APPENDIX-5 AGRICULTURAL DEVELOPMENT

CHAPTER 1 INTRODUCTION

This APPENDIX-5, AGRICULTURAL DEVELOPMENT, discusses about agricultural development plan together with the associated issues. In the compilation of this Annex, inputs have been received from concerned officers such as Eastern Regional Agriculture Directorate (ERAD), Sunsari District Agricultural Development Office (Sunsari DADO), Sunsari-Morang Irrigation Project Office (SMIP), as well as field observations and field surveys together with findings and results from other Annexes.

This Annex consists of, aside from this CHAPTER 1 INTRODUCTION, five chapters; namely, CHAPTER 2 PERFORMANCE REVIEW OF AGRICULTURAL SECTOR, CHAPTER 3 THE STUDY AREA, CHAPTER 4 COMMAND AREA IN THE SMIP, CHAPTER 5 DEVELOPMENT CONSTRAINS AND POTENTIALS, CHAPTER 6 DEVELOPMENT PLAN.

CHAPTER 2 gives an overview of agricultural sector in this Country as well as in Eastern Terai Area in order to make clear where we should place the Study area in agricultural sector. In CHAPTER 3, present situation in the Study area is discussed such as land use, production and productivity, farm management and marketing etc. CHAPTER 4 mentions of the impact of SMIP based on the performances in the command area. Following that, CHAPTER 5 details constrains and potentials for further development. Based on the constrains and potentials identified in CHAPTER 5, agriculture development plan is discussed in CHAPTER 6 which focuses on basic strategy and framework, land use, cropping pattern, supporting service and marketing aspects etc.

CHAPTER 2 PERFORMANCE REVIEW OF AGRICULTUREAL SECTOR

2.1 Overview

Agriculture is a dominant sector in Nepal, accounting for about 40 percent of GDP and for about 80 percent of total employment (see Table 2.1.1). The position of the agricultural sector in Nepalese economy is dropping gradually over the year along with the development of secondary and tertiary industries, however, annual growth rate of GDP of the agricultural sector is rising bullishly although there are some negative growth years due to erratic climate.

Table 2.1.1 A Position of Agriculture Sector in Nepalese Economy

Description	Fiscal Year	
	1990/91	2000/01*
GDP at current price (million US$)*	3,226	5,397
- Agricultural sector	1,538 (47.7%)	1,960 (36.3%)
Annual Growth Rate (%)	6.44	5.87
- Agricultural sector	2.15	3.99
GDP per capita (US$)*	183	243
Economically active population	7,339,586	-
- Agricultural sector	5,952,047 (81.1%)	-
Annual Population Growth Rate	2.3% (1981-1991)	2.1% (1991-2001)

Source: Statistical Year Book of Nepal (2001)
*: Preliminary estimate
**: Exchange rate; 36.0 Rs/US$ (1990/91), 73.7 Rs/US$ (2000/01)

Though agricultural sector is a backbone of the Nepalese economy, constant food security in the Country as a whole has not been achieved. In 1998/99, there was around 1.86 million MT (equivalent to 88 kg per capita) deficit of food grains including rice, maize, wheat, millet and barley. In general, food deficit exists in the Hills and the Mountains while surplus food grains are produced in the Terai.

In consideration of the present situation mentioned above, HMGN gives high priority to the agricultural sector for national development policy. Agricultural Perspective Plan (APP) as a long-term plan for agriculture development was formulated in cooperation with Asian Development Bank (ADB). Total amount of investment is estimated around 700 million US$ within twenty years (1994/95-2014/15). APP intends to transform the subsistence-based agriculture into a modern and diversified sector through introducing commercial farming and promoting agro-based enterprises that contributes to make opportunity for employment, to uplift farmers' living standard and to narrow regional imbalance.

The Ninth Plan (1997-2002), the national development plan, has been prepared in line with the policy of APP. The following national development plan, covering 2003 - 2008, which is preparing at present seems to follow the policy of The Ninth Plan.

2.2 Agriculture in Eastern Terai Area

Nepal is generally divided into three ecological zone; the Mountains, the Hills and the Terai mentioned in Section 2.1. Similarly, the Country can be sub-divided into five administrative regions; namely, Eastern Development Region, Central Development Region, West Development Region, Mid-western Development Region and Far-western Development Region.

The Terai, being an expansion of the Gangetic plains of India, forms a low flat land. Forty percent of its land is suitable for cultivation. Fertile land permits the cultivation of a wide variety of crops such as paddy, wheat, vegetables, sugarcane, tobacco and other crops. This region plays an important role in food supply for the nation.

Especially, Eastern Terai Area which consists of five districts is a representative base area of food grains production although land area contributes only five percent of total land of this Country. Average production of paddy in the last decade occupies 26.2% of the total production in Nepal while area planted occupies 24.9 % (see in Table 2.2.1). Agricultural products such as food grains and perishables are distributed not only to neighboring cities but also to the Hills including Kathmandu and the Mountains. Biratnagar ranked as the second biggest city in Nepal is a gateway of border-trade with India. Various agricultural products and inputs are flowing via Biratnagar and then are distributed to the Country

Table 2.2.1 Production of the Major Crops*

Crop	Nepal		Eastern Terai Area	
	Area Planted (ha)	Production (MT)	Area Planted (ha)	Production (MT)
Paddy	1,456,584	3,437,886	362,989 (24.9%)	901,039 (26.2%)
Wheat	629,735	950,614	75,804 (12.0%)	123,601 (13.0%)
Potato	100,994	889,312	9,412 (9.3%)	86,272 (9.7%)
Oilseeds	174,028	106,078	18,564 (10.7%)	10,181 (9.6%)
Tobacco	6,147	6,147	2,245 (36.5%)	2,034 (37.0%)
Sugarcane	44,255	1,375,939	4,247 (9.6%)	133,668 (9.7%)

Source: Statistical Year Book of Nepal (2001)
*: These data are the mean values from 1990/91 to 1999/2000

2.3 Related Project/Program

Nepal has received many aids from donor countries and international agencies for long time. For the past thirty years, over thirty projects/programs related to the agricultural sector have been implemented under international cooperation. Summary of on-going projects/programs related to agricultural sector except irrigation scheme is briefly described below.

2.3.1 Agricultural Extension and Research Program

(1) Lending Agency: World Bank (WB)

(2) Implementing Agency: Ministry of Agriculture and Cooperatives (MOAC)

(3) Project Cost: 30.5 millions US$

(4) Approval Date: 26/08/1997

(5) Closing Date: 30/09/2002

(6) Program Summary:

This project aims to assist the government in improving management and capacity in agricultural research and extension services by developing location-specific agricultural technology resulting from close consultation with farmers and improving the technology delivery system. The project consists of two components, agricultural research and extension service. The first component is;

- to strengthen the agricultural research institutions by improving the management information system, priority setting of research programs, monitoring implementation and evaluating impact,
- to support human resource development by training research scientists and introducing a results-oriented and performance-based reward system,
- to expand on-farm adaptive research responsive to farmers needs, and
- to provide facilities, infrastructure and working capital for research institutions.

The second component is;

- to strengthen the extension service by collaborating with NGOs, involving the private sector and strengthening farmer self-help groups,
- to develop human capital by training extension staff, and implement a reward system based on the results and performance, and
- to provide facilities, infrastructure, and working capital for individual participants.

2.3.2 Crop Diversification Program

(1) Lending Agency: ADB

(2) Implementing Agency: Department of Agriculture (DOA), MOAC

(3) Project Cost: 14.1 millions US$

(4) Approval Date: 09/11/2000

(5) Closing Date: 12/2006

(6) Program Summary:

The objective of this project is to promote production and marketing of secondary agricultural crops in potential pocket areas based on a farmers group approach, thereby contributing to poverty reduction in the most poverty stricken regions of the Country. The project puts emphasis on activating the participation of the private sector in agricultural extension and research as well as the involvement of women. The project scope includes the provision of extension services for farmers groups, promotion of private extension services, promotion of client-oriented research activities and project management support. The project covers 12 districts in phases in the mid-western and far-western development regions.

2.4 Sector Performance Review and Lessons

HMGN has made efforts to develop the agricultural sector for many years through implementation of many projects related to the improvement of productivity such as irrigation project. As the outcome of these efforts, annual growth rate of GDP of agricultural sector has been rising bullishly although a position occupied in national economy is coming down relatively year-by-year. Paddy production has achieved an increase by fifteen percent during the last decade. It is supposed that these results are caused by the intensive investment in the Terai which has potential for agricultural development.

On the other hand, it is true that it is expanding the imbalance between the Terai and the Hills and/or the Mountains instead of the development of agriculture sector as a whole. It is also getting obvious that a large-scaled irrigation schemes face difficulty to keep operation & maintenance of facilities well.

The policy of agricultural sector has been changed in recent years; it aims to solve the constraints by means of a bottom-up approach in the place of a top-down approach. As related on-going projects/programs are symbolic, the scheme targets to alleviate poverty rather than to raise the productivity of agricultural sector. Even irrigation projects are shifting to the small-scaled scheme on demand basis whose ownership is belonging to the beneficiaries.

CHAPTER 3 THE STUDY AREA

3.1 Survey Methodology

In order to grasp the present farming situation in the Study area, Rural Socio-economic Survey and RRA survey have been conducted. Methodology of each survey is described below.

3.1.1 Rural Socio-economic Survey

Interviews with a questionnaire have been conducted by local surveyors. The questionnaire was mainly prepared with intent to collect quantitative data & information related to farming aspects as well as social aspects (see ATTACHMENT 1 of APPENDIX-3).

Among the overall households in the Study area, 202 households were selected as sample households according to the category of land holding size presented in Table 3.1.1. Although Irrigation Development Plan will not target Sahebganj that is covered by Chanda Mohana Irrigation Project, the present farming situation was analyzed based on the result from 13 VDCs including Sahebganj.

Table 3.1.1 Sampling Method of Rural Socio-economic Survey

Area[1)]	VDC	No. of Sample Household	Land Holding Distribution		
			> 4ha	1-4 ha	< 1ha
Northern Area	Babiya	15	2	9	4
	Narsingha	17	2	9	6
	Jalpapur	14	1	7	6
Central Area	Ramanagar Bhutaha	21	2	6	13
	Gautampur	9	-	6	3
	Rajgunj Sinwari	22	2	10	10
	Madhya Harsahi	10	1	4	5
	Harinagara	14	0	8	6
Southern Area	Basantapur	9	1	4	4
	Dewanganj	17	2	9	6
	Ghuski	21	2	11	8
	Kaptanganj	20	2	9	9
	Sahebganj	13	1	7	5
TOTAL		202 (100%)	18 (9%)	99 (49%)	85 (42%)

1) Classification of the Area refers to irrigation development plan.

