 210	18 931	22 373	24 094	29 257	30 978	34 420
High Util.	Proportion x				0.50	0.55	0.65	0.70	0.85	0.90	1.00
Financial	Shallow TW										
	Machine drilled + lined channels	7.0	14 045	98 315	49 158	54 073	63 905	68 821	83 568	88 484	98 315
	Manually drilled + unlined channels	4.0	14 045	56 180	28 090	30 899	36 517	39 326	47 753	50 562	56 180
	Hand dug + unlined channels	3.0	14 045	42 135	21 068	23 174	27 388	29 494	35 815	37 922	42 135
Economic	Shallow TW										
	Machine drilled + lined channels	7.0	16 660	116 620	58 310	64 141	75 803	81 634	99 127	104 958	116 620
	Manually drilled + unlined channels	4.0	16 660	66 640	33 320	36 652	43 316	46 648	56 644	59 976	66 640
	Hand dug + unlined channels	3.0	16 660	49 980	24 990	27 489	32 487	34 986	42 483	44 982	49 980

Source: GDC estimates

The IP figures are net of present rainfed production levels while the HI returns are net of the forecast future rainfed cropping performance that has been discussed in Volume 2, Part B, Agriculture.

In the analyses, allowance has been made for the farmers' adjustment to the new, irrigated production regime. In the BC, this will be rapid since no new non-water cultural practices or substantially different levels of inputs are envisaged. A longer period to build up the "full development" yields and practices is expected for the IP and HI cases. The build up rates for full, two season years adopted were:

% full production	Year 1	2	3	4	5	6	7
BC	60	100	100	100	100	100	100
IP/HI	50	55	65	70	85	90	100

In the year of installation, 50% of the first full year benefits have been assumed.

8.2.4 Results

The results of the analyses are set out in Table 8.5.

TABLE 8.5

Summary of Shallow Tubewell Economic Analyses at 1993 (Prices)
(Central Stratum)

Well type	Economic analyses		
	IRR (%)	NPV (Rs'000)	B/C ratio
STW machine drilled (lined channels)			
- Base	neg	-243	0.45
- Improved Performance	8.4	-67	0.85
- IP+High Utilisation	13.4	37	1.06
STW manually drilled (unlined channels)			
- Base	8.1	-8	0.93
- Improved Performance	41.3	97	1.79
- IP+High Utilisation	70.2	207	2.26
Hand dug well (unlined channels)			
- Base	14.2	4	1.04
- Improved Performance	46.8	93	1.94
- IP+High Utilisation	74.4	159	2.33

Note: Over 20 years at 12% annual discount rate; neg = negative

Source: GDC estimates

The apparent advantage of cheap hand dug wells is interesting. Such wells installed where groundwater is shallow and percolation/recharge reasonable and where STWs are hard to install are attractive. Even with Base Case cropping the IRR reaches 14% with a B/C ratio of 1.04. The analysis is vulnerable to variations in well depth, digging conditions and the ability of the wells to sustain continuous pumping: STWs will be more capable of withstanding variations in watertable. In good conditions however, dug wells can perform very effectively.

Both the ILC and ADBN model STWs as specified for the analyses give unfavourable economic returns under present average cropping practices with the areas now typically irrigated from them. Even under IP cropping with its higher yields and returns the ILC model fails to reach the 12% IRR target (with 8.4% IRR and 0.85 B/C ratio). This reinforces the need to concentrate on expanding actual irrigation coverage to the 7 ha average target.

The standard manually drilled ADBN STWs will give acceptable economic returns, however, if crop cultivation practices are improved to the extent discussed in Chapter 4 and Volume 2B, Agriculture. With large (HU Case) command areas and IP benefits, ILC and ADBN STWs are likely to be economically viable as Table 8.5 shows. The key results of this analysis therefore clearly favour hand dug wells for very shallow aquifers and ADBN type manually drilled STWs with unlined distribution systems elsewhere, unless groundwater is at depth or in strata more technically suited to the more costly machine drilling practised by ILC. It is assumed that groundwater exploitation in the Study Area would be concentrated on the more favourable areas suited to manually drilled STWs unless farmers' demand was found to be particularly strong in other areas. Therefore, the following section of the analysis which compares returns to STWs throughout the main and inner Terai is based on the manually drilled model described above. It should be noted that while the machine and manually drilled STW models have been referred to as typical of the ILC and ADBN programmes, the results cannot be taken as detailed enough to provide any firm analysis of either programme's success or lack of success.

8.3 Study Area Shallow Tubewell Returns by Stratum

8.3.1 Introduction

As noted in Section 8.1, the comparison of returns to STWs in the four Study Area strata have been assessed on the basis of manually drilled boreholes, diesel pumpsets and unlined distribution systems. The analyses are to illustrate the differences across the Study Area taking into account the main variations in farmers' circumstances arising from their location and general climatic and other environmental conditions. These are reflected in the prices, cropping patterns and crop yields that were discussed earlier in this volume and in Volume 2, Land Resources and Agriculture.

8.3.2 Capital Costs

The cost of manually drilled STWs given in Section 8.2.2 (Table 8.2) has been used for all strata. While there will be some variation, these may be small and have been ignored bearing in mind the scale and scope of the study.

8.3.3 Recurrent Costs

Differences in fuel prices within the Study Area are taken into account in the annual pumping costs that are summarised in Table 8.6. Water requirement and pumping hour estimates are discussed in Volume 3, Groundwater. In general, requirements are significantly lower in the Inner Terai. They vary also from the east to the west of the main Terai, but less significantly. As shown in Table 8.6 one set of pumping hours has been used for the main Terai.

The other recurrent costs shown in Table 8.7 are as described for the previous STW analyses in Section 8.2.2.

8.3.4 Benefits

The incremental crop benefits and their build up for each analysis stratum and cropping case are given in Table 8.8. Their derivation has already been described and details are given in Appendix D.

8.4 Economic Analysis by Stratum

The analysis shows that returns to STWs under present conditions, the Base Case, are substantially better in the East and Inner Terai strata than elsewhere. In the West and Central strata, they are at best marginal with B/C ratios of 0.9 and 0.93 and IRR of 6 and 8%, respectively. Table 8.9 summarises the results.

Base Case

The Base Case results are of particular interest since they illustrate the effect of STW irrigation under present conditions. Farmers react to the availability of year round water within the limits imposed by their own and their area's particular conditions (price, input suppliers, market accessibility, etc.) and without significant HMGN or other support.

The Base Case clearly shows that economic returns to STWs are good in the East and Inner Terai strata, marginal in the Central and poor in the West.

Stratum	Economic	
	IRR (%)	B/C (ratio)
West	5.7	0.89
Central	8.1	0.93
East	38.0	1.54
Inner Terai	22.3	1.22

TABLE 8.6

Shallow Tubewell Annual Pumping Costs (Rs/ha per year)

Case stratum	Diesel (Rs/l)	Consumption (l/kWh)	Cost (Rs/kWh)	Energy use (kWh)	Annual pumping (h/ha)	Energy cost (Rs/ha/y)	Other costs (Rs/ha/y)(1)	Total costs (Rs/ha/y)
Financial								
Base								
- West	12.2	0.31	3.78	6	147	3 336	1 263	4 599
- Central	11.2	0.31	3.47	6	147	3 062	1 043	4 106
- East	10.9	0.31	3.38	6	147	2 980	1 043	4 024
- Inner Terai	12.2	0.31	3.78	6	100	2 269	960	3 229
Improved performance								
- West	12.2	0.31	3.78	6	154	3 495	1 263	4 758
- Central	11.2	0.31	3.47	6	154	3 208	1 043	4 252
- East	10.9	0.31	3.38	6	154	3 122	1 043	4 166
- Inner Terai	12.2	0.31	3.78	6	100	2 269	960	3 229
High Intensity								
- West	12.2	0.31	3.78	6	147	3 336	600	3 936
- Central	11.2	0.31	3.47	6	147	3 062	600	3 662
- East	10.9	0.31	3.38	6	147	2 980	600	3 580
- Inner Terai	12.2	0.31	3.78	6	100	2 269	600	2 869
Economic								
Base								
- West	13	0.31	4.03	6	147	3 554	884	4 439
- Central	12.0	0.31	3.72	6	147	3 281	730	4 011
- East	11.6	0.31	3.60	6	147	3 172	730	3 902
- Inner Terai	13.0	0.31	4.03	6	100	2 418	672	3 090
Improved performance								
- West	13	0.31	4.03	6	154	3 724	884	4 608
- Central	12.0	0.31	3.72	6	154	3 437	730	4 168
- East	11.6	0.31	3.60	6	154	3 323	730	4 053
- Inner Terai	13.0	0.31	4.03	6	100	2 418	672	3 090
High Intensity								
- West	13	0.31	4.03	6	147	3 554	420	3 974
- Central	12.0	0.31	3.72	6	147	3 281	420	3 701
- East	11.6	0.31	3.60	6	147	3 172	420	3 592
- Inner Terai	13.0	0.31	4.03	6	100	2 418	420	2 838

Note: (1) At 10% of pump capital cost over irrigated area

Source: GDC estimates

TABLE 8.7

Summary of Shallow Tubewell Annual Recurrent Costs
Central Stratum, Suction Mode, Diesel Powered (Rs/year)

Case Stratum	Area (ha)	Pumping cost	Distribution system	Land tax	Other costs	Total cost
Financial						
Base						
- West	1.9	8 738	0	224	333	9 295
- Central	2.3	9 442	0	271	402	10 116
- East	2.3	9 255	0	271	402	9 929
- Inner Terai	2.5	8 073	0	295	438	8 805
Improved performance						
- West	1.9	9 040	0	224	333	9 597
- Central	2.3	9 777	0	271	402	10 451
- East	2.3	9 582	0	271	402	10 256
- Inner Terai	2.5	8 073	0	295	438	8 805
High Intensity						
- West	4.0	15 852	0	472	700	17 024
- Central	4.0	14 640	0	472	700	15 812
- East	4.0	14 320	0	472	700	15 492
- Inner Terai	4.0	11 476	0	472	700	12 648
Economic						
Base						
- West	1.9	8 434	152	0	300	8 886
- Central	2.3	9 225	184	0	363	9 772
- East	2.3	8 975	184	0	363	9 522
- Inner Terai	2.5	7 725	200	0	395	8 320
Improved performance						
- West	1.9	8 755	152	0	300	9 207
- Central	2.3	9 584	184	0	363	10 131
- East	2.3	9 322	184	0	363	9 869
- Inner Terai	2.5	7 725	200	0	395	8 320
High Intensity						
- West	4.0	15 896	320	0	632	16 848
- Central	4.0	14 800	320	0	632	15 752
- East	4.0	14 368	320	0	632	15 320
- Inner Terai	4.0	11 352	320	0	632	12 304

Source: GDC estimates

TABLE 8.8

Summary of Annual Incremental Crop Benefits to Shallow Tubewells Main and Inner Terai (Rs/year)

Case / Stratum	Area (ha)	Gross margin (Rs/ha)	Gross margin (Rs/well)	Year 1	2	3	4	5	6	7
Financial										
Base										
- Proportion x				0.60	1.00	1.00	1.00	1.00	1.00	1.00
- West	1.9	6 051	11 497	6 898	11 497	11 497	11 497	11 497	11 497	11 497
- Central	2.3	7 320	16 836	10 102	16 836	16 836	16 836	16 836	16 836	16 836
- East	2.3	9 748	22 420	13 452	22 420	22 420	22 420	22 420	22 420	22 420
- Inner Terai	2.5	7 883	19 708	11 825	19 708	19 708	19 708	19 708	19 708	19 708
Improved performance										
- Proportion x				0.5	0.6	0.7	0.7	0.9	0.9	1.0
- West	1.9	12 414	23 587	11 793	12 973	15 331	16 511	20 049	21 228	23 587
- Central	2.3	14 584	33 543	16 772	18 449	21 803	23 480	28 512	30 189	33 543
- East	2.3	17 448	40 130	20 065	22 072	26 085	28 091	34 111	36 117	40 130
- Inner Terai	2.5	16 639	41 598	20 799	22 879	27 038	29 118	35 358	37 438	41 598
High Intensity										
- Proportion x				0.5	0.6	0.7	0.7	0.9	0.9	1.0
- West	4.0	13 465	53 860	26 930	29 623	35 009	37 702	45 781	48 474	53 860
- Central	4.0	14 045	56 180	28 090	30 899	36 517	39 326	47 753	50 562	56 180
- East	4.0	16 790	67 160	33 580	36 938	43 654	47 012	57 086	60 444	67 160
- Inner Terai	4.0	18 995	75 980	37 990	41 789	49 387	53 186	64 583	68 382	75 980
Economic										
Base										
- Proportion x				0.6	1.0	1.0	1.0	1.0	1.0	1.0
- West	1.9	8 167	15 517	9 310	15 517	15 517	15 517	15 517	15 517	15 517
- Central	2.3	7 502	17 255	10 353	17 255	17 255	17 255	17 255	17 255	17 255
- East	2.3	12 231	28 131	16 879	28 131	28 131	28 131	28 131	28 131	28 131
- Inner Terai	2.5	8 368	20 920	12 552	20 920	20 920	20 920	20 920	20 920	20 920
Improved performance										
- Proportion x				0.5	0.6	0.7	0.7	0.9	0.9	1.0
- West	1.9	18 450	35 055	17 528	19 280	22 786	24 539	29 797	31 550	35 055
- Central	2.3	17 212	39 588	19 794	21 773	25 732	27 711	33 649	35 629	39 588
- East	2.3	24 518	56 391	28 196	31 015	36 654	39 474	47 933	50 752	56 391
- Inner Terai	2.5	21 513	53 783	26 891	29 580	34 959	37 648	45 715	48 404	53 783
High Intensity										
- Proportion x				0.5	0.6	0.7	0.7	0.9	0.9	1.0
- West	4.0	18 879	75 516	37 758	41 534	49 085	52 861	64 189	67 964	75 516
- Central	4.0	16 663	66 652	33 326	36 659	43 324	46 656	56 654	59 987	66 652
- East	4.0	23 613	94 452	47 226	51 949	61 394	66 116	80 284	85 007	94 452
- Inner Terai	4.0	24 900	99 600	49 800	54 780	64 740	69 720	84 660	89 640	99 600

Source: GDC estimates

TABLE 8.9

Summary of Shallow Tubewell Economic Analyses All Strata (Constant 1993 prices)

Case Stratum	IRR %	NPV Rs'000	B/C ratio
Base			
- West	5.7	-13	0.89
- Central	8.1	-8	0.93
- East	38.0	64	1.54
- Inner Terai	22.3	25	1.22
Improved performance			
- West	44.4	104	1.89
- Central	41.3	97	1.79
- East	61.5	173	2.42
- Inner Terai	70.5	188	2.68
High utilisation			
- West	84.7	249	2.45
- Central	70.2	207	2.26
- East	135.0	364	3.26
- Inner Terai	161.6	413	3.92

Source: GDC estimates

Tables 8.10 and 8.11 illustrate some of the critical changes that occur in each of the four strata when STWs are installed. It can be seen from Table 8.10 that one major factor in the different results is the substantial rise in cropping intensities in the East (59%) and Inner Terai (87%) compared to 38% in the West and a very modest 19% in the Central stratum. In addition in the West, an average area irrigated is less than two hectares (1.9 ha) in contrast to 2.3 to 2.5 ha elsewhere.