3.1.2 RRA/Farmers' Consultation Workshop

RRA survey has been conducted in order to collect qualitative data & information related to farming aspects such as constraint on farming, potentials for agricultural development and farmers' intention of future development plan etc. Agriculture/Farm Management and Rural Sociology/Gender experts were in charge of this survey together with two counterparts who had same background. Direct interviews to 2 or 3 farmers have been done in each VDC. On the occasion of interview, it was considered to mainly focus on small-scale farmers.

Group discussion was also conducted when Farmers' Consultation Workshop was held at the beginning of August at four areas. Not only constrains on farming but also the solution to the problems were taken up for discussion.

3.2 Present Condition of Farming

3.2.1 Land Use

The present land use in the Sunsari district is classified into agricultural land, forest and other land which includes urban land, road and river etc. Out of total land area (127,077 ha), agricultural land constitutes 64.5 % equivalent to 81,944 ha while pasture, forest and other land occupies 5.0 % (6,471 ha), 18.3 % (23,204 ha) and 12.2 % (15,458 ha) respectively based on District Agricultural Statistics (2000/2001). Agricultural land is commonly utilized as both paddy field and upland field under alternative land usage system. Out of the overall agricultural land, irrigable land is estimated at 54,000 ha (65.9%), of which the greater part is covered with the command area of SMIP. Fully and partially irrigated land are estimated at 39,000 ha (72.2%) and 15,000 ha (27.8%) respectively.

Total cultivable area in the Study area is measured to be 10,544 ha on a map. Out of total agricultural land in the Study area, currently irrigated land occupies only 17% (shown in Table 3.2.1). In the southern area, there is no fully irrigated land. The large part of agricultural land in the Study area is cultivated under the rain-fed condition, however, it doesn't mean that there is no water source for irrigation except rainfall. STW irrigation comes into wide use in the Study area. 91 % of sample households cultivate winter crops by using STW. Even in monsoon season, supplementary irrigation by STW is indispensable to transplant paddy seedling in the southern area.

The Study area is a part of the command area of SMIP covered by both Suksena and Shankarpur Canals according to the original plan. However, these canals can provide irrigation water to the limited farmlands only along the canals due to incomplete watercourse network as well as insufficient water from Chatra Main Canal (CMC).

Table 3.2.1 Land Use on the Basis of Individual Land Holding

Land Use / Area	Agricultural Land (ha)				Pasture (ha)	Forest[1)] (ha)	Others[2)] (ha)	TOTAL (ha)
	Fully Irrigated	Partially Irrigated	Rain-fed	Sub total				
Northern Area	0.35	0.31	1.51	2.17	0.02	0.03	0.19	2.41
Central Area	0.20	0.20	1.32	1.72	0.01	0.04	0.15	1.92
Southern Area	-	0.10	2.12	2.22	0.00	0.03	0.16	2.41
TOTAL	**0.15 (8%)**	**0.19 (9%)**	**1.68 (83%)**	**2.02 (100%)**	**0.01**	**0.04**	**0.17**	**2.24**

Source: Rural Socio-economic Survey, JICA Study Team
1) includes bamboo, orchard and timber woods etc.
2) includes house and surroundings etc.

In the southern part of the Study area, there is some upland area which elevation ranges from 66 m to 68 m. As to this area that is estimated 397 ha, it is impossible to receive water by gravity from Sunsari irrigation system. There is also serious problem about inundation to cause damage to the production of monsoon crops, particularly paddy. The affected area that is estimated at 880 ha expands over Kaptanganj and Ghuski. Flood often occurs at the area along the Sunsari River during monsoon season, however, the extent of the damage is not serious. On the other hand, once inundation occurs in that area of Kaptanganj and Ghuski, it takes 30 to 50 days until the water in the farmland disappears.

3.2.2 Land Holding

Farmers are classified into four categories namely marginal, small, medium and large according to land holding size with a standard prepared by National Planning Commission. Majority in Sunsari district is marginal (below 1.02 ha) and small-scale farmer (1.02 to under 2.38) that occupy 47.7% and 40.3% of total households respectively. Average land holding per household is estimated at 1.93 ha.

As the result of Rural Socio-economic survey, average land holding among sample households is estimated at 2.02 ha per household that is as same as that on the District basis. Leaseholder and sharecropper are rare; leased area and share cropping area per household is 0.03 ha and 0.02 ha on average respectively. This result doesn't show the actual situation of land holding distribution in the Study area because sample households were intentionally selected according to their landholding size. However, the situation of the present farming in the Study area withdraws the result of this survey.

Table 3.2.2 Land Holding Distribution

Land Holding	Sample Household	Holding Area (ha)	Tenanted Area[1)] (ha)	Leased Area (ha)	Share Cropping Area (ha)	Total Cultivated Area (ha)	Number of Parcel
< 1.0 ha	85	0.55	-	0.05	0.04	0.64	2.95
1.0 to 4.0 ha	99	2.36	0.06	0.02	-	2.44	4.59
> 4.0 ha	18	7.11	-	-	-	7.11	7.88
TOTAL	**202**	**2.02**	**0.03**	**0.03**	**0.02**	**2.07**	**4.19**

Source: Rural Socio-economic Survey, JICA Study Team
1) Involved in holding area

Farmers usually hold four parcels which are in most cases scattered within the community or sometimes over the communities. Distance between residence and farmland ranges from 600 m to 1,500 m on average. Vegetable that requires interculture operation frequently tends to be cultivated in the farmland around residence.

3.2.3 Production

1) Cropping Pattern and Cropping Intensity

Major crops in the Study area are monsoon paddy, wheat, potato, oilseeds (mustard and linseed etc.), pulses (lentil, mungbean and local varieties etc.), vegetables (cucumber family, okra, eggplant, bitter guard, cauliflower, cabbage, onion and tomato etc.), jute and sugarcane. Cropping season is divided into three; spring, monsoon and winter. Typical cropping pattern is presented as follows (present cropping calendar is shown in ATTACHMENT 1).

1. Paddy (early maturity)	- Wheat/Pulse/Oilseed/ Potato/Winter Vegetables	
2. Paddy (early maturity)	- Wheat	- Mungbean
3. Paddy (late maturity)	- Wheat/Pulse	
4. Summer Vegetables	- Wheat/Potato/Winter Vegetables	
5. Jute	- Paddy/Fallow	- Wheat/Potato/ Winter Vegetables
6. Sugarcane		

Cropping intensity and area planted are shown in Table 3.2.3. Paddy and wheat are dominant in the Study area; cropping intensity of paddy and wheat is estimated at 68.1 % and 58.5 % respectively. The Study area is also well known for vegetable production area, particularly for potato and early cauliflower. Although there are some commercial vegetable growers, cropping intensity of vegetables is not more than 2.0 %. Sugarcane and jute are the most important cash crops as well as potato and vegetables. Jute occupies almost 20 % of the overall agricultural land during spring/monsoon season. However, jute and sugarcane suffer sharp fluctuations in price as compared with vegetables. Processing industry is monopolized so that cropping intensity also fluctuates every year. The overall cropping intensity of the Study area is estimated at 164 %.

Table 3.2.3 Cropping Intensity and Area Planted

Season	Crops	Cropping Intensity (%)	Area Planted (ha)
Spring/Monsoon	Paddy	68.1%	7,180
	Jute	19.3%	2,035
	Vegetables[1)]	1.4%	148
	Pulse (Mungbean)	1.9%	200
Winter	Wheat	58.5%	6,168
	Potato	8.7%	917
	Vegetables[2)]	1.0%	105
	Oilseed (Mustard)	1.0%	105
	Pulse (Lentil)	2.4%	253
Through the year	Others (Sugarcane)	1.4%	148
TOTAL		**163.7%**	**17,259**

Source: Rural Socio-economic Survey, JICA Study Team
1): Cucumber and okra represent summer vegetables
2): Cauliflower and cabbage present winter vegetables

Cropping intensity of monsoon paddy in the Study area is lower than that of other SMIP command areas; overall command area of SMIP resulted in 97.1 % of cropping intensity of paddy in the year 2001/2002. The Study area has difficulty to achieve high cropping intensity of paddy due to insufficient irrigation water and dominant sandy soil. However, intention to cultivating paddy is very strong among the farmers in the Study area. According to the Rural Socio-economic Survey, 84 % of sample households gave the first priority to cultivate paddy for the reason of necessity for self-consumption. Also, 85% of sample household answered they intended to cultivate paddy even if irrigation water was insufficient.

2) Production and Yield

Table 3.2.4 shows production and yield of the main crops. Total production of cereals is estimated at 28,850 MT (paddy; 16,514 MT, wheat; 12,336 MT). This doesn't meet cereal requirement for the population in the Study area. There are still 18,000 MT deficits at present. Marginal farmers who own only several katha of farmland cannot survive on their farmland. A farmer, who was an interviewee of RRA survey, harvests paddy to support his family only for five months from his 7-katha farmland. Production of cereals is not stable due to lack of irrigation water as well as calamity so that food security in the Study Area has not been achieved regionally.

Yield of paddy and wheat in the Study area is estimated at 2.3 MT/ha and 2.0 MT/ha respectively. These yield are below the district level; paddy and wheat have 40 % and 20 % lower yield respectively as compared with that of the district level so that there is around 70 kg per capita deficit of food grains at present. On the other hand, potato and vegetables that fit to cultivate in sandy soil nearly come up to the potential yield.

Table 3.2.4 Production and Yield

Season	Crops	Production (MT)	Yield (MT/ha)
Spring/Monsoon	Paddy	16,514	2.3
	Jute	3,460	1.7
	Vegetables[1)]	2,501	16.9
	Pulse (Mungbean)	100	0.5
Winter	Wheat	12,336	2.0
	Potato	14,947	16.3
	Vegetables[2)]	2,069	19.7
	Oilseed (Mustard)	42	0.4
	Pulse (Lentil)	177	0.7
Through the year	Others (Sugarcane)	13,169	40.0
TOTAL		65,315	

Source: Rural Socio-economic Survey, JICA Study Team
1): Cucumber and okra represent summer vegetables
2): Cauliflower and cabbage present winter vegetables

3.2.4 Farm Management

1) Farm input

1.1) Seed

Usage of improved seeds prevails among cereal growers in the Study area. Recently, almost 100 % of area planted of paddy and wheat are given improved variety except some local variety of paddy that is used in local festival, such as Basmati. Most commercial vegetable growers usually prefer F_1 variety. As to oilseeds and pulses, conversion to improved varieties is behind. Major varieties of main crops are shown in Table 3.2.5.