TABLE 8.10

Comparison of Changes with STW Irrigation in the Study Area

Stratum	STW area (ha)	Annual cropping (%)		Cropping change (%)
		rainfed	irrigated	
West	1.9	143	197	38
Central	2.3	171	204	19
East	2.3	129	205	59
Inner Terai	2.5	91	170	87

Source: Chapter 5 and Volume 2B, Agriculture

Except in the Central stratum, the area of wheat grown rises considerably from 220% (East) to 335% (Inner Terai), and Table 8.11 shows that the pattern is similar for vegetables. In the Central stratum, farmers grow larger areas of these two crops rainfed than elsewhere, which accounts for the lower increase when irrigation is available. The increased area of paddy grown is substantial in the Inner Terai (+132%), low in Central (3%) where it is grown rainfed on a large scale and moderate in the other two strata.

TABLE 8.11

Changes in Crop Areas with STW Irrigation (ha)

Status	Paddy	Wheat	Maize	Oilseed	Pulse	Vegetable	Total
West							
- rainfed	1.26	0.28	0.54	0.33	0.29	0.01	2.71
- irrigated	1.62	1.14	0.36	0.21	0.35	0.06	3.74
- change (ha)	0.36	0.86	-0.18	-0.12	0.06	0.05	1.03
- change (%)	28.6	307.1	-33.3	-36.4	20.7	500.0	38.0
Central							
- rainfed	2.12	0.74	0.43	0.31	0.27	0.07	3.94
- irrigated	2.45	0.83	0.49	0.48	0.25	0.19	4.69
- change (ha)	0.33	0.09	0.06	0.17	-0.02	0.12	0.75
- change (%)	15.6	12.2	14.0	54.8	-7.4	171.4	19.0
East							
- rainfed	2.20	0.39	0.27	0.07	0.02	0.01	2.96
- irrigated	2.26	1.25	0.51	0.18	0.14	0.37	4.71
- change (ha)	0.06	0.86	0.24	0.11	0.12	0.36	1.75
- change (%)	2.7	220.5	88.9	157.1	600.0	3600.0	59.1
Inner Terai							
- rainfed	1.06	0.20	0.42	0.42	0.18	0.00	2.28
- irrigated	2.46	0.87	0.29	0.42	0.11	0.11	4.26
- change (ha)	1.40	0.67	-0.13	0.00	-0.07	0.11	1.98
- change (%)	132.1	335.0	-31.0	0.0	-38.9	++	86.8

Source: Chapter 5 and Volume 2B, Agriculture

These differences in response to the use of STWs combined with generally rather low costs in the East stratum account for the very significant contrast in economic benefits. The differences can crudely be summarised as follows:

Ranking	Stratum	STW command area	Change in cropping intensity	Increase in crop area		
				Paddy	Wheat	Vegetables
1	East	M	VH	L	H	VH
2	Inner Terai	M	H	M	H	VH
3	Central	M	VL	M	L	M
4	West	L	L	M	H	H

Notes: L = low, M = medium, H = high, and V = very

Improved Performance

Conditions in the main and inner Terai give rise to very good irrigated production potential (Volume 2, Parts A and B). However, the study's social and institutional investigations show that support services and their ability to extend new ideas and techniques to farmers are poorly developed throughout the Study Area. This is particularly noticeable in the case of irrigated cropping. The move from rainfed to irrigated production requires considerable practice to realise the new situation's potential.

The requirements and possibilities discussed earlier in the report could result in the economic returns shown in Table 8.9 without any increase in STW command areas. Assuming a seven year period before a farmer reaches the full levels of output, assumed economic IRRs would vary from 41% in the Central to almost 70% in the Inner Terai with B/C ratios of 1.8 to 2.7, respectively.

If in addition, STW command areas can be increased from the present 1.9 to 2.5 ha range to 4 ha, STWs could become extremely attractive in all strata as shown for the high intensity case in Table 8.9. Benefit/cost ratios could rise to between 2.5 to 3.9. The assumptions underlying this future possibility are considered reasonable and practical but cannot be expected, except in the case of particular farmers, until support services, from DOI and DOA in particular, are improved.

The IP and HU case economic returns to STWs therefore can be considered as an indication of the medium term prospects to the sector.

8.5 Financial Analysis

8.5.1 General

STWs are considered in this section on the basis of the net income levels that can be expected in each study stratum at present and future levels of crop production - the Base and Improved Performance cases and also from a 4 ha area, the High Utilisation case.

The first analysis, however, is presented in terms of NPV - B/C and IRR at financial prices which gives a broader view of the financial value of STWs in the four Study Area strata.

8.5.2 Costs and Benefits

The total financial cost of manually drilled STWs has already been given. Farmers are able through ADBN to receive a substantial subsidy of 40% as an individual and 70% if bought by a group of four and more persons. The capital costs in these circumstances fall from Rs 51 600 to Rs 30 960 at 40% subsidy and Rs 15 480 at the 70% group subsidy rate.

The benefits used in the analysis are the full crop gross margins, that is, not net of the value of rainfed production from the same area. These are given below:

Stratum	Rs/ha		
	Base Case	Improved performance	IP + High Utilisation
West	12 320	20 290	21 340
Central	16 400	26 180	25 640
East	16 210	25 680	25 020
Inner Terai	12 180	21 860	24 220

The benefit flow is set out in Table 8.12 using the same build up periods as before.

8.5.3 Basic Analysis

Using the full crop gross margin benefits, the financial viability of STWs is good throughout the Study Area; this is true even at Base Case cropping and command areas and taking into account the full, unsubsidised cost of the STW. The BC analysis results with and without HMGN subsidies are given in Table 8.13.

TABLE 8.12

Summary of Financial Crop Gross margins with Shallow Tubewells Main and Inner Terai

Case Stratum	Area (ha)	Gross margin (Rs/ha)	Gross margin (Rs/well)	Year 1	2	3	4	5	6	7
Financial										
Base										
- Proportion x				0.60	1.00	1.00	1.00	1.00	1.00	1.00
- West	1.9	12 320	23 408	14 045	23 408	23 408	23 408	23 408	23 408	23 408
- Central	2.3	16 400	37 720	22 632	37 720	37 720	37 720	37 720	37 720	37 720
- East	2.3	16 200	37 260	22 356	37 260	37 260	37 260	37 260	37 260	37 260
- Inner Terai	2.5	12 180	30 450	18 270	30 450	30 450	30 450	30 450	30 450	30 450
Improved Performance										
- Proportion x				0.50	0.55	0.65	0.70	0.85	0.90	1.00
- West	1.9	20 290	38 551	19 276	21 203	25 058	26 986	32 768	34 696	38 551
- Central	2.3	26 180	60 214	30 107	33 118	39 139	42 150	51 182	54 193	60 214
- East	2.3	25 680	59 064	29 532	32 485	38 392	41 345	50 204	53 158	59 064
- Inner Terai	2.5	21 860	54 650	27 325	30 058	35 523	38 255	46 453	49 185	54 650
High Intensity										
- Proportion x				0.50	0.55	0.65	0.70	0.85	0.90	1.00
- West	4.0	21 340	85 360	42 680	46 948	55 484	59 752	72 556	76 824	85 360
- Central	4.0	25 640	102 560	51 280	56 408	66 664	71 792	87 176	92 304	102 560
- East	4.0	25 020	100 080	50 040	55 044	65 052	70 056	85 068	90 072	100 080
- Inner Terai	4.0	24 210	96 840	48 420	53 262	62 946	67 788	82 314	87 156	96 840

Source: GDC estimate

TABLE 8.13

Summary of STW Financial Analyses (1)
Base Case, All Strata (1993 prices)

Case Stratum	IRR (%)	NPV (Rs'000)	B/C ratio
Without subsidy			
- West	22.0	26	1.20
- Central	53.3	114	1.86
- East	52.7	112	1.85
- Inner Terai	39.6	75	1.61
40% subsidy			
- West	42.2	44	1.41
- Central	100.9	132	2.16
- East	99.5	130	2.16
- Inner Terai	73.5	93	1.89
70% subsidy			
- West	107.5	58	1.61
- Central	376.5	146	2.46
- East	364.0	144	2.46
- Inner Terai	210.7	107	2.17

Note: (1) Total net incremental crop gross margins at present performance levels

Source: GDC estimates

8.5.4 Returns to the Farmers

The returns more relevant to the STW owner have been assessed for each strata in terms of their likely loan repayment capacity. The basic assumption has been that the net value of production would have to be increased by 25% above pre-STW levels for the area that is irrigated by the STW before loan repayments would willingly be paid. Since data available for the study did not include farmers' views on this, the adopted minimum increase is necessarily an arbitrary one.

It is based on the following three considerations:

(a) STWs are well known in most areas of the Terai and are generally known to be reliable in operation. The level of confidence in them is good and the perceived investment risk is lower than would be the case with any irrigation system known to be unreliable. This applies under Terai conditions to many surface irrigation schemes where the date of the arrival and period of water availability is uncertain as it is dependent on the seasonal variations each year.

(b) An allowance has been made for the insurance effect against crop damage by dry periods in the main monsoon season and against low levels of residual moisture for the second winter crop season. As the LRMP study showed, a second, winter season crop is grown by many farmers throughout the Terai but, without irrigation, results are precarious owing to possible late planting and low soil moisture content.

These aspects have some value to farmers and lead to the adoption of a minimum expected increase in net farm income of 25% from irrigation.

The net income increases calculated for the BC in each stratum are summarised in Table 8.14 using data in Appendix D and Chapter 7. In the first year of installation, it has been assumed that the well operates for 30% of the time; in year two, 60% of the time; and the final benefits from year three are forecast, as in the earlier analyses. It is clear that with the exception of West stratum the increase in net income exceeds the extra 25% minimum. In the West it would be 18% extra each year. On this basis the funds possibly available for loan repayment from the second full year of operation would be as follows and detailed in Table 8.15.

Stratum	Rs/year
West	nil (-780)
Central	1 500
East	8 780
Inner Terai	8 220

TABLE 8.14

Shallow Tubewell Net Income: Base Case at 1993 Financial Prices (Rs)

Stratum	Area (ha)	Year		
		1	2	3
West	1.9			
With STW				
- Gross income		7 025	14 049	23 415
- Operating costs		4 648	9 295	9 295
- Net income		2 377	4 754	14 120
Without STW				
- Net income		5 959	11 917	11 917
- Increase Rs/unit		-3 582	-7 163	2 203
- Increase x		0.40	0.40	1.18
Central	2.3			
With STW				
- Gross income		11 315	22 630	37 717
- Operating costs		5 059	10 118	10 118
- Net income		6 256	12 512	27 599
Without STW				
- Net income		10 441	20 882	27 599
- Increase Rs/unit		-4 185	-8 370	
- Increase x		0.60	0.60	0.00
East	2.3			
With STW				
- Gross income		11 181	22 363	37 271
- Operating costs		4 965	9 929	9 929
- Net income		6 217	12 434	27 342
Without STW				
- Net income		7 425	14 849	14 849
- Increase Rs/unit		-1 208	-2 415	12 493
- Increase x		0.84	0.84	1.84
Inner Terai	2.5			
With STW				
- Gross income		9 133	18 266	30 444
- Operating costs		4 403	8 805	8 805
- Net income		4 371	9 641	21 639
Without STW				
- Net income		5 368	10 736	10 736
- Increase Rs/unit		-637	-1 275	10 903
- Increase x		0.88	0.88	2.02

Note: (1) Assume 30% income in the installation year

Source: GDC estimates

If the IP production levels could be reached in three years, in contrast to the seven year assumption used in the previous analyses, then repayment levels would rise substantially to those in the second part of Table 8.15 which are:

Stratum	Rs/year
West	10 280
Central	10 420
East	25 140
Inner Terai	29 530

This may be a possibility in the future when full, effective irrigation support services are available. The IP figures therefore assume that rainfed production is also greater to the extent described in Chapter 4.

TABLE 8.15

Summary of Improvement in Net STW Income and Loan Repayment Capacity

Stratum	Net income		Increase	Ratio +STW/ -STW	Target income (Rs)*	Repayment capacity (Rs)
	-STW (Rs)	+STW (Rs)	(Rs)			
Base Case						
- West	11 917	14 120	2 203	1.18	14 896	-776
- Central	20 882	27 599	6 717	1.32	26 103	1 497
- East	14 849	27 342	12 493	1.84	18 561	8 781
- Inner Terai	10 736	21 639	10 903	2.02	13 420	8 219
Improved Performance**						
- West	14 935	28 948	14 013	1.94	18 669	10 279
- Central	26 675	49 765	23 090	1.87	33 344	16 421
- East	18 937	48 812	29 875	2.58	23 671	25 141
- Inner Terai	13 050	45 841	32 791	3.51	16 313	29 529

Notes: * Target income before funds available for loan repayments taken as 125% of without STW income;

** At full development, for assumptions see text.

CHAPTER 9

DEEP TUBEWELL ANALYSIS

9.1 Scope

Table 9.1 summarises the full benefit/cost analyses carried out to assess the viability of medium and deep tubewells. All analyses are made for a DTW of 60 l/s capacity with a gravel packed borehole in a D2 aquifer and an open channel lined distribution system. This is sufficient under reasonable water management to serve a command area of 48 ha (at 1.25 l/s per hectare).

TABLE 9.1

Medium and Deep Tubewell Analysis Characteristics

Well capacity (l/s)	Distribution system	Command area (ha)*	Cropping level	Stratum (Terai)	Price basis	Land System		
						2M (mixed)	2U (upland)	2R (lowland)
60	Open Lined	48/52	Base	Main	finan	*		
					econ	*		
				Inner	econ	*		
			Improved	Main	finan	*		
					econ	*	*	*
				Inner	econ	*		

Note: * 52 ha for Land System 2 upland, 48 ha for other classes

Source: GDC.