Table 3.2.5 Varieties Grown in the Sunsari District

Crop	Variety
Paddy (improved)	Mansuli, Kanchi Mansuli, RadhaⅫ, B44B, Makawanpur1, Parwanipur1, Bindheswari, ChaiteⅣ, ChaiteⅥ, Sabitri, NDR 97
Paddy (local)	Basmati, Malbhog, Kariakagat, Chakanchur, Satraj, Balamasar, Babai
Wheat	NL297, NL251, UP262, BL1135, BL1473, BL1022, Bhrikuti, Achyut, Rohini
Potato	T.P.S (seed potato), CufriSinduri, Cordinal, Dazed, Helen, Lalgulab
Mustard	TypeⅨ, Bikashe, Sasls rayo, Kranti, Krishna, Pusabolt, Pragati
Lentil	Sindhu, Simrik, Sisir, Sikhar, Simal

Source: District Agricultural Statistics (1999/2000)

Amount of seed application of each crop is presented in Table 3.2.6. Farmers tend to apply much amount of seed than the recommendable ones. For example, 74 kg seed of paddy is applied for one-hectare production while recommendable amount is 50 kg/ha.

In case of crops produced for self-sufficient such as cereal, oilseed and pulse except mungbean, it is rare to purchase seed from supplier. As the result of self-produce repeatedly, a fall of yield and/or damage by pest & disease comes into problems since genetic ability decreases. On the other hand, it is common to procure seed of cash crops such as potato, vegetables, jute and sugarcane. Generally farmers prefer purchasing seed at Indian market rather than at Agricultural Inputs Cooperation (AIC) or local supplier.

Table 3.2.6 Amount of Seed Application

Crops	Amount of Seed Application			Unit Price (Rs/kg)
	Self-Supply (kg/ha)	Procurement (kg/ha)	Sub-total (kg/ha)	
Paddy	73.5	0.5	74.0	10
Wheat	135.8	8.9	144.7	12
Potato	85.9	1,112.8	1,198.7	17
Cucumber family	1.8	0.6	2.4	116 1)
Cauliflower	-	0.6	0.6	530 1)
Mungbean	20.3	2.9	23.2	21
Lentil	19.4	-	19.4	20
Mustard	11.4	2.4	13.8	43
Jute	0.1	6.7	6.8	95
Sugarcane	336.7	5,387.2	5,723.9	1.5

Source: Rural Socio-economic Survey, JICA Study Team
1); Unit: Rs/100g

1.2) Fertilizer and Chemicals

Table 3.2.7 shows the amount of fertilizer and chemicals applying to each crop. Urea (46:0:0), DAP (18:46:0) and potash (0:0:60) are commonly applied as a source of nitrogen, phosphate and potassium respectively. After the liberalization of farm inputs supply that had been monopolized by Agricultural Inputs Cooperation (AIC), farmers make a choice to purchase them at Indian market rather than at AIC or local suppliers due to the lower price. However, quality problem now arises as illegal inflow of fertilizer from India is increasing.

Even marginal or small-scale farmers apply chemical fertilizer. However, the amount of application is 20 % to 70 % lower than the recommendable amount due to lack of capital or poor access to official agricultural credit scheme. Farmers apply neither fertilizer nor chemicals for pulse and oilseed production.

Table 3.2.7 Application of Fertilizer and Chemicals

Farm Input / Crops	Fertilizers				Herbicide (Rs/ha)	Insecticide (Rs/ha)
	Urea (kg/ha)	DAP (kg/ha)	Potash (kg/ha)	FYM (kg/ha)		
Paddy	49.4	63.3	28.0	16.7	-	192
Wheat	73.7	95.3	29.5	9.4	-	115
Potato	76.8	126.6	27.6	50.5	13	253
Cucumber family	76.4	179.4	73.3	-	-	1,408
Cauliflower	121.2	307.8	110.8	-	-	915.7
Jute	38.3	57.5	28.5	-	-	25
Sugarcane	40.4	20.2	10.1	101.1	-	101

Source: Rural Socio-economic Survey, JICA Study Team

On the other hand, there is a tendency to apply excessive amount of fertilizer among commercial vegetable growers. They usually don't have appropriate knowledge of spraying chemicals either. This fact is supported by the result of soil analysis[1]. Regarding major elements except nitrogen, which is easily leached out from sandy soil, content of phosphorous and potash is far higher than standard level of them. Content by percentage of P_2O_5 in samples is 614.4 kg/ha on average, while standard level of that is provided 28 to 56 kg/ha. On the other hand, there are few deficits in micronutrients except zinc (Zn) to affect growth adversely. Boron (B), molybdenum (Mo) and manganese (Mn), which are ingredients of a compound micronutrients fertilizer that is common to apply among vegetable growers, are contained at the high level as compared with standard level. Application of pesticide and insecticide to home consumption crops is rare.

Farmers seldom apply farmyard manure (FYM) for the purpose of improving physical condition of the fields. Although there are much material of FYM in the Study area, such as straws and dung, these materials are used as an energy source for cooking and feed for livestock.

2) Labor and Draft Animal Use

Mechanization for farming is not progressed in the Study area. Regarding to land preparation, most farmers depend on draft cattle. Planting, wedding and harvesting including threshing are usually carried out manually. Pump and thresher are utilized on rental basis. Labor force and draft power requirement for farming at present condition are

[1] 96 soil samples were collected from the fields that were cultivated vegetable in the Study area. 19 composite soil samples to be submitted for analysis were prepared eventually to maintain the soil homogeneity. Physical and chemical analysis was carried out at Jumka Soil Research Institute under the Ministry of Agriculture and Cooperative. Details of the soil analysis are shown in attachment 3.

shown in Table 3.2.8.

The ratio of hired labor force to the overall labor force is estimated at around 40 % to 50 %. According to population census in 2001, landless people occupy over 40 % of total population in the Study area. Therefore it is easy to recruit farm labor within the Study area. However, in peak season of planting and/or harvesting, there is shortage of labor force in some part of southern area that is common to go to work to India as farm labor or skilled labor. 1.8 bullocks per household are raised on average so that lease of draft animal is rare in the Study area. The proportion of hiring draft animal is estimated at less than 10 %.

Table 3.2.8 Labor Force and Draft Power Requirement

Crops	Labor Force		Draft Power	
	Family (man day/ha)	Hired (man day/ha)	Family (Ani. day/ha)	Hired (Ani day/ha)
Paddy	104	71	50	6
Wheat	90	68	40	5
Potato	101	75	20	12
Cucumber family	251	139	41	5
Cauliflower	277	118	39	5
Pulse	46	11	21	3
Oilseed	47	9	19	3
Jute	94	73	20	16
Sugarcane	180	149	50	6

Source: Rural Socio-economic Survey, "Agri-Economic Analysis of Sunsari Morang Irrigation Project Area (FY 2000 to 2001)"

3.2.5 Marketing

There are three permanent markets (Ramnagar Bhutaha, Harinagara and Dewanganj) and three weekly markets (Harinagara, Dewanganj and Ghuski) in the Study Area (see Figure 3.2.1).

Most farm products are distributed to these local markets through local assembler (see in Table 3.2.9). Sugarcane is transacted under contract with Eastern Sugar Factory located in Amahlmelaha VDC, east side of the Study area, at a fix price (14.5 Rs/kg).

Difference of farm-gate price of home consumption crops between on-season and off-season is within around 30 %. Compared with home consumption crops, perishable crops and jute which processing industry is monopolized suffer sharp fluctuations in farm-gate

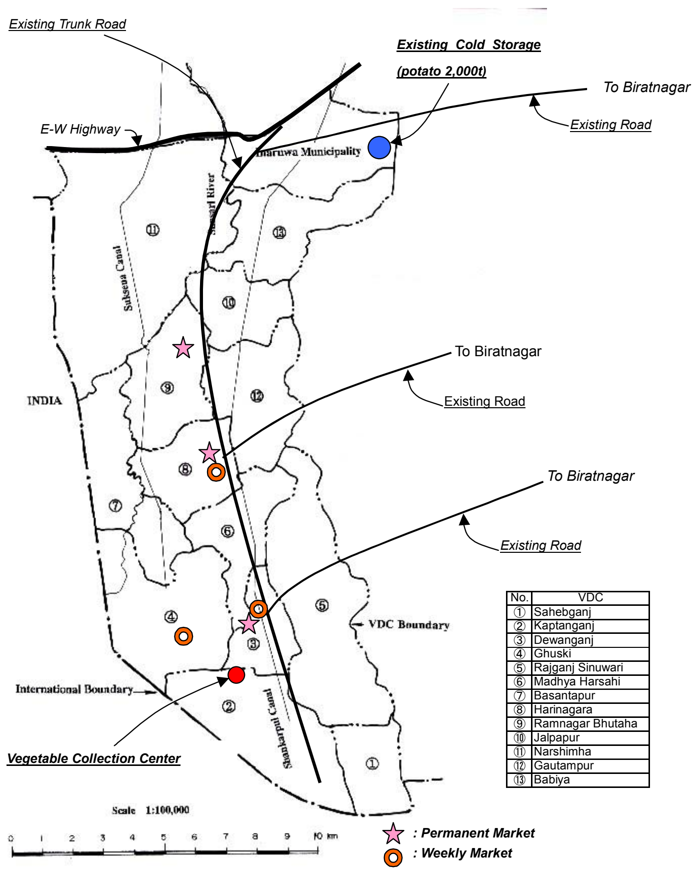


Figure 3.2.1 Location of Marketing Facility

price. In case of cauliflower, farm-gate price at a peak period declines by 80 %.