Economic analyses are provided to compare the following:

Land Classes: Classes 2 mixed, 2 upland, and 2R low land in the Main Terai, assuming the Improved Performance cropping level.

Main and Inner Terai: on Land Class 2, mixed for both the Base Case and Improved Performance cropping levels.

Details of the cropping patterns, yields, etc., for the different and land classes and cropping levels have already been presented in Chapter 4 and 6 based on details in Volume 2, Parts A and B, Land Resources and Agriculture.

Financial analyses cover only the main Terai, Land Class 2 mixed for Base and Improved Performance cropping. As for STWs (Chapter 8), the results are given in terms of NPV-B/C and IRRs and also, secondly, to show the net incomes that can be expected to accrue to farmers in MTW and DTW groups.

9.2 Costs

Table 9.2 summarises the capital costs for the 60 l/s DTW used in the analyses.

TABLE 9.2

Deep Tubewell (60 l/s) Capital Costs
Diesel, Gravel Pack, Lined Distribution System (Rs '000)

Pricing	Land Class (1)	Command area (ha)	Well and pumpset	Distribution system	Total
Financial	2M/2RL	48	1 146.38	1 684.32	2 830.70
	2U	52	1 146.38	1 824.68	2 971.06
Economic	2M/2RL	48	954.34	1 424.74	2 379.08
	2U	52	954.34	1 824.68	2 779.02

Note: (1) 2M = Class 2 mixed, 2U = Class 2 upland, 2RL = Class 2 lowland

The annual recurrent costs are set out in Table 9.3. Both sets of costs are derived from figures given earlier with a number of adjustments for pumping hours required for the different land classes and the two areas covered the main and inner Terai - and the size of command area. This is larger, 52 ha for Class 2 upland than for the other two classes (48 ha). Full details of pumping requirements and DTW coverage are given in Volume 3.

9.3 Benefits

The benefits from MTW and DTW cropping for the three land classes and the differences between the main Terai and the inner Terai were given in Chapter 6.

From the unit area figures given in Table 6.2, the total incremental crop gross margins were as shown in Table 9.4 for the DTW cases in the analyses. Table 9.5 sets out the total (not incremental) financial gross margins used to determine farmers' net income position discussed in Section 9.5.

The two tables also show the anticipated build up of benefits from the year the tubewells are installed. These are as discussed in Section 6.3.

TABLE 9.3

Deep Tubewell (60 l/s) Recurrent Costs Diesel, Gravel Pack, Lined Distribution System (Rs '000)

Cropping	Land class*	Command area (ha)	Pumping hours	Pumping cost	Land tax	Misc. crop costs	Distrib. system	Total
Financial								
Base Case								
- Main Terai	2M	48	1 100	80.6	5.7	15.6	50.5	152.4
- Inner Terai	2M	48	720	52.8	5.7	15.6	50.5	124.6
Improved Performance								
- Main Terai	2M	48	1 390	101.9	5.7	17.8	50.5	175.8
	2U	52	725	53.1	6.1	11.4	54.7	125.4
	2RL	48	1 800	131.9	5.7	19.4	50.5	207.5
- Inner Terai	2M	48	910	66.7	5.7	18.0	50.5	140.9
Economic								
Base Case								
- Main Terai	2M	48	1 100	78.2	0.0	14.0	42.7	134.9
- Inner Terai	2M	48	720	51.2	0.0	14.0	42.7	107.9
Improved Performance								
- Main Terai	2M	48	1 390	98.8	0.0	16.0	42.7	157.5
	2U	52	725	51.5	0.0	10.3	46.3	108.1
	2RL	48	1 800	127.9	0.0	17.5	42.7	188.1
- Inner Terai	2M	48	910	64.7	0.0	16.2	42.7	123.6

Note: * 2M = Class 2 mixed, 2U = Class 2 upland, 2RL = Class 2 lowland

Source: Consultants' estimates, Chapter 7

TABLE 9.4

Summary of Annual Incremental Crop Benefits to 60 l/s Deep Tubewell, Main Terai and Inner Terai (1993 prices in Rs '000/year)

Crop/ Area case	Land class (1)	Area (ha)	Gross margin (Rs/ha)	(Rs '000)	Year 1	2	3	4	5	6	7
Base (present)		Proportion x			0.20	0.40	0.70	1.00	1.00	1.00	1.00
Financial											
- Main Terai	2M	48	6 490	311.5	62	125	218	312	312	312	312
- Inner Terai	2M	48	8 330	399.8	80	160	280	400	400	400	400
Economic											
- Main Terai	2M	48	7 810	374.9	75	150	262	375	375	375	375
- Inner Terai	2M	48	9 860	473.3	95	189	331	473	473	473	473
Improved (future)		Proportion x			0.15	0.30	0.55	0.80	0.95	1.00	1.00
Financial											
- Main Terai	2M	48	13 780	661.4	99	198	364	529	628	661	661
	2U	52	9 960	517.9	78	155	285	414	492	518	518
	2RL	48	15 570	747.4	112	224	411	598	710	747	747
- Inner Terai	2M	48	17 660	847.7	127	254	466	678	805	848	848
Economic											
- Main Terai	2M	48	18 870	905.8	136	272	498	725	860	906	906
	2U	52	16 550	860.6	129	258	473	688	818	861	861
	2RL	48	15 710	754.1	113	226	415	603	716	754	754
- Inner Terai	2M	48	22 700	1 089.6	163	327	599	872	1 035	1 090	1 090

TABLE 9.5

Summary of Annual Total Crop Gross Margins (1993 financial prices)
60 l/s Deep Tubewells in Main Terai and Inner Terai (Rs'000/year)

Cropping Case Area	Land system*	Area (ha)	Annual gross margin (Rs/ha)	(Rs'000)	Build-up by year 1	2	3	4	5	6	7
Base (present)				Proportion x	0.20	0.40	0.70	1.00	1.00	1.00	1.00
Main Terai	2M	48	14 330	688	138	275	481	688	688	688	688
Inner Terai	2M	48	12 610	605	121	242	424	605	605	605	605
Improved (future)				Proportion x	0.15	0.30	0.55	0.80	0.95	1.00	1.00
Main Terai	2M	48	23 820	1 143	172	343	629	915	1 086	1 143	1 143
Inner Terai	2M	48	22 870	1 098	165	329	604	878	1 043	1 098	1 098

* 2M = Land System 2 mixed

Source: GDC estimates

9.4 Economic Analysis

The results of the economic analyses are summarised in Table 9.6.

TABLE 9.6

Summary of Deep Tubewell Economic Analyses

Case	Land system*	IRR (%)	NPV (Rs'000)	B/C ratio
Base (present)				
Main Terai	2M	5.48	-851	0.73
Inner Terai	2M	11.5	-71	0.98
Main Terai	2M	22.51	1 860	1.57
Inner Terai	2M	29.04	3 142	2.03
Main Terai	2U	20.13	1 594	1.48
Main Terai	2R	6.64	782	1.22

Note: * 2M = System 2 mixed; 2U = System 2 upland; 2R = System 2 lowland.

Source: GDC.

The comparison between the main and inner Terai areas shows that returns to DTWs on Land Class 2 mixed are highest in the inner Terai:

Item	IRR (%)	B/C (ratio)
Base Case		
Main Terai	5.5	0.73
Inner Terai	11.5	0.98
Improved Case		
Main Terai	22.5	1.57
Inner Terai	29.0	2.03

As with shallow tubewells, this arises from the greater increase in cropping intensity with irrigation (91 to 195%, inner Terai; 146 to 195%, main Terai), rather higher unit area crop gross margins and lower water requirements.

The results, however, highlight the poor returns under present crop cultivation practices represented by the Base Case. The good results under the Improved Performance case cropping nevertheless shows that MTW and DTW irrigation in both the Terai areas is economically worthwhile, with IRRs of 22% to 29% and B/C ratios of 1.6 to over 2.0.

The main Terai analyses compare economic benefits from the three main land classes under likely future (improved performance) cropping, firstly the widely-occurring Class 2 Mixed (see Section 6.1); secondly Class 2 Upland areas where rice production is not possible and a maize-wheat pattern predominates; and finally Class 2R Lowland areas where cropping is very restricted and water requirements early in the monsoon high.

The three classes compare as follows:

Land class	IRR (%)	B/C (ratio)
2 Mixed	22.5	1.57
2 Upland	20.1	1.48
2R Lowland	16.6	1.22

As discussed in Volume 2, Land Resources and Agriculture, there are substantial areas of Class 2 mixed land, and the results confirm that they should be given first priority for groundwater development. Apart from the better economic returns, such areas are versatile in terms of cropping diversification where circumstances allow for it.

9.5 Financial Benefits

9.5.1 General

Medium and deep tubewells benefit groups of farmers. One of the characteristics of such groups when freely formed would probably be that they are members of communities who are more willing than most to adopt new ideas and cooperate in the ways necessary to jointly operate a command area of 12 to 70 ha and more. The more likely level of cropping that they will practise is represented by the Improved Performance case. As illustrated in Table 9.7, this will result in the excellent returns presented below. Returns assuming lower cropping and water management standards, the Base Case, are also given.

TABLE 9.7

Summary of Deep Tubewell Financial Analyses 60 l/s (1993 prices)

Case	Land class (1)	IRR (%)	NPV (Rs'000)	B/C ratio
Base (present)	2M		455	1.12
Main Terai		14.6	148	1.04
Inner Terai		12.9		
Improved (future)	2M	24.3	2 609	1.67
Main Terai		24.4	2 597	1.71
Inner Terai				

Note: (1) 2M = Class 2 mixed

Source: GDC estimates

9.5.2 Basic Analysis

Table 9.7 summarises the financial internal rates of return, and benefit-cost ratios calculated over a 20 year period using a discount rate of 12%. The flow of benefits used in the analyses was given in Table 9.5. These are the "gross" benefits - the crop gross margins in full, without deducting the value of crops previously grown, rainfed, in the DTW command area.

As with the economic analyses IP standard cropping results in good returns in both areas. The Present or BC level of yields and inputs, however, shows marginal returns, 12.9% IRR and 1.04 B/C ratio, in the inner Terai. The returns are better under main Terai conditions, 14.6% IRR and 1.12 B/C ratio.

9.5.3 Returns to Farmers

The returns to farmers at 1993 financial prices generally prevailing in the main Terai (Central stratum) and the inner Terai as summarised in Table 9.8 for the Base Case and Table 9.9 for Improved Performance cropping conditions. As noted earlier, these two cases incorporate assumptions to reflect the present levels of MTW and DTW cropping, yields, use of inputs and intensities, and BC and medium term future crop cultivation practices and results (IP case). The IP case incremental benefits are net of forecast future rainfed cropping which, as discussed earlier in this volume, gives rather higher yields than at present.

TABLE 9.8

Deep Tubewell Net Income (60 l/s) Base Case Land Class 2 Mixed (Rs '000/year)

Stratum	Area (ha)	Year			
		1	2	3	4
Main Terai	48				
With DTW					
- Gross income		138	275	481	688
- Operating costs		76	152	152	152
- Net income		62	123	329	536
Without DTW					
- Net income		188	377	377	377
- Increase		-126	-254	-48	159
Rs/unit					
- Increase x		0.33	0.33	0.87	1.42
Inner Terai	48				
With DTW					
- Gross income		121	242	424	605
- Operating costs		63	126	126	126
- Net income		58	116	298	479
Without DTW					
- Net income		103	205	205	205
- Increase		-44	-89	93	274
Rs/unit					
- Increase x		0.57	0.57	1.45	2.33

Source: GDC estimates

TABLE 9.9

Deep Tubewell Net Income (60 l/s) Improved Performance Land Class 2 Mixed (1993 financial prices) (Rs '000/year)

Stratum	Area (ha)	Year					
		1	2	3	4	5	6
Main Terai	48						
With DTW							
- Gross income		172	343	629	915	1086	1143
- Operating costs		88	176	176	176	176	176
- Net income		84	167	453	739	910	967
Without DTW							
- Net income		241	482	482	482	482	482
- Increase		-157	-315	-29	257	428	485
Rs/unit							
- Increase x		0.35	0.35	0.94	1.53	1.89	2.01
Inner Terai	48						
With DTW							
- Gross income		165	329	604	878	1043	1098
- Operating costs		70	141	141	141	141	141
- Net income		95	188	463	737	902	957
Without DTW							
- Net income		125	250	250	250	250	250
- Increase		-30	-61	214	488	653	708
•Rs/unit							
- Increase x		0.76	0.75	1.86	2.95	3.61	3.83

Source: GDC estimates

Assuming, as discussed in Section 8.5.4, that farmers would be unwilling to meet loan repayments before attaining a threshold income 25% higher than they are able under rainfed conditions, farmers in both the BC and IP cropping cases would have funds available to repay, in part or entirely, the capital cost of a 60 l/s DTW.

The levels of this annual "surplus" for repayments are shown in Table 9.10. In terms of repayment for each hectare and for the whole command area, these amounts are forecast to be:

Base Case	Year		
	2	3	4
Main Terai			
Ratio: irrigated to rainfed income	0.33	0.87	1.42
"Surplus" (Rs/ha)	-	-	1 350
(Rs/DTW)	-	-	64 700
Inner Terai			
Ratio: irrigated to rainfed income	0.57	1.45	2.33
"Surplus" (Rs/ha)	-	870	4 640
(Rs/DTW)	-	41 800	222 800

TABLE 9.10

Summary of Improvement in Net DTW Income and Loan Repayment Capacity

Case	Target income*	Year				
		2	3	4	5	6
Base Case (present)						
Main Terai						
- Rs/ha	9 819	-7 256	-2 965	1 348	1 348	1 348
- Rs '000/DTW (48 ha)	471.3	-348.3	-142.3	64.7	64.7	64.7
Inner Terai						
- Rs/ha	5 338	-2 921	871	4 642	4 642	4 642
- Rs '000/DTW (48 ha)	256.2	-140.2	41.8	222.8	222.8	222.8
Improved Performance (future)						
Main Terai						
- Rs/ha	12 550	-9 071	-3 113	2 846	6 408	7 596
- Rs '000/DTW (48 ha)	602.4	-435.4	-149.4	136.6	307.6	364.6
Inner Terai						
- Rs/ha	6 513	-2 596	3 133	8 842	12 279	13 425
- Rs' 000/DTW (48 ha)	312.6	-124.6	150.4	424.4	589.4	644.4

Note: * (without tubewell net income) x 1.25 for a full year

Source: GDC estimates.