Table 3.2.9 Marketing Channel and Farm-gate Price

Crops	Home Consum-ption[1)] (%)	Marketing				Farm-gate price	
		Village Merchant (%)	Local Assembler (%)	Wholesaler (%)	Others (%)	Min. (Rs/kg)	Max. (Rs/kg)
Paddy	58.0	3.0	39.8	2.7	-	8.0	9.4
Wheat	50.2	3.8	42.4	2.8	1.1	8.0	10.0
Potato	16.8	4.5	75.9	2.8	-	6.3	11.3
Cucumber family	5.6	0.8	86.0	7.5	-	4.9	19.2
Cauliflower	2.4	3.0	86.3	8.3	-	5.1	26.3
Pulse	79.1	1.5	19.4	-	-	16.6	20.3
Oilseed	84.2	-	15.8	-	-	14.3	19.0
Jute	7.4	13.1	75.9	3.6	-	8.2	11.5
Sugarcane	-	-	25.0	-	75.0	1.45	1.45

Source: Rural Socio-economic Survey, JICA Study Team
1): including seed use for next cropping

Figure 3.2.2 shows retail price fluctuations of some products in local markets. Retail price of perishables also fluctuates sharply between on-season and off-season while that of cereal, pulses and animal products is stable through a year. In case of cabbage, there is around four times difference of the price. Source: District Agricultural Statistics (1999/2000)

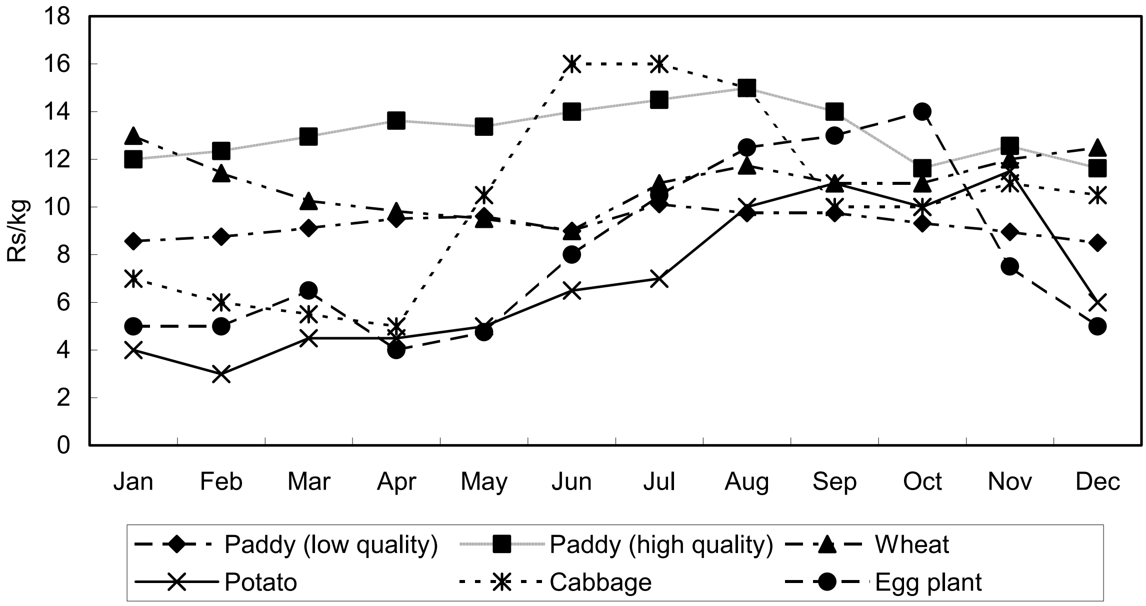


Figure 3.2.2 Retail Price Fluctuations

The Study area is close to Inaruwa, Biratnagr, Jumka and Itahari that have a large population. Agricultural product that is gathered by local assemblers is distributed to neighboring urban areas as mentioned above through trunk road to eastern highway. Cheaper price of products, apart from the quality, attracts middlemen and/or merchants in not only neighboring district like Jhapa but also Kathmandu. In winter season, 4 MT of early cauliflower are shipped to Kathmandu by bus or truck. There is also transaction of vegetables at local market in India on the individual farmer's basis.

3.2.6 Extension Services

In Nepal, Agricultural Service Center (ASC) and Sub Centers (SC) under DADO are in charge of agricultural extension services at the front line. One ASC and three SCs are arranged in the Study area (see Table 3.2.10 and Figure 3.2.3). These extension centers provide extension services covering not only crop husbandry but also livestock raising and fishery. According to Rural Socio-economic survey, some sample households received agricultural extension services from NGOs.

Table 3.2.10 Extension Centers in the Study area

ASC/SC	Service Area in the Study area	Manpower
Babiya ASC	2 VDCs (Babiya, Jallpapur)	Officer (1) JT (3), JTA (1) Peon (1)
Gautampur SC	2 VDCs (Gautampur, Rajganj Sinuwari)	JTA (1) Peon (1)
Harinagara SC	5 VDCs (Harinagara, Narsimha, Ramnagar Bhutaha, Basantapur, Ghuski)	JTA (1) Peon (1)
Dewanganj SC	4 VDCs (Dewanganj, Madhay Harsahi, Sahebganj, Kaptanganj)	JTA (1) Peon (1)

Source: District Agricultural Statistics (1999/2000)

Extension worker, called Junior Technician (JT) and Junior Technical Assistant (JTA), play a role to disseminate improved technology and to give advice related to farm management. Group approach as a method of extension service is introduced for the purpose of raising up farmers participation. There are twenty-four farmers groups certificated by Sunsari DADO in the Study area. Although extension system exists as mentioned above, access to services is limited to few farmers. Rural Socio-economic survey shows that only 28 % of sample households received extension services.

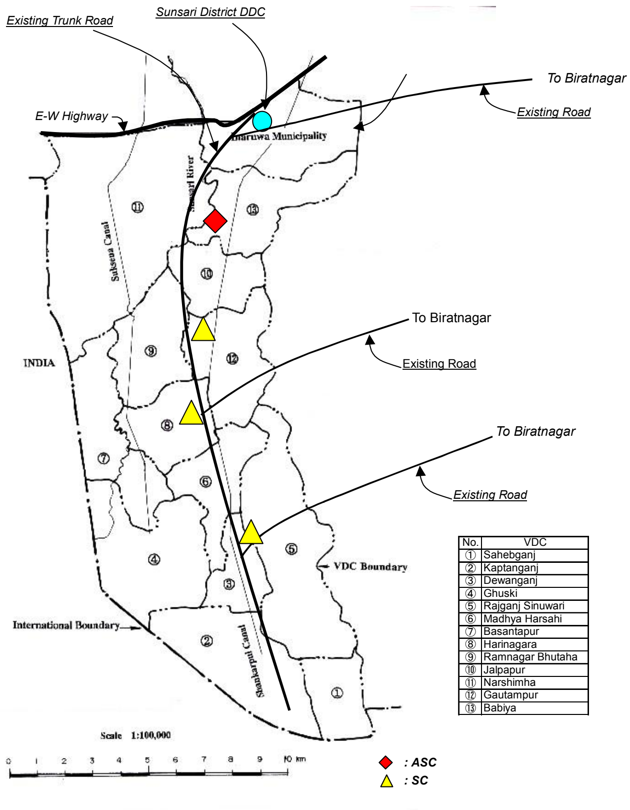


Figure 3.2.3 Location of ASC/SC

3.3 Concerned Government Offices and Activities

ERAD in Biratnagar, as a lower branch of Department of Agriculture Development (DOAD), controls sixteen DADOs in the Eastern dev. Region. Out of sixteen DADOs, Sunsari DADO is responsible for agricultural development in the Study area.

Sunsari DADO was established in 1966 as the agency to provide practical technology and information related to crop husbandry, livestock raising and marketing for farmers. Livestock field has been separated from DADO to operate as a different agency since 1995.

Under district chief, six sections (administration, planning, agronomy, horticulture, fishery and plant protection section) and fifteen extension centers (four ASCs and eleven SCs) are organized. Their working policies are;

- to increase the agricultural production through introduction of appropriate technology and making the best use of the limited sources,
- to develop the farming skills in order to lift farmers economy up through organizing training and seminars, farmer's visit and discussion about the related issues,
- to involve farmers in the process of development program throughout project cycle, appraisal, implementation and evaluation stage, and
- to increase the production and productivity through introducing commercial farming in accordance with the policy of APP in cooperation with other department.

One of the main activities in line with working policies is Pocket Package Program. This program, which is carried out in the area appointed Pocket Area, provides farmers group technical package which consists of distribution of certificated seed and technical information for cultivation etc. There are several on-going programs in the Study area (see Table 3.3.1).

Table 3.3.1 Pocket Area in the Study area

Crop	VDC
Paddy	Babiya, Jallpapur, Gautampur, Rajganj Sinuwari, Basantapur, Ghuski, Ramganj Belgachia
Wheat	Dewanganj, Kaptanganj, Madhay Harsahi, Narasimha
Pulses	Dewanganj, Kaptanganj
Oilseeds	Narasimha
Sugarcane	Narasimha, Jallpapur, Babiya, Ramnagar bhutaha, Harinagara, Madhay Harsahi, Rajganj Sinuwari, Basantapur
Potato and Vegetables	Babiya, Dewanganj, Kaptanganj, Harinagara, Basantapur, Narasimha, Gautampur, Ghuski, Ramnagar Bhutaha

Source: District Agricultural Statistics (1999/2000)

As to research institutes, Regional Agriculture Research Station (RARS) is located in Tarhara. Their research covers four fields: agronomy, horticulture, animal science and forage, and fishery. They also have four Outreach Research Site Offices (ORSO), mission of which is to prove new on-farm technology. One ORSO to cover agronomy and poultry is proposed to be established in Simariya VDC by RARS.

CHAPTER 4 COMMAND AREA IN THE SMIP

Over 20 years have passed since Stage I development of SMIP was undertaken. Stage I and Stage II development have already completed though canal networks have not covered all the command area of SMIP. Now Phase 1 of Stage III development is in progress in Biratnagar and Harinagara canals area. Out of the overall command area of SMIP (68,000 ha), 26,300 ha of farmland receive irrigation water from SMIP.

Experiences in the developed area of SMIP provides useful information in formulating agricultural development plan in the Study area, which is a part of Stage III area. Therefore present condition of farming in the command area of SMIP will be investigated based on the report on crop coverage and crop cutting survey, which is being carried out in all season (summer, winter and spring) every year since 1991.

4.1 Present Condition of Farming

4.1.1 Cropping Pattern and Productivity

1) Cropping Pattern

Figure 4.1.1 shows cropping intensity from 1995 to 2000 in the overall command area of SMIP including the Study area. Cropping intensity in the year 2000 is estimated at 198.5 % that shows an increase of 37.5 % since the year 1995, which is the year the Stage III area feasibility study was carried out. Cropping intensity has a tendency to increase year by year, although a growth rate is not high recently.