Taking year one as the year when the well is installed repayments under typical present conditions some repayment of capital costs could be made from year four in the main Terai and a year earlier in the Inner Terai when benefits are greater, as demonstrated earlier. In the future, when cultivation practices are improved, the repayment possibilities would be as summarised below:

Improved Case		Year				
		2	3	4	5	6
Main Terai						
Ratio: rainfed income		0.35	0.94	1.53	1.89	2.01
"Surplus"	(Rs/ha)	-	-	2 850	6 410	7 600
	(Rs/DTW)	-	-	136 600	307 600	364 600
Inner Terai						
Ratio: rainfed income		0.75	1.86	2.95	3.61	3.83
"Surplus"	(Rs/ha)	-	3 310	8 840	12 280	13 430
	(Rs/DTW)	-	150 400	424 400	589 400	644 400

The relative differences between the two areas are the same but repayments would be significantly higher.

APPENDICES

APPENDIX I

STUDY AREA POPULATION AND FARM STRUCTURE

1 Population

Details of the Study Areas 1971, 1981 and 1991 population by District Development Region and Study Area analysis strata are given in Table I.1. The number of households and household sizes is shown in Table I.2. Table I.3 from 1981 census data gives the District figures for literacy and the proportions of the population that were economically active in agriculture at that time. The figures will have changed but data from the 1991 census are not available.

2 Farm Structure

The following tables of preliminary results from the 1990/91 National Sample Census of Agriculture provide background to the characteristics of agriculture in the Study Area outlined in Chapter 2.

Table I.4 Holding size distribution by District and Study Stratum

Table I.5 Fragmentation of holding by stratum

Table I.6 Land tenure type by stratum

TABLE I.1

Terai Study Area Population 1971, 1981, 1991

Development region/districts/ stratum	Area (km2)	1971 (Nr)	1971 (Pers/km2)	1981 (Nr)	1981 (Pers/km2)	1991 (Nr)	1991 (Pers/km2)	Annual Growth Rate (%) 1971-81	Annual Growth Rate (%) 1981-91
Far West									
Kanchanpur	1,610	68,863	43	168,971	105	258,508	161	9.39	4.34
Kailali	3,235	128,877	40	257,905	80	420,035	130	7.18	5.00
sub-total	4,845	197,740	41	426,876	88	678,543	140	8.00	4.74
Mid West									
Bardia	2,025	101,793	50	199,044	98	289,840	143	6.94	3.83
Banke	2,337	125,709	54	205,323	88	284,430	122	5.03	3.31
sub-total	4,362	227,502	52	404,367	93	574,270	132	5.23	3.25
Total West Stratum	9,207	425,242	46	831,243	90	1,252,813	136	6.93	4.19
West									
Kapilvastu	1,738	205,216	118	270,045	155	372,205	214	2.78	3.26
Rupandehi	1,360	243,346	179	379,096	279	507,689	373	4.53	2.96
Nawalparasi	2,162	146,548	68	308,828	143	435,256	201	7.74	3.49
sub-total	5,260	595,110	113	957,969	182	1,315,150	250	4.88	3.22
Central									
Parsa	1,353	202,123	149	284,338	210	371,533	275	3.47	2.71
Bara	1,190	233,401	196	318,957	268	413,294	347	3.17	2.63
Rautahat	1,126	320,093	284	332,526	295	412,921	367	0.38	2.19
Sarlahi	1,259	175,543	139	398,766	317	490,390	390	8.55	2.09
Mahottari	1,002	324,831	324	361,054	360	440,774	440	1.06	2.02
Dhanusha	1,180	330,061	280	432,569	367	541,975	459	2.74	2.28
sub-total	7,110	1,586,052	223	2,128,210	299	2,670,887	376	3.04	2.40
Total Central Stratum	12,370	2,181,162	176	3,086,179	249	3,986,037	322	3.53	2.59
East									
Siraha	1,188	302,304	254	375,358	316	460,122	387	2.19	2.06
Saptari	1,363	312,565	229	379,055	278	464,500	341	1.95	2.05
Sunsari	1,257	223,434	178	344,594	274	464,767	370	4.43	3.04
Morang	1,855	301,557	163	534,692	288	676,417	365	5.90	2.38
Jhapa	1,606	247,698	154	479,743	299	594,100	370	6.83	2.16
Udayapur (1)	2,063	112,622	55	159,805	77	218,889	106	3.56	3.20
Total East Stratum	9,332	1,500,180	161	2,273,247	244	2,878,795	308	4.24	2.39
Inner Terai									
Surket	2,451	104,933	43	166,196	68	225,296	92	4.71	3.09
Dangdeukhuri	2,955	167,820	57	266,393	90	352,237	119	4.73	2.83
Chitwan	2,218	183,644	83	259,571	117	355,298	160	3.52	3.19
Total Inner Terai	7,624	456,397	60	692,160	91	932,831	122	4.20	3.03
Study area	38,533	4,562,981	118	6,882,829	179	9,050,476	235	4.28	2.78
National	147,181	11,555,983	79	15,022,839	102	18,462,081	125	2.66	2.08
Study Area % nation	26.2	39.5	150.8	45.8	175.0	49.0	187.2	160.90	133.70

(1) Small area outside Terai included for completeness.

Source: Statistical Yearbook of Nepal 1991, Statistical Pocket Book, Nepal 1992
Central Bureau of Statistics, Kathmandu Provisional 1991 Population Census data.

TABLE I.2

Study Area Household Sizes 1991

Development region, stratum and districts	Households (Nr)	Male (Nr)	Female (Nr)	Total (Nr)
Far West				
Kanchanpur	40,298	3.26	3.16	6.41
Kailali	61,001	3.46	3.42	6.89
sub-total	101,299	3.38	3.32	6.70
Mid West				
Bardia	41,194	3.58	3.46	7.04
Banke	49,059	3.00	2.80	5.80
sub-total	90,253	3.27	3.10	6.36
Total West Stratum	191,552	3.33	3.21	6.54
West				
Kapilvastu	60,990	3.16	2.95	6.10
Rupandehi	84,235	3.08	2.95	6.03
Nawalparasi	74,482	2.92	2.92	5.84
sub-total	219,707	3.05	2.94	5.99
Central				
Parsa	61,554	3.13	2.90	6.04
Bara	68,786	3.10	2.90	6.01
Rautahat	76,860	2.79	2.58	5.37
Sarlahi	87,985	2.89	2.69	5.57
Mahottari	80,396	2.85	2.64	5.48
Dhanusha	98,239	2.86	2.65	5.52
sub-total	473,820	2.92	2.71	5.64
Total Central Stratum	693,527	2.96	2.78	5.75
East				
Siraha	83,950	2.80	2.68	5.48
Saptari	85,772	2.74	2.67	5.42
Sunsari	84,897	2.77	2.70	5.47
Morang	129,136	2.66	2.58	5.24
Jhapa	110,939	2.70	2.65	5.36
Udayapur (1)	40,430	2.69	2.72	5.41
Total East Stratum	535,124	2.73	2.65	5.38
Inner Terai				
Surket	39,830	2.81	2.85	5.66
Dangdeukhuri	56,213	3.14	3.13	6.27
Chitwan	65,882	2.68	2.71	5.39
Total Inner Terai	161,925	2.87	2.89	5.76
Study area	1,582,128	2.92	2.80	5.72
National	3,345,052	2.76	2.76	5.52
Study Area % national	47.30	105.82	101.47	103.65

(1) Small area outside Terai included for completeness.

Source: Statistical Yearbook of Nepal 1991, Statistical Pocket Book, Nepal 1992
Central Bureau of Statistics, Kathmandu Provisional 1991 Population Census data.

TABLE I.3

Economically Active Population 1981

Development Region & Districts	Total Nr	Economically active (%) (2)	Agriculture (1) (Nr)	(%) (2)	% econ active	Literate (Nr)	(%)
Far West							
Kanchanpur	72,203	42.7	68,621	40.6	95.0	30,792	18.2
Kailali	102,661	39.8	96,361	37.4	93.9	32,138	12.5
sub-total	174,864	41.0	164,982	38.6	94.3	62,930	14.7
Mid West							
Bardia	103,230	51.9	100,329	50.4	97.2	21,239	10.7
Banke	88,183	42.9	75,693	36.9	85.8	29,721	14.5
sub-total	191,413	47.3	176,022	43.5	92.0	50,960	12.6
Total West Stratum	366,277	44.1	341,004	41.0	93.1	113,890	13.7
West							
Kapilvastu	138,253	51.2	131,359	48.6	95.0	28,141	10.4
Rupandehi	132,292	34.9	113,232	29.9	85.6	85,521	22.6
Nawalparasi	136,907	44.3	126,529	41.0	92.4	56,873	18.4
sub-total	407,452	42.5	371,120	38.7	91.1	170,535	17.8
Central							
Parsa	123,901	43.6	111,364	39.2	89.9	47,741	16.8
Bara	116,429	36.5	10,400	3.3	8.9	45,863	14.4
Rautahat	172,759	52.0	164,132	49.4	95.0	33,922	10.2
Sarlahi	140,651	35.3	120,381	30.2	85.6	50,236	12.6
Mahottari	143,597	39.8	127,853	35.4	89.0	46,752	12.9
Dhanusha	154,385	35.7	124,265	28.7	80.5	64,691	15.0
sub-total	851,722	40.0	658,395	30.9	77.3	289,205	13.6
Total Central Stratum	1,259,174	40.8	1,029,515	33.4	81.8	459,740	14.9
East							
Siraha	149,302	39.8	131,532	35.0	88.1	53,488	14.2
Saptari	143,375	37.8	111,836	29.5	78.0	77,179	20.4
Sunsari	122,759	35.6	90,172	26.2	73.5	86,393	25.1
Morang	219,563	41.1	178,728	33.4	81.4	132,543	24.8
Jhapa	193,555	40.3	154,562	32.2	79.9	145,011	30.2
Udayapur (3)	74,997	46.9	66,866	41.8	89.2	25,116	15.7
Total East Stratum	903,551	39.7	733,696	32.3	81.2	519,730	22.9
Inner Terai							
Surket	70,464	42.4	66,399	40.0	94.2	27,564	16.6
Dangdeukhuri	98,500	37.0	91,945	34.5	93.3	46,025	17.3
Chitwan	91,732	35.3	77,017	29.7	84.0	71,588	27.6
Total Inner Terai	260,696	37.7	235,361	34.0	90.3	145,177	21.0
Study area	2,789,698	40.5	2,339,576	34.0	83.9	1,238,537	18.0

Notes: (1) Agriculture, forestry and fisheries.
(2) Proportion of total population.
(3) Small area outside Terai included for completeness.

Source: Statistical Yearbook of Nepal 1991, Central Bureau of Statistics, Kathmandu

TABLE I.4

Terai Holding Size Distribution 1990/91

Stratum/ District	Marginal (under 1 ha)(1)			Small (1-3 ha)			Medium (3-5 ha)			Large (over 5 ha)			Total		
	HH ('000)	Area ('000 ha)	Aver. (ha)	HH ('000)	Area ('000 ha)	Aver. (ha)	HH ('000)	Area ('000 ha)	Aver. (ha)	HH ('000)	Area ('000 ha)	Aver. (ha)	HH ('000)	Area ('000 ha)	Aver. (ha)
West															
Kanchanpur	15.13	7.12	0.47	16.73	25.64	1.53	1.88	6.83	3.64	1.03	7.38	7.18	34.76	46.98	1.35
Kailali	26.05	10.49	0.40	17.58	29.39	1.67	3.86	14.64	3.80	1.96	15.54	7.94	49.45	70.06	1.42
Bardia	13.40	5.29	0.40	12.74	21.55	1.69	3.08	11.66	3.79	1.62	12.21	7.56	30.83	50.72	1.64
Banke	17.36	8.27	0.48	14.60	24.75	1.69	2.33	8.64	3.70	0.93	7.41	8.01	35.22	49.06	1.39
sub-total	71.94	31.17	0.43	61.65	101.33	1.64	11.14	41.77	3.75	5.53	42.55	7.70	150.26	216.82	1.44
Central															
Kapilvastu	22.23	11.00	0.49	21.26	36.99	1.74	3.96	14.79	3.74	2.88	27.60	9.60	50.32	90.39	1.80
Rupandchi	40.63	19.28	0.47	21.77	34.85	1.60	2.48	9.03	3.64	1.39	10.04	7.24	66.27	73.19	1.10
Nawalparasi	39.73	16.61	0.42	19.90	31.07	1.56	2.64	9.88	3.74	1.55	14.01	9.02	63.82	71.56	1.12
Parsa	26.35	9.82	0.37	9.89	16.29	1.65	1.92	7.17	3.74	1.14	10.17	8.95	39.30	43.45	1.11
Bara	32.93	13.59	0.41	15.15	25.30	1.67	3.03	11.17	3.69	1.47	10.90	7.41	52.58	60.96	1.16
Rautahat	40.18	16.03	0.40	17.74	29.99	1.69	2.93	10.98	3.75	1.26	8.96	7.11	62.11	65.97	1.06
Sarlahi	37.55	15.45	0.41	19.76	32.16	1.63	2.91	11.26	3.87	1.96	16.28	8.30	62.18	75.15	1.21
Mahottari	37.19	15.09	0.41	15.76	26.23	1.66	3.40	13.14	3.87	1.18	9.28	7.85	57.53	63.75	1.11
Dhanusha	44.98	17.73	0.39	18.35	29.92	1.63	2.91	11.17	3.84	1.79	14.79	8.27	68.03	73.61	1.08
sub-total	321.77	134.60	0.42	159.58	262.80	1.65	26.18	98.60	3.77	14.62	122.04	8.35	522.14	618.04	1.18
East															
Siraha	38.22	15.84	0.41	19.77	33.25	1.68	3.88	14.36	3.70	1.56	13.50	8.66	63.43	76.94	1.21
Saptari	36.67	15.95	0.44	21.64	37.05	1.71	3.47	13.24	3.82	2.03	16.89	8.32	63.81	83.13	1.30
Sunsari	20.29	6.90	0.34	17.14	29.92	1.75	3.17	11.77	3.71	1.90	15.21	8.02	42.49	63.80	1.50
Morang	38.65	14.45	0.37	29.36	50.04	1.70	6.31	23.68	3.75	2.34	22.73	9.70	76.66	110.90	1.45
Jhapa	37.67	14.14	0.38	28.22	47.63	1.69	4.99	18.93	3.79	2.74	24.39	8.90	73.62	105.09	1.43
Udayapur	24.82	11.61	0.47	9.51	14.61	1.54	0.63	2.32	3.68	0.29	2.41	8.22	35.25	30.94	0.88
sub-total	196.32	78.89	0.40	125.65	212.50	1.69	22.45	84.30	3.76	10.86	95.11	8.76	355.27	470.81	1.33
Teral total	590.02	244.66	0.41	346.88	576.63	1.66	59.77	224.66	3.76	31.01	259.70	8.38	1027.67	1305.66	1.27
Inner Teral															
Surket	25.93	12.21	0.47	8.15	12.05	1.48	0.26	0.98	3.71	0.12	1.36	11.14	34.46	26.60	0.77
Dangdeukhuri	27.70	12.34	0.45	15.83	25.22	1.59	2.93	11.04	3.77	0.84	7.85	9.31	47.30	56.44	1.19
Chitwan	37.57	14.61	0.39	14.06	22.06	1.57	1.19	4.34	3.65	0.22	1.80	8.15	53.04	42.81	0.81
sub-total	91.20	39.16	0.43	38.04	59.33	1.56	4.38	16.36	3.73	1.19	11.01	9.28	134.81	125.85	0.93
Study area	681.22	283.82	0.42	384.91	635.96	1.65	64.15	241.02	3.76	32.19	270.70	8.41	1162.47	1431.50	1.23

Source: National Sample Census of Agriculture 1990/91. Preliminary results.