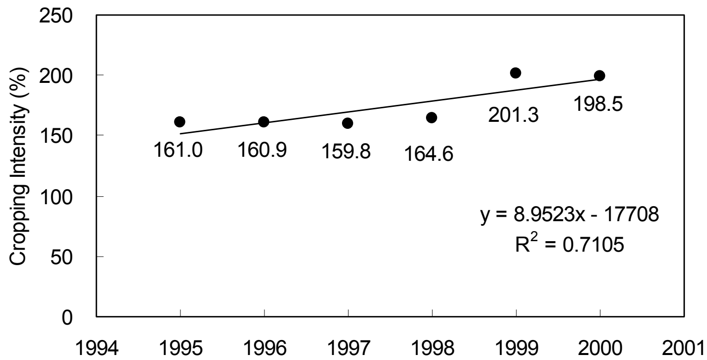


Figure 4.1.1 Cropping Intensity in the Command Area of SMIP

According to the interview to farmers in S13 and SS9 service area, which have continued irrigated farming for many years, a most remarkable impact on farming caused by SMIP is that cropping intensity in winter season has increased drastically. Before the implementation of SMIP, which is over 20 years ago, it was impossible to cultivate wheat in winter season. Even now, cropping intensity of wheat still continues to increase.

2) Productivity

Present yield of paddy and wheat is around 70 % more as compared with the initial stage that has started construction work in the Stage I area. However, a remarkable increase of yield is not recognized nowadays judging from the data in the recent years. Figure 4.1.2 shows a trend of yield of paddy and wheat by stage-wise for the past 6 years. Due to large fluctuation by year, there is no clear trend of continuous increment.

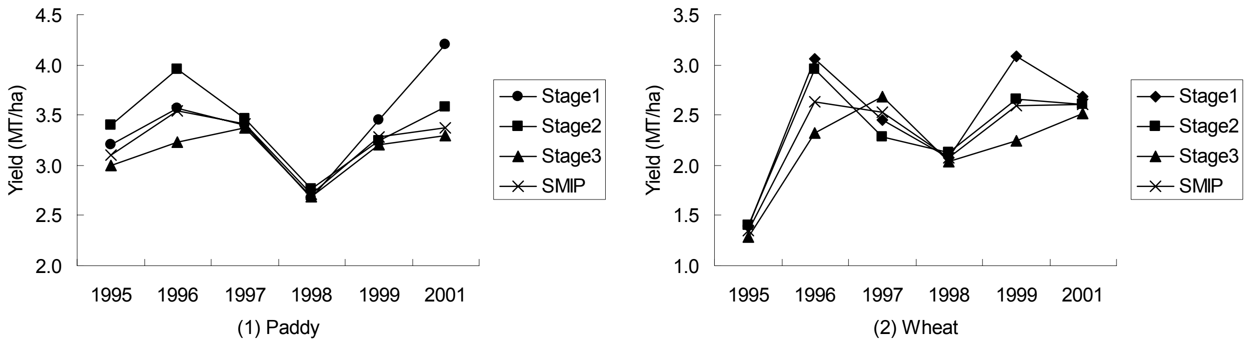


Figure 4.1.2 Yield of Cereals by Stage-wise of SMIP

On the other hand, there is difference of yield among the command area. Stage Ⅲ area, which has not completed the work yet, has a lower yield as compared with the developed area, Stage Ⅰ and Stage Ⅱ area. In the year 2001, yield of paddy in Stage Ⅲ area is estimated at 3.3 MT/ha while 4.2 MT/ha in Stage Ⅰ area.

4.1.2 Farm Management

Figure 4.1.3 shows application amount of fertilizer by stage-wise of SMIP. The data indicates total application amount of urea, DAP and potash on average in the recent three years. There is little difference among the command area whether irrigation facilities are developed or not. Application amount of fertilizer for paddy and wheat production in the Stage Ⅲ area, which is estimated at 153 kg/ha and 53 kg/ha respectively, is almost same as that in the Stage Ⅰ area. This data shows that there is not always tendency to increase the amount of farm-input application according to the progress of the work in the command area.

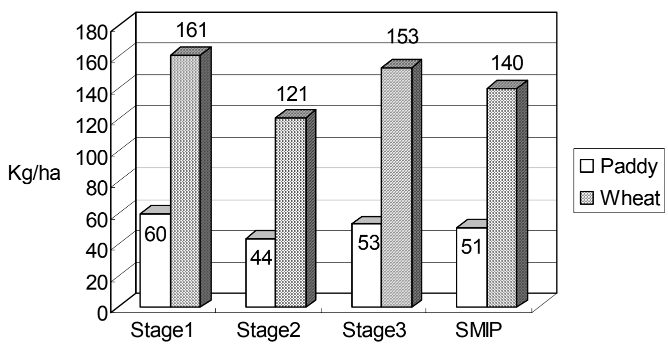


Figure 4.1.3 Application Amount of Fertilizer by Stage-wise of SMIP

4.1.3 Extension Services

For the purpose of accelerating the effects of irrigation on farming aspects, SMIP provides several agricultural supporting services to the beneficiaries in cooperation with government agencies such as ERAD, DADO and RARS in Tarahara. Crop coverage survey and crop cutting survey are conducted as part of their activity. 11 pilot areas are selected in order to focused on their activities.

Stage Ⅰ: Manikchauri, Babiya

Stage Ⅱ: Aurabani, Sattarjhora, Purba Kushaha

Stage Ⅲ: Hattimuda, Sirwani Badhara, Dangarha, Tankisinwari, Tetariya, Dadarbirya

Major activities carried out in the pilot areas are summarized below:

(1) Seed Multiplication

This activity aims at establishing the system that farmers take the responsibility of multiplication of certified cereal seed by themselves. In winter cropping season of the year 2001/2002, 11 farmers from the pilot areas of Sunsari district and 9 farmers from the pilot areas of Morang district have participated in seed production program.

(2) Farmers' Field School

The concept of Farmers' Field School, which is an approach of extension works promoted by FAO, is that farmers learn the improved farming practice and/or new technologies for themselves through demonstration in the pilot field and that innovator farmers to disseminate the introduced farming practices through demonstration will be brought up. The topics covered in this program were:

- Yield and pest response to different doses of fertilizers
- Comparative study of improved versus farmers' practice
- Varietial performance
- Effect of fertilizer and micro-nutrients
- Effect of herbicide

They are proceeding to a new program, Integrated Program (IP), which targets selected WUAs. The selected WUAs are correspondent to their respective tertiaries (secondary in SRIP), called Nucleus Tertiary (NT). This program is to help them towards self-reliance in irrigation system. The program will be terminated in June 2003.

4.2 Lessons from the Experiences in the Command Area of SMIP

No one could have doubts as to the effect of SMIP. The implementation of SMIP has brought an increase of cropping intensity and yield that leads to improve farmers' living standard. However, it is considered that full benefit of the project has not been achieved in all the aspects. As indicated by the result of crop coverage survey and crop cutting survey, there is still a room to improve yield and farming practice. Even in the developed area, farmers express dissatisfaction with irregular irrigation supply and poor maintenance of facilities.

It is considered that delay of full benefit of the project may be caused by the weakness of institutional arrangement including agricultural supporting system as well as water management system. Therefore SMIP tackles this issue to be solved through the implementation of the program to strengthen institutional aspects. In order to get real success in the Project and sustainability of the Project, it is necessary to realize appropriate agricultural supporting system under the Project by making the use of the lessons from the experiences in the command area of SMIP.

CHAPTER 5 DEVELOPMENT CONSTRAINS AND POTENTIALS

The Terai including Eastern Terai Area is the granary to provide food grains to the Hills and the Mountains, which are disadvantageous area for agricultural production. HMGN gives agricultural development in the Terai the highest priority with a strategy for achieving national food security. Though the Study area is also a part of this region and regarded as an advanced area of agricultural production in comparison with the Hills and the mountains, it seems that the Study area has not achieved the food sufficiency yet. According to our fact-findings, development constrains and potentials are described below.

5.1 Development Constrains

5.1.1 Uneven Distribution of Rainfall and Irrigation Water

Most of the farmers to whom the Study Team interviewed through RRA survey as well as the participants in farmers' level consultation workshops were complaining about lack of irrigation water. It is no doubt that lack of irrigation water is the main cause of low productivity of crops, especially paddy and wheat. However, there is a rainfall of around 1,500mm a year on average that can cultivate paddy under rain-fed condition. Farmers also have an option to irrigate their farmland by STW although this irrigation method is very costly as compared with surface irrigation. It is considered that water deficit is not substantial constrains for agricultural development in the Study area. The problem is that rainfall is erratic and unevenly distributed in monsoon season, in other word, irrigation water is not supplied timely and cheaply.

There is a gap of access to irrigation water provided by SMIP. Access to irrigation water is limited to northern part of the Study area and/or to the farmland along the Shankarpur and Suksena Canals, because water from CMC is not sufficient and watercourses that convey irrigation water to the farmland do not exist. Irregular supply of irrigation water causes low productivity even in the area that is provided irrigation water by SMIP facilities. As the result of imbalanced water supply, differences of cropping pattern, cropping intensity and productivity are given rise in the Study area.

5.1.2 Soil Unsuitable for Paddy Production

According to the outcome of Land Resource Mapping Project (LRMP) which was conducted as a technical cooperation by the Canadian International Development Agency (CIDA), the Study area is classified into the area suitable for diversified crop production. Area suitable for paddy production is limited to some parts in Ghuski, Rajganj Sinuwari, Madhay Harsahi and Gautampur VDCs. Physical soil condition is also a limiting factor for paddy production that requires much irrigation water. Sandy soil that has little capacity to hold moisture and nutrients prevails in the Study area. The ratio of sandy field to arable land in the downstream is higher than that in the upstream.

However, the present land utilization in monsoon season is represented by paddy production. Farmers who have an intense preference for rice eating tend to plant paddy in monsoon season whether it will be harvested or not. This fact shows there is a gap between rational land use in theory and farmers' intention of farming.

5.1.3 Poor Access to Quality Farm Inputs

Next concern following irrigation water among farmers is how to access quality farm inputs, particularly fertilizer. Nepal that has no factory to manufacture chemical fertilizer completely depends on imported fertilizer from a third country, mainly from India. After the liberalization of farm input supply, fertilizer without certification of nutrient contents is imported illegally in large quantity. Poor quality of fertilizer causes not only ineffectiveness in production increase but also growth injury such as salt injury.