TABLE I.5

Land Fragmentation in the Terai

Stratum	1	2-3	4-5	6-9	Over 10	Aver# per HH
All holdings						
West	29	48	15	6	2	2.7
Central	11	41	21	16	11	4.8
East	29	40	15	10	6	3.4
Inner Terai	40	40	11	6	3	2.7
Study Area	22	41	17	12	7	3.8
Large holdings (over 5 ha)						
West	3	20	36	26	15	5.9
Central	0	10	16	26	48	11.3
East	7	27	26	18	22	6.3
Inner Terai	0	14	21	25	40	8.8
Study Area	3	18	23	23	33	6.6
Medium holdings (3-5 ha)						
West	4	34	36	20	5	4.6
Central	1	9	20	33	37	3.6
East	7	36	20	21	15	5.5
Inner Terai	8	13	20	32	26	12.0
Study Area	4	24	23	27	23	7.2
Small holdings (1-3 ha)						
West	15	56	20	7	1	3.1
Central	2	25	27	27	18	6.5
East	16	41	20	15	9	5.5
Inner Terai	13	45	22	14	6	4.0
Study Area	10	37	23	18	11	5.0
Marginal holdings (under 1 ha)						
West	48	45	5	1	0	1.8
Central	16	53	19	9	3	3.2
East	42	40	11	6	1	2.4
Inner Terai	53	39	5	2	1	1.8
Study Area	32	47	14	5	2	2.7

Note: HH Household

Source: National Sample Census of Agriculture 1990/91. Preliminary data.

TABLE I.6

Nepal Terai Land Tenure 1990/91 (%)

Stratum	One Tenure Holdings							Mixed Tenure Holdings						Grand Total
	Owner Operator	Rent Cash	Rent Kind	Total rent	Share crop	Other	Total	Rent Cash	Rent Kind	Total rent	Share crop	Other	Total	
West	86.95	0.12	0.06	0.18	0.77	0.64	1.59	0.27	0.70	0.97	8.85	1.64	11.46	100.00
Central	77.05	0.04	0.10	0.14	0.35	0.32	0.81	1.73	6.54	8.27	11.49	2.38	22.14	100.00
East	70.00	1.02	1.18	2.20	3.35	2.03	7.58	1.04	8.10	9.14	10.14	3.15	22.43	100.00
Inner Terai	85.69	0.06	0.03	0.09	0.79	0.79	1.67	0.63	0.38	1.01	9.15	2.49	12.65	100.00
Study Area	77.59	0.33	0.38	0.71	1.31	0.91	2.93	1.18	5.34	6.52	10.43	2.51	19.46	100.00

Source: National Sample Census of Agriculture 1990/91. Preliminary results.

APPENDIX II

CROP LABOUR REQUIREMENTS

1 Background

Crop labour requirement estimates were derived from a number of sources in Nepal, Pakistan, Indonesia and elsewhere. The requirements, by operation are given in Tables II.1 to II.4.

In each case land preparation by bullock ploughing and puddling has been assumed and all other work is by hand. The tables show the different levels of input related to the crop yields in each stratum adopted for the study analyses. They are given for four yield cases :

Without Tubewell Present (rainfed)
Without Tubewell Future (rainfed)
With Tubewell Present - Base Case
With Tubewell Future - Improved Performance Case

TABLE II.1

Crop Labour Requirements: Rice (hours/hectare)

	West				Central				East				Inner Terai			
Operation	-TW pres	-TW fut	+ TW pres	+ TW fut	-TW pres	-TW fut	+ TW pres	+ TW fut	-TW pres	-TW fut	+ TW pres	+ TW fut	-TW pres	-TW fut	+ TW pres	+ TW fut
Yield (kg/ha)	1,700	2,150	2,800	4,000	1,800	2,250	2,800	4,000	1,800	2,250	2,800	4,000	1,900	2,350	2,900	4,500
Land preparation	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Transplanting	250	300	300	300	250	300	300	300	250	300	300	300	250	300	300	300
Cultivation and irrigation	60	100	170	170	60	100	170	170	60	100	170	170	60	100	170	170
Harvesting	123	139	163	206	131	145	163	206	131	151	163	206	127	152	162	211
Post harvesting	114	144	187	269	121	151	187	269	121	151	187	269	127	157	194	302
Total (h/ha)	947	1,083	1,220	1,344	962	1,096	1,220	1,344	962	1,102	1,220	1,344	965	1,109	1,227	1,383
Std. days/ha (1)	118	135	153	168	120	137	153	168	120	138	153	168	121	139	153	173
Rates (kg/day)																
Harvesting	110	124	137	156	110	124	137	156	110	119	137	156	119	124	143	171
Post harvesting	120	119	120	119	119	119	120	119	119	119	120	119	119	119	119	119

Note: (1) Assumes an 8 hour day

Source: GDC estimates

TABLE II.2

Crop Labour Requirements: Wheat (hours/hectare)

Operation	West				Central				East				Inner Terai			
	-TW pres	-TW fut	+ TW pres	+ TW fut	-TW pres	-TW fut	+ TW pres	+ TW fut	-TW pres	-TW fut	+ TW pres	+ TW fut	-TW pres	-TW fut	+ TW pres	+ TW fut
Yield (kg/ha)	1,000	1,450	1,600	2,800	1,200	1,650	1,600	2,800	1,500	1,950	2,000	3,200	800	1,100	1,600	2,800
Land preparation and planting	110	150	150	190	110	150	150	190	110	150	150	190	110	150	150	190
Irrigation	15	15	80	80	15	15	80	80	15	15	80	80	15	15	80	80
Harvesting	95	109	120	168	90	123	120	168	112	139	143	192	76	105	120	168
Post harvesting	22	28	31	41	23	32	31	41	29	37	38	47	17	24	31	41
Total (h/ha)	242	302	381	479	238	320	381	479	266	341	411	509	219	294	381	479
Std. (days/ha) (1)	30	38	48	60	30	40	48	60	33	43	51	64	27	37	48	60
Rates (kg/ha)																
Harvesting	84	107	107	133	107	107	107	133	107	112	112	133	84	84	107	133
Post harvesting	366	413	413	549	413	413	413	549	413	424	424	549	366	366	413	549

Note: (1) Assumes an 8 hour day

Source: GDC estimates

TABLE II.3

Crop Labour Requirements: Maize (hours/hectare)

Operation	West				Central				East				Inner Terai			
	-TW pres	-TW fut	+ TW pres	+ TW fut	-TW pres	-TW fut	+ TW pres	+ TW fut	-TW pres	-TW fut	+ TW pres	+ TW fut	-TW pres	-TW fut	+ TW pres	+ TW fut
Yield (kg/ha)	1,000	1,450	1,600	2,800	1,400	1,850	1,800	3,000	1,500	1,950	2,000	3,200	1,000	1,250	1,100	1,500
Land preparation and planting	110	150	150	190	110	150	150	190	110	150	150	190	110	150	150	190
Cultivation and Irrigation	35	50	96	96	35	50	96	96	35	50	96	96	35	50	96	96
Harvesting	120	160	160	224	168	204	180	240	180	215	200	256	120	138	110	120
Post harvesting	160	232	256	448	224	296	288	480	240	312	320	512	160	200	176	240
Total (h/ha)	425	592	662	958	537	700	714	1,006	565	727	766	1,054	425	538	532	646
Std. (days/ha) (1)	53	74	83	120	67	87	89	126	71	91	96	132	53	67	67	81
Rates (kg/day)																
Harvesting	67	73	80	100	67	73	80	100	67	73	80	100	67	73	80	100
Post harvesting	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

(1) Assumes an 8 hour day

Source: GDC estimates

TABLE II.4

Crop Labour Requirements: Non-Cereal Crops (hours/hectare)

Operation	Potato Irrig	Potato Irrig	Potato Irrig	Potato Irrig	Oilseed Unirrig	Oilseed Irrig	Oilseed Irrig	Pulse Unirrig	Pulse Irrig
Yield (kg/ha)	5,000	6,000	10,000	13,000	500	560	700	460	700
Land preparation and planting	320	320	400	400	40	55	110	37	100
Cultivation and Irrigation	180	220	220	220	15	80	80	15	80
Harvesting	551	661	787	1,024	42	47	59	22	33
Post harvesting	80	96	100	130	30	34	42	35	53
Total (h/ha)	1,131	1,297	1,507	1,774	127	216	291	109	267
Std. (days/ha) (1)	141	162	188	222	16	27	36	14	33
Rates (kg/day)									
Harvesting	73	73	102	102	95	95	95	167	167
Post harvesting	500	500	800	800	133	133	133	105	105

Note: (1) Assumes an 8 hour day

Source: Consultants' estimates

APPENDIX III

CROP BUDGETS

1 Financial

The crop gross margin budgets used in the analyses are set out at 1993 financial prices in Tables III.1 to III.8 for each of the four Study Strata: West, Central, East and Inner Terai. The basis for the gross margins is discussed in Chapter 4 and, in detail in Volume 2, Part B, Agriculture.

2 Economic

Tables III.9 to III.16 present the same budgets at projected economic values which are at constant 1993 prices. The derivation of the values is given in Chapter 3.

TABLE III.1

Gross Margin: Cereal Crops Without Irrigation Present 1993 Financial Prices (Rs/ha)

	West			Central			East			Inner Terai		
	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize
Gross income	7,990	3,500	3,300	9,180	4,800	6,300	8,100	6,150	6,600	9,120	3,200	3,300
Variable costs												
Seed	691	700	190	750	800	259	662	820	253	706	1,008	190
Fertiliser												
- Urea	116	58	0	290	174	0	116	58	0	116	58	0
Bullock	605	275	55	605	165	165	440	165	110	605	275	55
Labour	1,817	116	260	1,890	126	328	1,932	139	348	1,906	113	260
- Containers	64	50	50	68	60	70	68	75	75	71	40	50
Total variable costs	3,293	1,199	554	3,602	1,325	822	3,217	1,257	786	3,404	1,494	554
Gross margin	4,697	2,302	2,746	5,578	3,475	5,478	4,883	4,893	5,814	5,716	1,706	2,746

Source: GDC estimates (ref Volume 2, Agriculture)

TABLE III.2

Gross Margin: Other Crops Without Irrigation Present 1993 Financial Prices (Rs/ha)

	West			Central			East			Inner Terai		
	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato
Gross Income	6,150	6,808	13,500	6,700	6,440	12,500	6,700	6,072	12,000	6,150	4,370	13,500
Variable Costs												
Seed	277	289	2,700	302	273	2,500	302	257	2,400	277	185	2,700
Fertiliser												
- Manure/comp.	0	0	200	0	0	200	0	0	200	0	0	200
- Urea	0	0	290	0	0	290	0	0	290	0	0	290
Agro-chemicals	0	0	100	0	0	100	0	0	100	0	0	100
Bullock	0	0	550	0	0	550	0	0	550	0	0	550
Labour	39	44	1,234	39	44	1,234	39	44	1,234	39	44	1,234
Containers	21	23	231	21	23	231	21	23	231	21	23	231
Total VC	337	356	5,305	362	340	5,105	362	325	5,005	337	252	5,305
Gross margin	5,813	6,452	8,195	6,338	6,100	7,395	6,338	5,748	6,995	5,813	4,118	8,195

Source: GDC estimates (ref Volume 2, Agriculture)

TABLE III.3

Gross Margin: Cereal Crops Without Irrigation Future
1993 Financial Prices (Rs/ha)

	West			Central			East			Inner Terai		
	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize
Gross Income	10105	5075	4785	11475	6600	8325	10125	7585	8140	11280	4400	4125
Variable Costs												
Seed	691	700	190	750	800	259	662	820	253	706	800	190
Fertiliser												
- Urea	290	290	174	464	348	290	290	290	290	290	174	0
Bullock	619	253	63	578	182	190	436	162	124	619	253	63
Labour	2079	146	363	2158	168	426	2222	181	446	2174	155	328
Containers	108	97	97	113	111	124	113	124	124	118	74	63
Total variable costs	3787	1486	887	4062	1608	1289	3722	1576	1237	3906	1456	644
Gross margin	6318	3589	3898	7413	4992	7036	6403	6009	6903	7374	2944	3481

Source : GDC estimates (ref. Volume 2, Agriculture)

TABLE III.4

Gross Margin: Other Crops Without Irrigation Future
1993 Financial Prices (Rs/ha)

	West			Central			East			Inner Terai		
	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato
Gross Income	6150	6808	16200	6700	6440	15000	6700	6072	14400	6150	4370	16200
Variable Costs												
Seed	277	289	3240	302	273	3000	302	257	2880	277	185	3240
Fertiliser												
- Manure/compos	0	0	200	0	0	200	0	0	200	0	0	200
- Urea	0	0	290	0	0	290	0	0	290	0	0	290
Pesticides	0	0	200	0	0	200	0	0	200	0	0	200
Bullock	0	0	550	0	0	550	0	0	550	0	0	550
Labour	39	44	1418	39	44	1418	39	44	1418	39	44	1418
Containers	21	23	371	21	23	371	21	23	371	21	23	371
Total VC	337	356	6269	362	340	6029	362	325	5909	337	252	6269
Gross Margin	5813	6452	9931	6338	6100	8971	6338	5748	8491	5813	4118	9931

Source : consultants estimates (ref. Volume 2, Agriculture)

TABLE III.5

Gross Margin: Cereal Crops With Irrigation Base Case(1)
1993 Financial Prices (Rs/ha)