Another problem is that it is difficult for farmers to access farm input when the need arises and at a low price. Lack of capital is a main cause, to be sure, but it is also problems that there is no practical credit scheme. Farmers have an opportunity to lend money from local moneylender. However, over 60 % of annual interest rate leads to pressing farm household economy. Existing credit scheme provided by ADBN is also inconvenient for farmers due to complimented paper works and necessity of mortgage.

5.1.4 Poor Access and Quality of Extension Services

One ASC and three SCs staffed with 8 technicians (JT/JTA) in total are responsible for provision of extension services in the Study area. This fact shows that one technician should cover around two thousand households. In case of Japan, it is common one extension worker take care of around 300 households. Limited manpower makes extension system no functional practically even though group approach is applied with intent to deliver the services efficiently.

Most farmers point out that the problem of extension services is poor quality as well as poor access. According to the interview to a farmer, when he tried to control disease according to JT/JTA's advice, it was not effective to improve the situation. JTA who has not received higher education or has few experiences in the field generally has difficulty to provide useful advises/solution corresponding to the farmers' demand

5.1.5 Poor Marketing/Distribution System

Marketing and distribution system in the Study area is not developed well. It is common to transact agricultural products in the local market or in Inaruwa and Biratnagar through middlemen or directly. Fortunately, there is a main trunk road that runs from north to south so that it is easy to carry agricultural products out of the Study area. However, feeder roads that connect between farmlands and the trunk road have not been provided fully. During monsoon season, distribution network is often interrupted since heavy flood often cuts off some feeder-roads.

Although the number of commercial vegetable growers is not many, the Study area is well known for a vegetable production area. Marketing channel to the Hills, such as Kathmandu and Dharan, has already been established though transactions between individual farmers and middlemen/merchants are the majority. Vegetables are generally profitable to be a good income source for farmers. However, lack of storage facilities is a limiting factor of marketing activities of perishables. Farmers have no choice but to sell their products at low price at a peak period of harvesting since shipping depending on supply and demand in balance is out of control without storage facility.

5.2 Development Potentials

5.2.1 Soil Suitable for Diversified Crop Production

It is true that sandy soil with less moisture holding ability is not suitable for paddy production that requires much irrigation water. On the other hand, this limiting factor turns to advantage in terms of promoting upland crops, particularly wheat and vegetables that are weak to wet injury or root rot which is serious limiting factor for growth.

Fortunately, vegetables have been already familiar to the farmers as a secondary crop after monsoon paddy in the Study area. There are some commercial vegetables growers who have already established production procedure based on their experiences, leaving the question of the effectiveness of their own way. The Study area has several communities of Metha, which is a caste of vegetables grower. For this reason, it is expected that existing commercial vegetable growers play a role of the core farmer to distribute their skills to the newcomer of vegetable production commercially. It seems that it is not difficult to promote diversified crop production furthermore.

5.2.2 Advantageous Position for Marketing Geographically

The Study area is located at advantageous position for marketing geographically. There is several urban areas that have a large number of consumers; Biratnagar (population; 161,036 in 2001), which is ranked as the second largest city in Nepal and some neighboring cities, Inaruwa (population; 23,200 in 2001), Ithahari (population; 41,210 in 2001) and Darhan (population; 95,332 in 2001) are the targets as the destination for the present. A trunk road that runs from north to south connects to East-West highway so that it is possible to transport perishables to Kathmandu within the same day. Supposed that marketing system including regulations, infrastructures and fair-trading is developed properly, there is every possibility for the Study area of being the center of vegetables production.

The Study area maintains close ties with India socially and culturally. Regarding to distribution flow between the Study area and India, inflow is exceeding than outflow. especially most of fertilizer is imported from India. However, some farmers in southern part have a chance to sell their produce in Indian market depending on the price. They transport their produce by bicycle to nearby Indian market through the open-border. In the future, there is a possibility of being a major supplier of agricultural product to Indian towns bordered on Nepal, which are Kulkaha, Basmatiya and Bathnaha that belong to Bihar state of India, as the competitiveness with India in terms of quality and price of product is increasing.

CHAPTER 6 DEVELOPMENT PLAN

6.1 Development Strategy and Framework

Sunsari district is a part of the Terai that is placed in the center of food grain supply in Nepal. In fact, command area of SMIP as a whole has already achieved more than 200 % of cropping intensity in the year 1999/2000 and has produced 300,000 MT of cereals including spring paddy, wheat and maize in addition to monsoon paddy. Particularly, cropping intensity of monsoon paddy is more than 90 %. Sunsari district has been developed into the granary in Nepal thanks to the implementation of SMIP.

On the other hand, the Study area has difficulty to increase cereal production due to incomplete irrigation networks, insufficient irrigation water from CMC and dominant sandy soil although the Study area is a part of command area of SMIP, as described in CHAPTER 5 DEVELOPMENT CONSTRAINTS AND POTENTIALS,. Even in the Study area, there is a differential to access to irrigation water between the upper area and the lower area.

In consideration of the present condition in the Study area, two phased strategies for agriculture development will be devised as follows:

6.1.1 Short-term Strategy

Food security in the Study area has not been established; there are 7,000 MT (equivalent to 70 kg per capita) deficits of food grains in the year 2001/2002. With the problem in mind, establishment of food security is given first priority as a short-term strategy. Cereal requirement for the population in the Study area will be met by paddy and wheat. The year 2012 will be targeted to reach the goal of short-term strategy.

6.1.2 Mid-term Strategy

Not only is the Study area conveniently located at a position geographically for marketing activity, but also the Study area has favorable agricultural environment, particularly for vegetable production that is fit to sandy soil as well as temperate climate throughout the year. Vegetable production will be promoted for the purpose of improving farmers' economy as a mid-term strategy. The year 2017 will be targeted to reach the goal of mid-term strategy.

Based on the two phased strategies, agricultural development plan will be drawn up in detail in the sections that follow.

6.2 Development Plan

6.2.1 Land Use

Land use in future follows the present situation fundamentally; it means that reclamation is not taken into account in future. However, land use in two areas, which have a limitation on land use geographically, will be considered separately as follows.

(1) Highland Area in Kaptanganj

Highland area in Kaptanganj that occupies 3.8 % of the overall agricultural land in the Study area, which is equivalent to 397 ha, is not able to receive irrigation water from gravity irrigation system under the Project. Therefore farmland in this area will be utilized as upland field through introducing groundwater irrigation system, particularly vegetable production throughout the year will be put emphasis on.

(2) Inundated Area in Kaptanganj and Ghuski

It is actually impossible to cultivate upland crops in monsoon season at the farmland in Kaptanganj and Ghuski, which is estimated at 880 ha, due to serious inundation problem. This farmland will be basically utilized for paddy or jute production that is tolerant to water logging during spring/monsoon season.

Total irrigable area under the Project is estimated at 10,147 ha as the result of eliminating upland area mentioned above. In consideration of the present farming situation and differences of percolation rate within the Study area, the northern area will be placed cereal production area while the central and the southern area including upland area will be placed vegetable production area. Also, the farmland for vegetable production that requires frequent operation during growing period will be arranged nearby residential area or access road.

6.2.2 Cropping Pattern

Proposed crops under the Project are basically same as the prevailing crops in the Study area; there is no idea to introduce new crops. The difference between the present cropping pattern and the proposed cropping pattern shows itself the cropping intensity of each crop. Proposed cropping pattern is considered from the point of view of food security as well as the strategy of vegetable production promotion.

(1) Cereal Production

Although farmers' intention of paddy production is strong in the Study area, it is quite obvious that it is impossible to meet cereal requirement for the population in future to meet only by paddy production due to limited irrigation water to be developed from Sunsari River under the Project. Therefore required cropping intensity of paddy with project condition will be calculated back based on the present and the expected production of wheat. Assumptions of calculations will be set force as follows:

- The population of the Study area in 2012, which is the targeted year of short-term strategy, is projected based on the Population Census in 2001.
- Expected paddy yield will be set on 4.2 MT/ha on the basis of the actual result in the Stage I area of SMIP.
- Cropping intensity of wheat will be set on 50 % roughly according to the present

condition.

Regarding the expected yield of wheat, three alternatives will be considered as follows:

Alternative A
The expected yield of wheat will be set on the present level in the Study area (2.0 MT per hectare).

Alternative B
The expected yield of wheat will be set on the present level in the Stage I area of SMIP (2.7 MT per hectare).

Alternative C
The expected yield of wheat follows the figure that is applied in the Detailed Feasibility Report in the Stage Ⅲ area of SMIP (3.5 MT per hectare).

As the result of the calculation based on the three alternatives mentioned above, required cropping intensity of paddy is estimated at 59.0 %, 47.3 % and 34.2 % respectively (see in Table 6.2.1 and details refer to ATTACHMENT 2). According to the water management plan in winter season based on the availability of irrigation water from Sunsari River, operation of facility has to follow preventive irrigation method so that an increase yield of wheat will not be expected during the initial stage of the Project. Also, it is not expected that cropping intensity of paddy is less than 50 % judging from the present situation. Consequently, proposed cropping intensity of paddy is set on 60 % in accordance with the Alternative A.

Table 6.2.1 Required Cropping Intensity of Cereals With Project Condition

Season	Crop	Alternative A	Alternative B	Alternative C
Monsoon	Paddy	5,990 ha (59.0%)	4,601 ha (47.3%)	3,471 ha (34.2%)
Winter	Wheat	5,074 ha (50.0%)		
Total Irrigable Area		10,147 ha (100%)		

However, on condition that environmental issues, which are water pollution caused by paper factory and compensation for fishermen, will be clear in future, it is expected that yield of wheat reaches 3.5 MT/ha as the result of full irrigation management in the half of the irrigable area.

(2) Vegetables and Other Crops

Proposed cropping intensity of other crops except cereals with project condition will be determined as follows:

Jute; Cropping intensity of jute will be reduced according as a recent trend that synthetic fiber is taking the place of jute.

Vegetables; Vegetable production will be promoted aggressively according to the mid-term strategy for agricultural development.

Other crops; Cropping intensity of other crops will be set on the same level as compared with the present condition or be increased slightly.