	West			Central			East			Inner Terai		
	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize
Gross Income	13,160	5,600	5,280	14,280	6,400	8,100	12,600	8,200	8,800	13,440	6,400	3,630
Variable Costs												
Seed	691	700	190	750	800	259	662	820	253	706	1,008	190
Fertiliser												
- Urea	580	580	290	580	580	290	580	580	290	580	580	0
Bullock	817	308	74	712	198	223	316	215	215	817	231	74
Labour	2,410	420	726	2,410	420	779	2,410	446	840	2,410	420	586
Containers	141	107	107	141	107	121	141	134	134	141	107	74
Pesticides	170	70	0	170	70	80	170	70	80	170	70	0
Total VC	4,808	2,185	1,387	4,762	2,175	1,751	4,278	2,265	1,812	4,823	2,416	924
Gross Margin	8,352	3,415	3,893	9,518	4,225	6,349	8,322	5,935	6,989	8,617	3,984	2,706

Source: GDC estimates (ref. Volume 2, Agriculture)

TABLE III.6

Gross Margin: Other Crops With Irrigation Base Case(1)
1993 Financial Prices (Rs/ha)

	West			Central			East			Inner Terai		
	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato
Gross Income	6,888	6,808	27,000	7,504	6,440	25,000	7,504	6,072	24,000	6,888	4,370	27,000
Variable Costs												
Seed	277	289	4,860	302	273	4,500	302	257	4,320	277	185	4,860
Fertiliser												
- Manure/compos	0	0	400	0	0	400	0	0	400	0	0	400
- Urea	0	0	580	0	0	580	0	0	580	0	0	580
Pesticides	0	0	200	0	0	200	0	0	200	0	0	200
Bullock	0	0	550	0	0	550	0	0	550	0	0	550
Labour	236	123	2,632	236	123	2,632	236	123	2,632	236	123	2,632
Containers	32	31	618	32	31	618	32	31	618	32	31	618
Total VC	545	442	9,840	570	426	9,480	570	411	9,300	545	339	9,840
Gross margin	6,343	6,366	17,160	6,934	6,014	15,520	6,934	5,661	14,700	6,343	4,031	17,160

Source: GDC estimates (ref. Volume 2, Agriculture)

TABLE III.7

Gross Margin: Cereal Crops With Irrigation Improved Performance Case 1993 Financial Prices (Rs/ha)

	West			Central			East			Inner Terai		
	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize
Gross Income	18,330	9,800	9,240	20,400	11,200	13,500	18,000	13,120	14,080	21,600	11,200	4,950
Variable Costs												
Seed	691	700	190	750	800	259	662	820	253	706	1,008	190
Fertiliser												
- Urea	580	580	435	580	580	435	580	580	435	580	580	290
Pesticides	340	140	160	340	140	160	340	140	160	340	140	0
Bullock	817	308	74	712	198	223	316	215	215	817	231	74
Labour	2,630	525	1,050	2,646	525	1,103	2,646	560	1,155	2,725	709	709
Containers	196	188	188	201	188	201	201	214	214	226	188	101
Total VC	5,254	2,441	2,097	5,229	2,431	2,380	4,745	2,529	2,432	5,393	2,855	1,363
Gross margin	13,076	7,359	7,143	15,171	8,769	11,120	13,255	10,591	11,648	16,207	8,345	3,587

Source : GDC estimates (ref. Volume 2, Agriculture)

TABLE III.8

Gross Margin: Other Crops With Irrigation Improved Performance Case 1993 Financial Prices (Rs/ha)

	West			Central			East			Inner Terai		
	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato
Gross Income	8,610	10,360	35,100	9,380	9,800	32,500	9,380	9,240	31,200	8,610	6,650	35,100
Variable Costs												
Seed	277	289	5,940	302	273	5,500	302	257	5,280	277	185	5,940
Fertiliser												
- Manure/compos	0	0	600	0	0	600	0	0	600	0	0	600
- Urea	0	0	870	0	0	870	0	0	870	0	0	870
Pesticides	70	70	600	70	70	600	70	70	600	70	70	600
Bullock	0	0	550	0	0	550	0	0	550	0	0	550
Labour	315	289	3,108	315	289	3,108	315	289	3,108	315	289	3,108
Containers	40	47	804	40	47	804	40	47	804	40	47	804
Total VC	702	694	12,472	727	679	12,032	727	663	11,812	702	591	12,472
Gross Margin	7,908	9,666	22,628	8,653	9,121	20,468	8,653	8,577	19,388	7,908	6,059	22,628

Source : GDC estimates (ref. Volume 2, Agriculture)

TABLE III.9

Gross Margin: Cereal Crops Without Irrigation Present at 1993 Economic Values (Rs/ha)

	West			Central			East			Inner Terai		
	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize
Gross Income	9,690	8,000	6,700	10,620	9,960	9,800	10,800	12,900	10,950	10,830	6,400	6,700
Variable Costs												
Seed	838	1,600	385	867	1,660	402	882	1,720	420	838	1,600	385
Fertiliser												
- Urea	264	132	0	645	387	0	252	126	0	264	132	0
Bullock	1,375	1,265	1,265	1,650	1,815	1,265	1,815	1,155	825	1,375	1,265	1,265
Labour	3,068	780	1,378	3,120	780	1,742	3,120	858	1,846	3,146	702	1,378
Pesticides	0	0	0	0	0	0	0	0	0	0	0	0
Containers	115	90	90	122	108	126	122	135	135	128	72	90
Total Vc	5,660	3,867	3,118	6,404	4,750	3,536	6,191	3,994	3,226	5,751	3,771	3,118
Gross Margin	4,030	4,133	3,582	4,216	5,210	6,265	4,610	8,906	7,724	5,079	2,629	3,582

Source: GDC estimates (ref. Volume 2, Agriculture)

TABLE III.10

Gross Margin: Other Crops Without Irrigation Present at 1993 Economic Values (Rs/ha)

	West			Central			East			Inner Terai		
	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato
Gross Income	6,150	6,808	13,500	6,700	6,440	12,500	6,700	6,072	12,000	6,150	4,370	13,500
Variable Costs												
Seed	277	289	2,700	302	273	2,500	302	257	2,400	277	185	2,700
Fertiliser												
- Manure/compos	0	0	200	0	0	200	0	0	200	0	0	200
- Urea	0	0	660	0	0	645	0	0	630	0	0	660
Pesticides	0	0	90	0	0	90	0	0	90	0	0	90
Bullock	1,265	1,265	2,200	1,265	1,265	2,200	1,265	1,265	2,200	1,265	1,265	2,200
Labour	416	364	3,666	416	364	3,666	416	364	3,666	416	364	3,666
Containers	39	41	415	39	41	415	39	41	415	39	41	415
Total VC	1,996	1,959	9,931	2,021	1,943	9,716	2,021	1,928	9,601	1,996	1,856	9,931
Gross Margin	4,154	4,849	3,569	4,679	4,497	2,784	4,679	4,144	2,399	4,154	2,514	3,569

Source: GDC estimates (ref. Volume 2, Agriculture)

TABLE III.11

Gross Margin: Cereal Crops Without Irrigation Future at 1993 Economic Values (Rs/ha)

	West			Central			East			Inner Terai		
	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize
Gross Income	12,255	11,600	9,715	13,275	13,695	12,950	13,500	15,910	13,505	13,395	8,800	8,375
Variable Costs												
Seed	838	1,600	385	867	1,660	402	882	1,720	420	838	1,600	385
Fertiliser												
- Urea	660	660	396	1,032	774	645	630	630	630	660	396	0
Bullock	1,375	1,265	1,265	1,650	1,815	1,265	1,815	1,155	825	1,375	1,265	1,265
Labour	3,510	988	1,924	3,562	1,040	2,262	3,588	1,118	2,366	3,588	962	1,742
Pesticides	0	0	0	0	0	0	0	0	0	0	0	0
Containers	145	131	131	152	149	167	152	167	167	159	99	113
Total VC	6,528	4,644	4,101	7,263	5,438	4,741	7,067	4,790	4,407	6,620	4,322	3,505
Gross Margin	5,727	6,957	5,614	6,012	8,258	8,209	6,433	11,121	9,098	6,775	4,478	4,870

Source: GDC estimates (ref. Volume 2, Agriculture)

TABLE III.12

Gross Margin: Other Crops Without Irrigation Future at 1993 Economic Values (Rs/ha)

	West			Central			East			Inner Terai		
	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato
Gross Income	6,150	6,808	16,200	6,700	6,440	15,000	6,700	6,072	14,400	6,150	4,370	16,200
Variable Costs												
Seed	277	289	3,240	302	273	3,000	302	257	2,880	277	185	3,240
Fertiliser												
- Manure/comp.	0	0	200	0	0	200	0	0	200	0	0	200
- Urea	0	0	660	0	0	645	0	0	630	0	0	660
Pesticides	0	0	180	0	0	180	0	0	180	0	0	180
Bullock	1,265	1,265	2,200	1,265	1,265	2,200	1,265	1,265	2,200	1,265	1,265	2,200
Labour	416	364	4,212	416	364	4,212	416	364	4,212	416	364	4,212
Containers	39	41	498	39	41	498	39	41	498	39	41	498
Total VC	1,996	1,959	11,190	2,021	1,943	10,935	2,021	1,928	10,800	1,996	1,856	11,190
Gross Margin	4,154	4,849	5,010	4,679	4,497	4,065	4,679	4,144	3,600	4,154	2,514	5,010

Source: GDC estimates (ref. Volume 2, Agriculture)

TABLE III.13

Gross Margin: Cereals Crops With Irrigation Base Case at 1993 Economic Values (Rs/ha)

	West			Central			East			Inner Terai		
	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize
Gross Income	15960	12800	10720	16520	13280	12600	16800	17200	14600	15960	12800	7370
Variable Costs												
Seed	838	1600	385	867	1660	402	882	1720	420	838	1600	385
Fertiliser												
- Urea	1320	1320	660	1290	1290	645	1260	1260	630	1320	1320	0
Bullock	1815	1540	1485	2035	1980	1485	1265	1430	1430	1815	1155	1485
Labour	3978	1248	2158	3978	1248	2314	3978	1326	2496	3978	1248	1742
Pesticides	153	63	0	153	63	72	153	63	72	153	63	0
Containers	189	144	144	189	144	162	189	180	180	189	144	99
Total VC	8293	5915	4832	8512	6385	5081	7727	5979	5228	8293	5530	3711
Gross margin	7667	6885	5888	8008	6895	7520	9073	11221	9372	7667	7270	3659

Source: GDC estimates (ref. Volume 2, Agriculture)

TABLE III.14

Gross Margin: Other Crops With Irrigation Base Case at 1993 Economic Values (Rs/ha)

	West			Central			East			Inner Terai		
	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato
Gross Income	6888	6808	27000	7504	6440	25000	7504	6072	24000	6888	4370	27000
Variable Costs												
Seed	277	289	4860	302	273	4500	302	257	4320	277	185	4860
Fertiliser												
- Manure/compost	0	0	400	0	0	400	0	0	400	0	0	400
- Urea	0	0	1320	0	0	1290	0	0	1260	0	0	1320
Pesticides	0	0	180	0	0	180	0	0	180	0	0	180
Bullock	0	0	2200	0	0	2200	0	0	2200	0	0	2200
Labour	702	364	4888	702	364	4888	702	364	4888	702	364	4888
Containers	43	41	831	43	41	831	43	41	831	43	41	831
Total VC	1022	694	14679	1047	678	14289	1047	663	14079	1022	591	14679
Gross margin	5866	6114	12321	6457	5762	10711	6457	5409	9921	5866	3779	12321

Source: GDC estimates (ref. Volume 2, Agriculture)

TABLE III.15

Gross Margin: Cereals Crops With Irrigation Improved Performance Case at 1993 Economic Values (Rs/ha)

	West			Central			East			Inner Terai		
	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize
Gross Income	22,230	22,400	18,760	23,600	23,240	21,000	24,000	27,520	23,360	25,650	22,400	10,050
Variable Costs												
Seed	838	1,600	385	867	1,660	402	882	1,720	420	838	1,600	385
Fertiliser												
- Urea	1,320	1,320	990	1,290	1,290	968	1,260	1,260	945	1,320	1,320	660
Bullock	1,815	1,540	1,485	2,035	1,980	1,485	1,265	1,430	1,430	1,815	1,155	1,485
Labour	4,342	1,560	3,120	4,368	1,560	3,276	4,368	1,664	3,432	4,498	2,106	2,106
Pesticides	306	126	144	306	126	144	306	126	144	306	126	0
Containers	263	252	252	270	252	270	270	288	288	304	252	135
Total VC	8,884	6,398	6,376	9,136	6,868	6,545	8,351	6,488	6,659	9,081	6,559	4,771
Gross Margin	13,346	16,002	12,384	14,464	16,372	14,455	15,649	21,032	16,701	16,569	15,841	5,279

Source: GDC estimates (ref. Volume 2, Agriculture)

TABLE III.16

Gross Margin: Other Crops With Irrigation Improved Performance Case at 1993 Economic Values (Rs/ha)

	West			Central			East			Inner Terai		
	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato	Oilseed	Pulse	Potato
Gross Income	8,610	10,360	35,100	9,380	9,800	32,500	9,380	9,240	31,200	8,610	6,650	35,100
Variable Costs												
Seed	277	289	5,940	302	273	5,500	302	257	5,280	277	185	5,940
Fertiliser												
- Manure/compost	0	0	600	0	0	600	0	0	600	0	0	600
- Urea	0	0	1,980	0	0	1,935	0	0	1,890	0	0	1,980
Pesticides	63	63	540	63	63	540	63	63	540	63	63	540
Bullock	0	0	2,200	0	0	2,200	0	0	2,200	0	0	2,200
Labour	936	858	5,772	936	858	5,772	936	858	5,772	936	858	5.772
Containers	54	63	1,080	54	63	1,080	54	63	1,080	54	63	1,080
Total Vc	1,330	1,273	18,112	1,355	1,257	17,627	1,355	1,241	17,362	1,330	1,169	18,112
Gross Margin	7,280	9,087	16,988	8,026	8,543	14,873	8,026	7,999	13,838	7,280	5,481	16,988

Source: GDC estimates (ref. Volume 2, Agriculture)

APPENDIX IV

SHALLOW TUBEWELL BENEFITS

1 Shallow Tubewell Benefits

Tables IV.1 to IV.8 set out details of the STW gross margins for the four Study Strata and at financial (IV.1-IV.4) and economic (IV.5-IV.8) prices using the cropping patterns and intensities discussed in Chapter 5 and the individual crop budgets presented in Chapter 4.4 and Appendix III.