Proposed cropping pattern with project condition is presented in Table 6.2.2 (proposed cropping calendar is referred to ATTACHMENT 1). Total cropping intensity is estimated at 180 % as a whole. As the result of explaining this cropping pattern when Farmers' Consultation Workshops were held at four places, attendances agreed with this plan basically. Marketability of produce and availability of labor force under this cropping pattern will be verified in the sections that follow. Meanwhile, cropping intensity without project condition is same as compared with the present condition.

Table 6.2.2 Proposed Cropping Pattern With Project Condition

	Cultivated Area	Upland Area		Irrigable Area		TOTAL	
		397 ha		10,147 ha		10,544 ha	
Season	Crops	Cropping Intensity (%)	Area Planted (ha)	Cropping Intensity (%)	Area Planted (ha)	Cropping Intensity (%)	Area Planted (ha)
Spring/Monsoon	Paddy	- %	-	60.0%	6,088	57.7%	6,088
	Jute	25.0%	99	15.0%	1,522	15.4%	1,621
	Vegetables (Summer1))	60.0%	238	10.0%	1,015	11.9%	1,253
	Pulse (Mungbean)	- %	-	5.0%	507	4.8%	507
Winter	Wheat	40.0%	159	50.0%	5,074	49.6%	5,233
	Potato	25.0%	99	10.0%	1,015	10.6%	1,114
	Vegetables (Winter2))	20.0%	79	10.0%	1,015	10.4%	1,094
	Oilseed (Mustard)	5.0%	20	5.0%	507	5.0%	527
	Pulse (Lentil)	5.0%	20	10.0%	1,015	9.8%	1,035
Through the year	Others (Sugarcane)	- %	-	5.0%	507	4.8%	507
TOTAL		**180.0%**	**714**	**180.0%**	**18,265**	**180.0%**	**18,979**

1): Cucumber and okra represent summer vegetables
2): Cauliflower and cabbage present winter vegetables

6.2.3 Yield and Production

The Project will bring an increase yield of crops to the beneficiaries in the Study area. This benefit is caused not only by providing irrigation water but also by realizing progressed and recommendable farming system as an indirectly effects of the Project. On the other hand, even without project condition, it is expected that productivity will be improved as compared with the present condition, although in a small scale, through not only the efforts of agricultural supporting services, needless to say, also farmers own efforts. Way of thinking of expected yield without/with project condition is described below.

Without project: It is expected that yield of each crop except vegetables will increase

10 % as compared with the present yield[2]. In case of vegetables that have nearly reached potential yield, it is considered that expected yield is same as the present yield.

With project: Expected yield of each crop except vegetables basically follows the figures that were targeted in the plan of SMIP. Expected yield of vegetables is referred to the experimental data derived from RARS in Tarahara.

Table 6.2.3 shows expected yield and production without/with project condition according to the principal mentioned above. It is expected that yield of paddy and wheat will reach 4.2 MT/ha and 3.5 MT/ha respectively on condition that full irrigation and dissemination of improved farming practices will be achieved as mentioned in the SECTION 6.2.2. In case of pulses and oilseeds, which are seldom applied irrigation water and farm-inputs at present, will be on big increase. Total production with project condition is estimated at 162,327 MT that is about 2.5 times higher than that without project condition.

Table 6.2.3 Expected Yield and Production Without/With Project Condition

Season	Crops	Without Project		With Project		Potential Yield (t/ha)
		Yield (t/ha)	Production (t)	Production (t)	Yield (t/ha)	
Spring/Monsoon	Paddy	2.5	17,950	25,570	4.2	3.5 - 6.0
	Jute	1.9	3,867	4,053	2.5	2.1 - 3.1
	Vegetables (Summer[1)])	18.6	2,753	25,060	20.0	20.0 - 30.0
	Pulse (Mungbean)	0.5	100	507	1.0	1.0 - 1.5
Winter	Wheat	2.2	13,570	18,316	3.5	4.0 - 5.0
	Potato	17.9	16,414	24,508	22.0	20.0 - 35.0
	Vegetables (Winter[2)])	19.7	2,069	21,880	20.0	20.0 - 30.0
	Oilseed (Mustard)	0.4	42	527	1.0	0.9 - 1.1
	Pulse (Lentil)	0.8	202	1,346	1.3	1.5 - 3.5
Through the year	Others (Sugarcane)	44.0	6,512	40,560	80.0	52.0 - 80.0
TOTAL			**63,479**	**162,327**		

1): Cucumber and okra represent summer vegetables
2): Cauliflower and cabbage present winter vegetables
Sources; Report on Snsari Morang Irrigation Ⅲ Detailed Feasibility and Design (Annexes Volume Ⅱ), Experimental data at Tarhara RARS

Marketable amount of perishables at full development stage is presented in Table 6.2.4. Marketable surplus of potato and vegetables is estimated at 15,947 MT and 34,543 MT respectively. In turn, the population in 2017 of the Eastern Terai that consists of 5 districts, namely, Jhapa, Morang, Sunsari, Saptari and Siraha, is projected at 4,770,657 based on the Statistical Year Book of Nepal 2001. Surplus of vegetables will meet the requirement for 13 % of the projected population of the Eastern Terai.

2 A rate of increase is referred to the Report on the Stage Ⅲ feasibility study. Yield of paddy in the Stage Ⅲ area in the year 2000 also increased by 8 % as compared with the year the detailed feasibility study was carried out based on the Report on Agri-Economic Analysis of Sunsari Morang Irrigation Project Area (FY 2000 to 2001).

The present surplus of potato, which is equivalent to 10,000 MT, is supplied to 9.0 % of the total population in the Eastern Terai so that marketable surpluses of perishables produced in the Study area will be handled regionally. It is also expected that shipment to Kathmandu, which has a large amount of urban population, will be increased.

Table 6.2.4 Marketable Surplus of Perishables With Project Condition

Crops	Production (MT)	Seed Use (MT)	Waste (MT)	Amount of Food (MT)	Per Capita Consumption (kg/year)[3]	Regional Consumption (MT)[4]	Marketable Surplus (MT)
Potato	24,508	1,671	3,175	19,161	35.1	3,214	15,947
Vegetables (Summer)[1]	25,060	-	3,759	39,899	58.5	5,356	34,543
Vegetables (Winter)[2]	21,880	-	3,282				

1): Cucumber and okra represent summer vegetables
2): Cauliflower and cabbage present winter vegetables
3): FAOSTAT Database
4): Regional population in 2017 is projected at 91,556 based on "Statistical Year Book of Nepal 2001"

6.2.4 Farm Management

Application of improved seed, fertilizer and chemicals is common in the Study area at present. Therefore it is considered that farm-inputs that have not reached the recommendable amount of application will be applied furthermore even without project condition. In case of vegetables production, there is a tendency to apply farm-input excessively as compared with the recommendable amount so that the present amount will be taken as required amount without project condition in this case. Labor force requirement without project condition is set on the same level as compared with the present condition (shown in Table 6.2.5).

Table 6.2.5 Proposed Farm-input Requirement Without Project Condition

Crops	Seed (kg/ha)	Fertilizers			Chemicals (Rs/ha)	Labor	
		Urea (kg/ha)	DAP (kg/ha)	Potash (kg/ha)		Human (MD/ha)	Draft (MD/ha)
Paddy	74	54	69	31	210	175	56
Jute	8	42	58	32	28	167	36
Cucumber family	3.0	84	179	73	1,408	390	46
Mungbean	15	-	-	-	-	57	24
Wheat	145	81	105	32	127	158	45
Potato	1,319	85	140	31	295	176	32
Cauliflower	1.0	133	308	111	1,008	395	44
Mustard	14	-	-	-	-	56	22
Lentil	21	-	-	-	-	57	24
Sugarcane	5,724	44	22	11	111	329	56

Source: Consultants estimation

On the other hand, proposed farm-input requirement with project condition is set on based on 1) the related projects including SMIP and Mahakali Irrigation Project (MIP), 2) experimental data derived from RARS in Tarahara and 3) Trainer's Manual prepared by DOA under the Agricultural Training and Manpower Development Program. Labor force requirement also follows the sources mentioned above, however, in case of paddy and wheat, it is estimated separately according to the present farming practice based on Rural Socio-economic Survey conducted by JICA Study Team.

Table 6.2.6 Proposed Farm-input Requirement With Project Condition

Farm Input / Crops	Seed (kg/ha)	Fertilizers			Chemicals (Rs/ha)	Labor	
		Urea (kg/ha)	DAP (kg/ha)	Potash (kg/ha)		Human (MD/ha)	Draft (MD/ha)
Paddy	50	140	87	50	505	190	70
Jute	8	81	35	40	450	220	45
Cucumber family	2.5	96	87	67	1010	260	40
Mungbean	40	9	87	33	404	80	30
Wheat	120	175	109	33	202	170	50
Potato	1,500	106	174	100	505	260	40
Cauliflower	0.7	167	130	83	1010	260	40
Mustard	8	97	87	33	202	90	30
Lentil	40	9	87	33	404	80	30
Sugarcane	5,000	275	130	67	505	320	60

Sources: Report on Snsari Morang Irrigation Ⅲ Detailed Feasibility and Design (Annexes Volume Ⅱ), Draft Report on Mahakali Irrigation Project Stage-Ⅲ Detailed Feasibility (Volume Ⅱ Annexes 1/3), Trainer's Manual prepared by DOA under Manpower Development Agriculture Project and Experimental data at Tarhara RARS

6.2.5 Post-harvesting and Marketing System

Through the implementation of the Project, a large amount of marketable surpluses, particularly vegetables, will be produced. Vegetables are so perishable that it is difficult to keep them without appropriate post-harvest treatment. Regarding the matter of marketing, farmers have a wide range of trade connection of vegetables while sugarcane and jute are transacted with specified processing factories. Therefore, it is indispensable for marketing of vegetables to arrange post-harvesting facilities and to establish distribution system opportunely.

However, it is undesirable that the government intervenes in marketing activities such as controlling distribution system, supporting minimum price etc. Needless to say, state intervention prohibits a private business. In fact, it is impossible for the government to support marketing business financially. Therefore it is proposed that a role of government in this field is limited to provision of software services, such as dissemination of market price information, strengthening inspection system in order to control illegal inflow of farm-inputs from India etc.

Action plans for improvement of post-harvesting and marketing system area proposed as follows.