Each table sets out the benefits for the following STW cases :

(i) Base or present achievement levels

(ii) Improved Performance which is equivalent to possible future production levels

(iii) High Utilisation assuming Base Case production

(iv) High Utilisation combined with Improved Performance output.

The tables also set out the present and forecast future crop production values under rainfed conditions. These are used to calculate the following incremental, or increased benefits from STWs in each stratum.

Present

Base STW Utilisation
High Utilisation

Future

Improved Performance
High Utilisation and Improved Performance

TABLE IV.1

Main Terai Shallow Tubewell Net Benefits West Stratum (1993 Financial Prices)

	Rainfed							Irrigated						
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**						
Area ha	1.26	0.28	0.54	0.33	0.29	0.01	2.71	1.62	1.14	0.36	0.21	0.35	0.06	3.74
Gross margin Rs/ha	4,697	2,302	2,746	5,813	6,452	8,195		8,352	3,415	3,893	6,343	6,366	17,160	
Rs total	5,918	645	1,483	1,918	1,871	82	11,917	13,530	3,893	1,401	1,332	2,228	1,030	23,415
Future								**Improved performance**						
Area ha	1.26	0.28	0.54	0.33	0.29	0.01	2.71	1.62	1.14	0.36	0.21	0.35	0.06	3.74
Gross margin Rs/ha	6,318	3,589	3,898	5,813	6,452	9,931		13,076	7,359	7,143	7,908	9,666	22,628	
Rs total	7,961	1,005	2,105	1,918	1,871	99	14,959	21,183	8,389	2,571	1,661	3,383	1,358	38,545
								High Utilisation Base Case						
								Area ha	4.00	2.16	0.64	0.4	0.67	0.13	8.00
								Gross margin Rs/ha	8,352	3,415	3,893	6,343	6,366	17,160	
								Rs total	33,408	7,376	2,492	2,537	4,265	2,231	52,309
								High Utilisation IP Case						
								Area ha	4.00	2.16	0.64	0.4	0.67	0.13	8.00
								Gross margin Rs/ha	13,076	7,359	7,143	7,908	9,666	22,628	
								Rs total	52,304	15,895	4,572	3,163	6,476	2,942	85,352

Incremental benefits (1993 financial prices)

Case	Rs/TW	Rs/hectare
(a) Present		
Base	11,498	6,051
High intensity	27,221	6,805
(b) Future		
Improved performance	23,586	12,414
HI+IP	53,859	13,465

Command area (ha)	
Rainfed/Base/IP	1.90
High Intensity	4.00

TABLE IV.2

Main Terai Shallow Tubewell Net Benefits Central Stratum (1993 Financial Prices)

	Rainfed							Irrigated						
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**						
Area ha	2.12	0.74	0.43	0.31	0.27	0.07	3.94	2.45	0.83	0.49	0.48	0.25	0.19	4.69
Gross margin Rs/ha	5,578	3,475	5,478	6,338	6,100	7,395		9,518	4,225	6,349	6,934	6,014	15,520	
Rs total	11,825	2,572	2,356	1,965	1,647	518	20,882	23,319	3,507	3,111	3,328	1,504	2,949	37,717
Future								**Future**						
Area ha	2.12	0.74	0.43	0.31	0.27	0.07	3.94	2.45	0.83	0.49	0.48	0.25	0.19	4.69
Gross margin Rs/ha	7,413	4,992	7,036	6,338	6,100	8,971		15,171	8,769	11,120	8,653	9,121	20,468	
Rs total	15,716	3,694	3,025	1,965	1,647	628	26,675	37,169	7,278	5,449	4,153	2,280	3,889	60,219

Incremental benefits (1993 financial prices)

Case	Rs/TW	Rs/hectare
(a) Present		
Base	16,836	7,320
High intensity	27,885	6,971
(b) Future		
Improved performance	33,544	14,584
HI+IP	56179.	14045
Command area (ha)		
Rainfed/Base/IP	2.30	
High Intensity	4.00	

High Utilisation Base Case							
Area ha	4.18	1.42	0.84	0.82	0.43	0.31	8.00
Gross margin Rs/ha	9,518	4,225	6,349	6,934	6,014	15,520	
Rs total	39,785	6,000	5,333	5,686	2,586	4,811	64,201
High Utilisation IP Case							
Area ha	4.18	1.42	0.84	0.82	0.43	0.31	8.00
Gross margin Rs/ha	15,171	8,769	11,120	8,653	9,121	20,468	
Rs total	63,415	12,452	9,341	7,095	3,922	6,345	102,570

TABLE IV.3

Main Terai Shallow Tubewell Net Benefits East Stratum (1993 Financial Prices)

	Rainfed							Irrigated						
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**						
Area ha	2.20	0.39	0.27	0.07	0.02	0.01	2.96	Area ha	2.26	1.25	0.51	0.18	0.14	0.37	4.71
Gross margin Rs/ha	4,883	4,893	5,814	6,338	5,748	6,995		Gross margin Rs/ha	8,322	5,935	6,989	6,934	5,661	14,700	
Rs total	10,743	1,908	1,570	444	115	70	14,849	Rs total	18,808	7,419	3,564	1,248	793	5,439	37,271
Future								**Future**						
Area ha	2.2	0.39	0.27	0.07	0.02	0.01	2.96	Area ha	2.26	1.25	0.51	0.18	0.14	0.37	4.71
Gross margin Rs/ha	6,403	6,009	6,903	6,338	5,748	8,491		Gross margin Rs/ha	13,255	10,591	11,648	8,653	8,577	19,388	
Rs total	14,087	2,344	1,864	444	115	85	18,937	Rs total	29,956	13,239	5,940	1,558	1,201	7,174	59,067

Incremental benefits (1993 financial prices)

Case	Rs/TW	Rs/hectare
(a) Present		
Base	22,421	9,748
High intensity	37,251	9,313
(b) Future		
Improved performance	40,130	17,448
HI+IP	67,160	16,790
Command area (ha)		
Rainfed/Base/IP	2.30	
High Intensity	4.00	

High Utilisation Base Case							
Area ha	4	2.04	0.84	0.32	0.24	0.56	8.00
Gross margin Rs/ha	8,322	5,935	6,989	6,934	5,661	14,700	
Rs total	33,288	12,107	5,871	2,219	1,359	8,232	63,076
High Utilisation IP Case							
Area ha	4	2.04	0.84	0.32	0.24	0.56	8.00
Gross margin Rs/ha	13,255	10,591	11,648	8,653	8,577	19,388	
Rs total	53,020	21,606	9,784	2,769	2,058	10,857	100,095

TABLE IV.4

Main Terai Shallow Tubewell Net Benefits Inner Terai Stratum (1993 Financial Prices)

	Rainfed							Irrigated						
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**						
Area ha	1.06	0.20	0.42	0.42	0.18	0.00	2.28	2.46	0.87	0.29	0.42	0.11	0.11	4.26
Gross margin Rs/ha	5,716	1,706	2,746	5,813	4,118	8,195		8,617	3,984	2,706	6,343	4,031	17,160	
Rs total	6,059	341	1,153	2,441	741	0	10,736	21,198	3,466	785	2,664	443	1,888	30,444
Future								**Future**						
Area ha	1.06	0.2	0.42	0.42	0.18	0	2.28	2.46	0.87	0.29	0.42	0.11	0.11	4.26
Gross margin Rs/ha	7,374	2,944	3,481	5,813	4,118	9,931		16,207	8,345	3,587	7,908	6,058	22,628	
Rs total	7,816	589	1,462	2,441	741	0	13,050	39,869	7,260	1,040	3,321	666	2,489	54,646

Incremental benefits (1993 financial prices)

Case	Rs/TW	Rs/hectare
(a) Present		
Base	19,708	7,883
High intensity	37,268	9,317
(b) Future		
Improved performance	41,596	16,639
HI+IP	75,981	18,995
Command area (ha)		
Rainfed/Base/IP	2.50	
High Intensity	4.00	

High Utilisation Base Case							
Area ha	4	1.92	0.68	0.96	0.24	0.2	8.00
Gross margin Rs/ha	8,617	3,984	2,706	6,343	4,031	17,160	
Rs total	34,468	7,649	1,840	6,089	967	3,432	54,446
High Utilisation IP Case							
Area ha	4	1.92	0.68	0.96	0.24	0.2	8.00
Gross margin Rs/ha	16,207	8,345	3,587	7,908	6,058	22,628	
Rs total	64,828	16,022	2,439	7,592	1,454	4,526	96,861

TABLE IV.5

Main Terai Shallow Tubewell Net Benefits West Stratum (constant 1993 economic values)

	Rainfed								Irrigated						
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total	+ TW	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**							
Area ha	1.26	0.28	0.54	0.33	0.29	0.01	2.71	Area ha	1.62	1.14	0.36	0.21	0.35	0.06	3.74
Gross margin Rs/ha	4030	4133	3582	4154	4849	3588		Gross margin Rs/ha	7667	6885	5888	5866	6114	12321	
Rs total	5078	1157	1934	1371	1406	36	10982	Rs total	12421	7849	2120	1232	2140	739	26500
Future								**Future**							
Area ha	1.26	0.28	0.54	0.33	0.29	0.01	2.71	Area ha	1.62	1.14	0.36	0.21	0.35	0.06	3.74
Gross margin Rs/ha	5727	6857	5614	4154	4849	5010		Gross margin Rs/ha	13346	16002	12384	7280	9087	16986	
Rs total	7216	1920	3032	1371	1406	50	14995	Rs total	21621	18242	4458	1529	3180	1019	50049

Incremental benefits (1993 financial prices)

Case	Rs/TW	Rs/hectare
(a) Present		
Base	15517.	8167
High intensity	34231.	8558
(b) Future		
Improved performance	35054.	18450
HI+IP	75514.	18879

High Utilisation Base Case							
Area ha	4	2.16	0.64	0.4	0.67	0.13	8.00
Gross margin Rs/ha	7667	6885	5888	5866	6114	12321	
Rs total	30668	14872	3768	2346	4096	1602	57352
High Utilisation IP Case							
Area ha	4	2.16	0.64	0.4	0.67	0.13	8.00
Gross margin Rs/ha	13346	16002	12384	7280	9087	16986	
Rs total	53384	34564	7926	2912	6088	2208	107083

Command area (ha)
Rainfed/Base/IP 1.90
High Intensity 4.00

TABLE IV.6

Main Terai Shallow Tubewell Net Benefits Central Stratum (constant 1993 economic values)

	Rainfed							Irrigated							
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total	+ TW	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**							
Area ha	2.12	0.74	0.43	0.31	0.27	0.07	3.94	Area ha	2.45	0.83	0.49	0.48	0.25	0.19	4.69
Gross margin Rs/ha	4216	5210	6265	4679	4497	2784		Gross margin Rs/ha	8008	6895	7520	6457	5762	10711	
Rs total	8938	3855	2694	1450	1214	195	18347	Rs total	19620	5723	3685	3099	1441	2035	35602
Future								**Future**							
Area ha	2.12	0.74	0.43	0.31	0.27	0.07	3.94	Area ha	2.45	0.83	0.49	0.48	0.25	0.19	4.69
Gross margin Rs/ha	6012	8258	8209	4679	4497	4065		Gross margin Rs/ha	14464	16372	14455	8026	8543	14873	
Rs total	12745	6111	3530	1450	1214	285	25335	Rs total	35437	13589	7083	3852	2136	2826	64923

Incremental benefits (1993 financial prices)

Case	Rs/TW	Rs/hectare
(a) Present		
Base	17255.	7502
High intensity	28766.	7192
(b) Future		
Improved performance	39587.	17212
HI+IP	66653.	16663

Command area (ha)
Rainfed/Base/IP 2.30
High Intensity 4.00

High Utilisation Base Case							
Area ha	4.18	1.42	0.84	0.82	0.43	0.31	8.00
Gross margin Rs/ha	8008	6895	7520	6457	5762	10711	
Rs total	33473	9791	6317	5295	2478	3320	60674
High Utilisation IP Case							
Area ha	4.18	1.42	0.84	0.82	0.43	0.31	8.00
Gross margin Rs/ha	14464	16372	14455	8026	8543	14873	
Rs total	60460	23248	12142	6581	3673	4611	110715

TABLE IV.7

Main Terai Shallow Tubewell Net Benefits East Stratum (constant 1993 economic values)

	Rainfed								Irrigated						
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total	+ TW	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**							
Area ha	2.20	0.39	0.27	0.07	0.02	0.01	2.96	Area ha	2.26	1.25	0.51	0.18	0.14	0.37	4.71
Gross margin Rs/ha	4610	8906	7724	4679	4144	2399		Gross margin Rs/ha	9073	11121	8372	6457	5408	9921	
Rs total	10142	3473	2085	328	83	24	16135	Rs total	20505	13901	4270	1162	757	3671	44266
Future								**Future**							
Area ha	2.2	0.39	0.27	0.07	0.02	0.01	2.96	Area ha	2.26	1.25	0.51	0.18	0.14	0.37	4.71
Gross margin Rs/ha	6433	11121	9098	4679	4144	3600		Gross margin Rs/ha	15649	21032	16701	8026	7999	13638	
Rs total	14153	4337	2456	328	83	36	21393	Rs total	35367	26290	8518	1445	1120	5046	77785

Incremental benefits (1993 financial prices)

Case	Rs/TW	Rs/hectare
(a) Present		
Base	28130.	12231
High intensity	46869.	11717
(b) Future		
Improved performance	56392.	24518
HI+IP	94450.	23613

Command area (ha)	
Rainfed/Base/IP	2.30
High Intensity	4.00

High Utilisation Base Case							
Area ha	4	2.04	0.84	0.32	0.24	0.56	8.00
Gross margin Rs/ha	9073	11121	8372	6457	5408	9921	
Rs total	36292	22687	7032	2066	1298	5556	74931
High Utilisation IP Case							
Area ha	4	2.04	0.84	0.32	0.24	0.56	8.00
Gross margin Rs/ha	15649	21032	16701	8026	7999	13638	
Rs total	62596	42905	14029	2568	1920	7637	131655

TABLE IV.8

Main Terai Shallow Tubewell Net Benefits Inner Terai Stratum (constant 1993 economic values)

	Rainfed								Irrigated						
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total	+ TW	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**							
Area ha	1.06	0.20	0.42	0.42	0.18	0.00	2.28	Area ha	2.46	0.87	0.29	0.42	0.11	0.11	4.26
Gross margin Rs/ha	5079	2629	3582	4154	2514	3568		Gross margin Rs/ha	7687	7270	3659	5866	3779	12321	
Rs total	5384	526	1504	1745	453	0	9611	Rs total	18910	6325	1061	2464	416	1355	30531
Future								**Future**							
Area ha	1.06	0.2	0.42	0.42	0.18	0	2.28	Area ha	2.46	0.87	0.29	0.42	0.11	0.11	4.26
Gross margin Rs/ha	6775	4478	4870	5154	2514	5010		Gross margin Rs/ha	18569	15841	5279	7280	5481	16988	
Rs total	7182	896	2045	2165	453	0	12740	Rs total	45680	13782	1531	3058	603	1869	66522

Incremental benefits (1993 financial prices)

Case	Rs/TW	Rs/hectare
(a) Present		
Base	20919.	8368
High intensity	40819.	10205
(b) Future		
Improved performance	53781.	21513
HI+IP	99598.	24900
Command area (ha)		
Rainfed/Base/IP	2.50	
High Intensity	4.00	

High Utilisation Base Case							
Area ha	4	1.92	0.68	0.96	0.24	0.2	8.00
Gross margin Rs/ha	7687	7270	3659	5866	3779	12321	
Rs total	30748	13958	2488	5631	907	2464	56197
High Utilisation IP Case							
Area ha	4	1.92	0.68	0.96	0.24	0.2	8.00
Gross margin Rs/ha	18569	15841	5279	7280	5481	16988	
Rs total	74276	30415	3590	6989	1315	3398	119982

APPENDIX V

MEDIUM AND DEEP TUBEWELL GROSS MARGIN BENEFITS

1 Financial Benefits

Tables V.1 to V.8 set out the calculation of incremental crop gross margins each hectare for the cropping patterns adopted for medium and deep tubewells. The tables illustrated the derivation of the unit area figures from a 90 s DTW with a 90 ha command area. The figures for other sizes of tubewell are very similar since they have the same cropping patterns.

The tables cover three land classes in the Main Terai using Central Stratum price data and one land class in the Inner Terai using price appropriate to that stratum.

Main Terai	**Financial**	**Economic**
Land Class 2 mixed	E.1	E.5
Class 2 upland	E.2	E.6
Class 2R Lowland	E.3	E.7
Inner Terai		
Land Class 2 (mixed)	E.4	E.8

The assumptions behind the derivation of benefits are given in Chapter 6 and earlier sections.

Each table also shows the present and future incremental TW gross margins.

As discussed in Chapters 6 and 8 this is used to illustrate the comparative benefits to the different types of TW; two DTW and three MTW of different capacities; expected in each of the three land classes; and the difference between tubewells in the Main and Inner Terai strata on Land Class 2 (mixed).

The gross margins do not include the cost of pumping water or of course fixed costs such as land tax and the repayment of capital costs. These are included in Chapter 7, Tubewell Costs.

TABLE V.1

Main Terai DTW 90 l/s Net Benefits Central Stratum
Land Class 2 Mixed 1993 Financial Prices

'000 Rs/90 ha

	Rainfed								Irrigated						
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total		Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**							
Area ha	76.50	18.00	18.00	9.00	9.00	0.90	131.40	Area ha	81.00	58.50	13.50	9.00	9.00	4.50	175.50
Gross margin '000 Rs/ha	5.58	3.47	5.48	6.34	6.10	7.40		Gross margin '000 Rs/ha	9.52	4.23	6.35	6.93	6.01	15.52	
'000 Rs total	427	63	99	57	55	7	706	'000 Rs total	771	247	86	62	54	70	1,290
Future								**Improved performance**							
Area ha	76.50	18.00	18.00	9.00	9.00	0.90	131.40	Area ha	81.00	58.50	13.50	9.00	9.00	4.50	175.50
Gross margin '000 Rs/ha	7.41	4.99	7.04	6.34	6.10	8.97		Gross margin '000 Rs/ha	15.17	8.77	11.12	8.65	9.12	20.47	
'000 Rs total	567	90	127	57	55	8	904	'000 Rs total	1,229	513	150	78	82	92	2,144

Incremental benefits (1993 financial prices)

Case	'000 Rs/TW	Rs/hectare
Present		
- Base	584	6,486
- Improved performance	1,438	15,973
Future		
- Improved performance	1,240	13,782
Command area (rainfed/base/IP) (ha)	90	

Source: GDC estimates

TABLE V.2

Main Terai DTW 90 l/s Net Benefits Central Stratum
Land Class 2 Upland 1993 Financial Prices

'000 Rs/90 ha

	Rainfed								Irrigated						
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total		Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**							
Area ha	0.00	0.00	72.00	36.00	9.00	0.00	117.00	Area ha	0.00	45.00	90.00	13.50	9.00	4.50	162.00
Gross margin '000 Rs/ha	5.58	3.47	5.48	6.34	6.10	7.40		Gross margin '000 Rs/ha	9.52	4.23	6.35	6.93	6.01	15.52	
'000 Rs total	0	0	394	228	55	0	677	'000 Rs total	0	190	571	94	54	70	979
Future								**Improved performance**							
Area ha	0.00	0.00	72.00	36.00	9.00	0.00	117.00	Area ha	0.00	45.00	90.00	13.50	9.00	4.50	162.00
Gross margin '000 Rs/ha	7.41	4.99	7.04	6.34	6.10	8.97		Gross margin '000 Rs/ha	15.17	8.77	11.12	8.65	9.12	20.47	
'000 Rs total	0	0	507	228	55	0	790	'000 Rs total	0	395	1,001	117	82	92	1,686

Incremental benefits (1993 financial prices)

Case	'000 Rs/TW	Rs/hectare
Present		
- Base	302	3,351
- Improved performance	1,009	11,210
Future		
- Improved performance	897	9,964
Command area (rainfed/base/IP) (ha)	90	

Source: GDC estimates

TABLE V.3

Main Teral DTW 90 l/s Net Benefits Central Stratum
Land Class 2 Lowland 1993 Financial Prices

'000 Rs/90 ha

	Rainfed								Irrigated						
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total		Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**							
Area ha	89.10	0.00	0.00	0.90	0.00	0.00	90.00	Area ha	131.40	0.00	0.00	0.00	0.00	3.60	135.00
Gross margin '000 Rs/ha	5.58	3.47	5.48	6.34	6.10	7.40		Gross margin '000 Rs/ha	9.52	4.23	6.35	6.93	6.01	15.52	
'000 Rs total	497	0	0	6	0	0	503	'000 Rs total	1,251	0	0	0	0	56	1,307
Future								**Improved performance**							
Area ha	89.10	0.00	0.00	0.90	0.00	0.00	90.00	Area ha	131.40	0.00	0.00	0.00	0.00	3.60	135.00
Gross margin '000 Rs/ha	7.41	4.99	7.04	6.34	6.10	8.97		Gross margin '000 Rs/ha	15.17	8.77	11.12	8.65	9.12	20.47	
'000 Rs total	660	0	0	6	0	0	666	'000 Rs total	1,993	0	0	0	0	74	2,067

Incremental benefits (1993 financial prices)

Case	'000 Rs/TW	Rs/hectare
Present		
- Base	804	8,931
- Improved performance	1,564	17,383
Future		
- Improved performance	1,401	15,566
Command area (rainfed/base/IP) (ha)	90	

Source: GDC estimates

TABLE V.4

Inner Terai Stratum DTW 90 l/s Net Benefits
Land Class 2 Mixed 1993 Financial Prices

'000 Rs/90 ha

	Rainfed								Irrigated						
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total		Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**							
Area ha	37.80	7.20	15.30	15.30	6.30	0.00	81.90	Area ha	79.20	54.90	15.30	15.30	6.30	4.50	175.50
Gross margin '000 Rs/ha	5.72	1.71	2.75	5.81	4.12	8.20		Gross margin '000 Rs/ha	8.62	3.98	2.71	6.34	4.01	15.52	
'000 Rs total	216	12	42	89	26	0	385	'000 Rs total	682	219	41	97	25	70	1 135
Future								**Improved performance**							
Area ha	37.80	7.20	15.30	15.30	6.30	0.00	81.90	Area ha	79.20	54.90	15.30	15.30	6.30	4.50	175.50
Gross margin '000 Rs/ha	7.37	2.94	3.48	5.81	4.12	8.97		Gross margin '000 Rs/ha	16.21	8.35	3.59	7.91	6.06	22.63	
'000 Rs total	279	21	53	89	26	0	468	'000 Rs total	1 284	458	55	121	38	102	2 058

Incremental benefits (1993 financial prices)

Case	'000 Rs/TW	Rs/hectare
Present		
- Base	750	8 328
- Improved performance	1 672	18 582
Future		
- Improved performance	1 590	17 661
Command area (rainfed/base/IP) (ha)	90	

Source: GDC estimates

TABLE V.5

Main Terai DTW 90 l/s Net Benefits Central Stratum
Land Class 2 Mixed 1993 Economic Values

'000 Rs/90 ha

	Rainfed							Irrigated						
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**						
Area ha	76.50	18.00	18.00	9.00	9.00	0.90	131.40	81.00	58.50	13.50	9.00	9.00	4.50	175.50
Gross margin '000 Rs/ha	4.22	5.21	6.27	4.68	4.50	2.78		8.01	6.99	7.52	6.46	5.76	10.71	
'000 Rs total	323	94	113	42	40	3	614	649	409	102	58	52	48	1,317
Future								**Improved performance**						
Area ha	76.50	18.00	18.00	9.00	9.00	0.90	131.40	81.00	58.50	13.50	9.00	9.00	4.50	175.50
Gross margin '000 Rs/ha	6.01	8.26	8.21	4.68	4.50	4.07		14.46	16.37	14.46	8.03	8.54	14.87	
'000 Rs total	460	149	148	42	40	4	843	1,172	958	195	72	77	67	2,541

Incremental benefits (1993 financial prices)

Case	'000 Rs/TW	Rs/hectare
Present		
- Base	703	7,809
- Improved performance	1,926	21,404
Future		
- Improved performance	1,698	18,866
Command area (rainfed/base/IP) (ha)	90	

Source: GDC estimates

TABLE V.6

Main Terai DTW 90 l/s Net Benefits Central Stratum
Land Class 2 Upland 1993 Economic Values

'000 Rs/90 ha

	Rainfed								Irrigated						
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total		Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**							
Area ha	0.00	0.00	72.00	36.00	9.00	0.00	117.00	Area ha	0.00	45.00	90.00	13.50	9.00	4.50	162.00
Gross margin '000 Rs/ha	4.22	5.21	6.27	4.68	4.50	2.78		Gross margin '000 Rs/ha	8.01	6.99	7.52	6.46	5.76	10.71	
'000 Rs total	0	0	451	168	40	0	660	'000 Rs total	0	314	677	87	52	48	1,178
Future								**Improved performance**							
Area ha	0.00	0.00	72.00	36.00	9.00	0.00	117.00	Area ha	0.00	45.00	90.00	13.50	9.00	4.50	162.00
Gross margin '000 Rs/ha	6.01	8.26	8.21	4.68	4.50	4.07		Gross margin '000 Rs/ha	14.46	16.37	14.46	8.03	8.54	14.87	
'000 Rs total	0	0	591	168	40	0	800	'000 Rs total	0	737	1,301	108	77	67	2,290

Incremental benefits (1993 financial prices)

Case	'000 Rs/TW	Rs/hectare
Present		
- Base	518	5,759
- Improved performance	1,630	18,110
Future		
- Improved performance	1,490	16,554
Command area (rainfed/base/IP) (ha)	90	

Source: GDC estimates

TABLE V.7

Main Terai DTW 90 l/s Net Benefits Central Stratum
Land Class 2 Lowland 1993 Economic Values

'000 Rs/90 ha

	Rainfed								Irrigated						
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total		Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**							
Area ha	89.10	0.00	0.00	0.90	0.00	0.00	90.00	Area ha	131.40	0.00	0.00	0.00	0.00	3.60	135.00
Gross margin '000 Rs/ha	4.22	5.21	6.27	4.68	4.50	2.78		Gross margin '000 Rs/ha	8.01	6.99	7.52	6.46	5.76	10.71	
'000 Rs total	376	0	0	4	0	0	380	'000 Rs total	1,052	0	0	0	0	39	1,091
Future								**Improved performance**							
Area ha	89.10	0.00	0.00	0.90	0.00	0.00	90.00	Area ha	131.40	0.00	0.00	0.00	0.00	3.60	135.00
Gross margin '000 Rs/ha	6.01	8.26	8.21	4.68	4.50	4.07		Gross margin '000 Rs/ha	14.46	16.37	14.46	8.03	8.54	14.87	
'000 Rs total	536	0	0	4	0	0	540	'000 Rs total	1,901	0	0	0	0	54	1,954

Incremental benefits (1993 financial prices)

Case	'000 Rs/TW	Rs/hectare
Present		
- Base	711	7,899
- Improved performance	1,574	17,492
Future		
- Improved performance	1,414	15,714
Command area (rainfed/base/IP) (ha)	90	

Source: GDC estimates

TABLE V.8

Inner Terai DTW 90 l/s Net Benefits
Land Class 2 Mixed 1993 Economic Values

'000 Rs/90 ha

	Rainfed								Irrigated						
	Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total		Paddy	Wheat	Maize	Oilseed	Pulse	Potato	Total
Present								**Base Case**							
Area ha	37.80	7.20	15.30	15.30	6.30	0.00	81.90	Area ha	79.20	54.90	15.30	15.30	6.30	4.50	175.50
Gross margin '000 Rs/ha	5.08	2.63	3.58	4.15	2.51	3.57		Gross margin '000 Rs/ha	7.69	7.27	3.66	5.87	3.78	12.32	
'000 Rs total	192	19	55	64	16	0	345	'000 Rs total	609	399	56	90	24	55	1,233
Future								**Improved performance**							
Area ha	37.80	7.20	15.30	15.30	6.30	0.00	81.90	Area ha	79.20	54.90	15.30	15.30	6.30	4.50	175.50
Gross margin '000 Rs/ha	6.78	4.48	4.87	4.15	2.51	5.01		Gross margin '000 Rs/ha	16.57	15.84	5.28	7.28	5.48	16.99	
'000 Rs total	256	32	75	64	16	0	442	'000 Rs total	1,312	870	81	111	35	76	2,485

Incremental benefits (1993 financial prices)

Case	'000 Rs/TW	Rs/hectare
Present		
- Base	888	9,864
- Improved performance	2,140	23,777
Future		
- Improved performance	2,043	22,698
Command area (rainfed/base/IP) (ha)	90	

Source: GDC estimates