(1) Arrangement of Collection Points

There is one collection point in Kaptanganj that was constructed with assistance of Department of Cooperatives under MOAC, however, this facility has not functioned yet due to misarrange of middleman and/or merchant. Although the first consideration is to make this collecting point function, it is proposed that additional collecting point be arranged along the main trunk road in the central area in order to make it convenient to ship the product. Construction cost of simple facility that has tin roof and concrete floor is estimated at 20 USD per square meter, which is equivalent to 1,560 Rs per square meter.

(2) Arrangement of Cold Storage

One private cold storage in Inaruwa starts full operation in this year. Capacity of this storage is as much as 2,000 MT of Potato, which is equivalent to 10 % of total production of potato in the Study area. Potato as well as vegetables suffers sharp fluctuations in price so that there is a potential to utilize cold storage that makes it possible to control shipping time.

It is considered that there is little possibility of managing storage facility by farmers organization including water users organization since it is required a large investment for construction as well as a lot of maintenance cost. Existing facility in Inaruwa costed 65 million Rs for construction and annual electricity cost is estimated at 2.4 million Rs. Therefore it is expected that arrangement of old storage will be proceeding by the vitality of the private sector.

6.2.6 Agricultural Supporting System

It is necessary that both irrigation system and agricultural supporting system should function well and work closely together in order to achieve expected benefit. Although there is a system of extension service, it is the reality that farmers are not satisfied with the services. It is caused by lack of personnel who is in charge of provision of extension services, however, a big increase in the budget allocation for this sphere is not expected in future.

This issue is not always special in the Study area. It is considered that all over the country has same constraint about agricultural supporting services. The government tackles this problem through the implementation of various programs, such as Agricultural Extension and Research Program funded by World Bank. The policy of the program is to decentralize responsibility of supporting services to NGOs involving the private sector and to strengthen farmers for themselves. SMIP is also challenging to develop farmers' faculties through Farmers' Field School program as mentioned in CHAPTER 4.

The Project follows these policies in order to provide appropriate agricultural supporting services to the beneficiaries together with irrigation water. Now, a structure of agricultural supporting services under the Project is proposed below.

It is proposed that water users organization, to put it concretely, an agriculture committee as a lower branch of the organization, should play a role of a window to receive supporting services instead of setting up new farmers organization. Supporting services will be provided on demand or needs of farmers basically. After that, water users organization will disseminate supporting services to each member.

According to the government policy on decentralization of supporting service, NGOs and private firms like Seed Company etc are regarded as a provider of supporting services. On the other hand, although the authority of the government for agricultural supporting services is minimized gradually, the government should be responsible for research in agronomy. RARS in Tarhara and Soil Testing Laboratory in Jumka are expected to be a core research institute to develop technology and farming practice suitable for the Study area.

Matters related to extension services to be solved as soon as possible are described below.

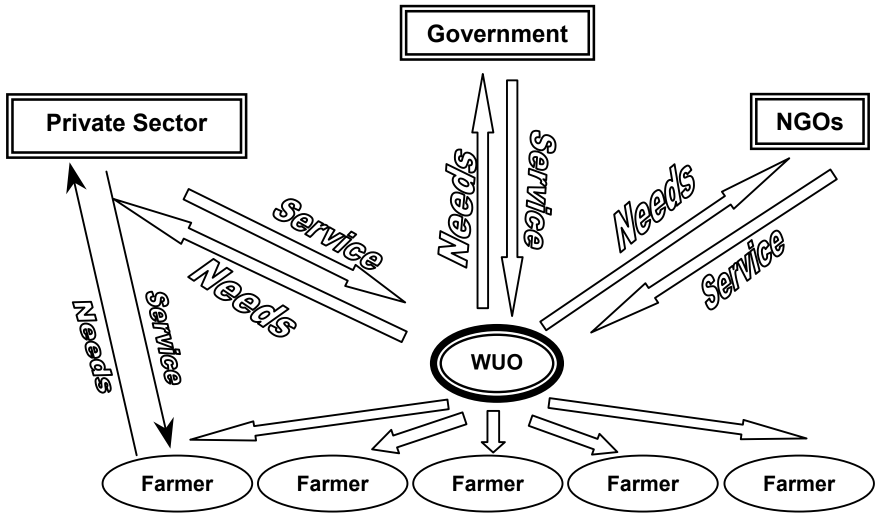


Figure 6.2.1 Structure of Agricultural Supporting System under the Project

(1) Dissemination of Appropriate Application Method of Fertilizer and Chemicals

Although application of fertilizer and chemicals is common in the Study area, in general, a method of application depends on farmers' experiences. Commercial vegetables growers tend to apply farm-input excessively so that content of some soil nutriments in the vegetables farmland exceed the recommendable level as the result of soil analysis survey. The problem is application of chemicals rather than that of fertilizer. Application of chemicals without proper knowledge causes not only residual toxicity to product but also harm to growers. Way of fertilization and pest & disease control directly affects not only the productivity but also the quality of product. Therefore it is desired that appropriate application method of fertilizer and chemicals should be disseminated in order to promote vegetable production.

(2) Acceleration of Research on Low-input Farming Practice

Application of chemical fertilizer, herbicide and insecticide, named a modern farming practice, is a shortcut to increase productivity. However, such farming practice is hardly acceptable from the point of view of the sustainability of agriculture. Particularly, the Study area is dominant with sandy soil with less fertility. Therefore continuous application of chemical fertilizer makes soil poor furthermore and imposes financial burden on marginal and small-scaled farmers, which is the majority in the Study area.

Low-input farming practice that lightens the burden imposed on environment and farmers' economy will be promoted in future. This farming practice doesn't have a concept to deny high-input farming. It goes toward spreading the best-suited technology harmonized with high-input farming, such as multiple application of chemical fertilizer and manure/green manure, introduction of Integrated Pest Management (IPM) etc. RARS in Tarhara has already tried to develop these farming practice. It is expected that research on this issue should be accelerated furthermore.

6.3 Project Benefit

Three items, namely crop production, labor force requirement and marketable surplus of perishables, are considered as an indicator of the project benefit in the field of agriculture. Project benefit is estimated under the three conditions as follows:

Base Case; Whole farmland will be irrigated preventively in winter season.

Reference 1; 50 % of the total farmland will be irrigated in winter season

Reference 2; Whole farmland will be irrigated completely.

In all cases, whole farmland will be irrigated completely in spring/monsoon season.

Table 6.3.1 Project Benefits in the Field of Agriculture

Case	Items	Without Project	With Project	Increment
Base Case	(1) Crop Production (MT)	63,479	63,479	-
	(2) Marketable Surplus of Perishables (MT)	13,938	13,938	-
	(3) Labor Force Requirement (man-day)	2,911,869	2,911,869	-
Reference 1	(1) Crop Production (MT)	63,479	145,187	81,708
	(2) Marketable Surplus of Perishables (MT)	13,938	38,630	24,692
	(3) Labor Force Requirement (man-day)	2,911,869	3,437,737	525,868
Reference 2	(1) Crop Production (MT)	63,479	162,327	98,848
	(2) Marketable Surplus of Perishables (MT)	13,938	50,490	36,552
	(3) Labor Force Requirement (man-day)	2,911,869	3,635,840	723,971

Under the base case, there is no agricultural benefit; only fuel cost for STW operation will be reduced (see Table 6.3.1). At the full development stage (Reference 2), crop production with project condition is estimated at 162,327MT that shows an increase of 250 % as compared to without project condition. The Project also brings 36,552 MT of marketable surpluses of perishables including potato and vegetables. Increment of labor force requirement, or 723,971 man-days, is equivalent to job creation for 2,479 persons as a full-time worker.

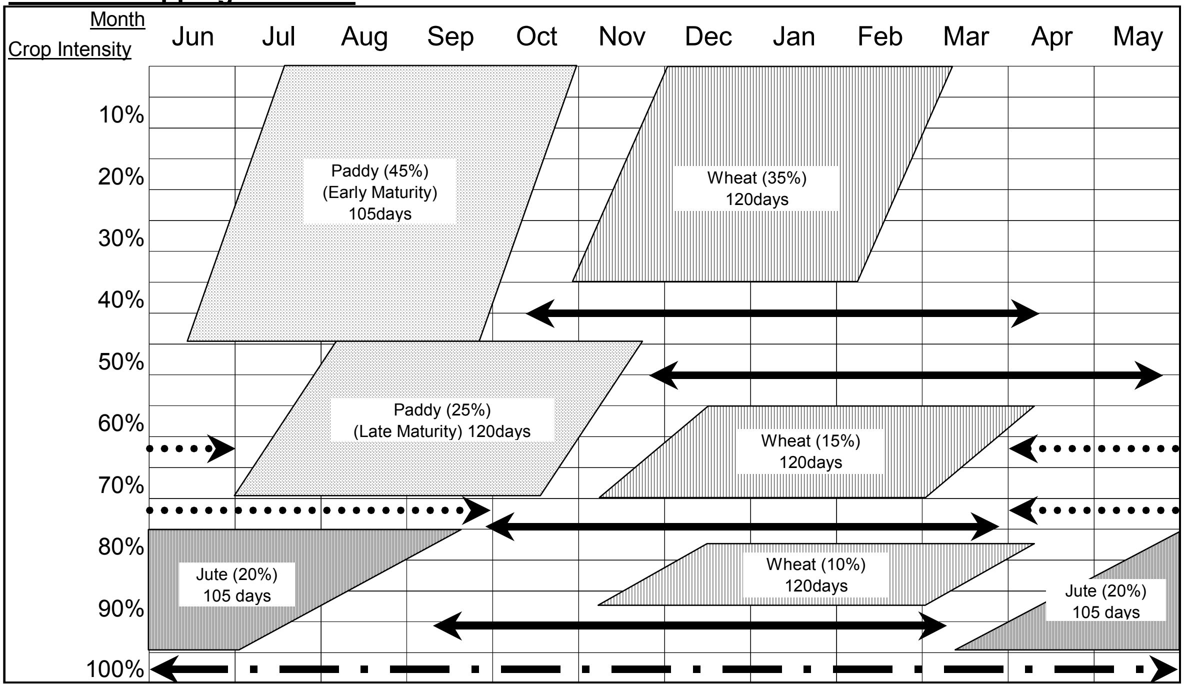
6.4 Risks

There are several risks that expected effects of agricultural development plan under the Project would not make themselves felt. Some killer assumptions that lead to the risks are considered as follows:

- A case that sufficient irrigation water will not be provided to the Study area due to mismanagement of irrigation facility and water users organization,
- A case that agricultural supporting services will not be provided to farmers opportunely, and
- A case that marketing system of perishables will not be arranged well.

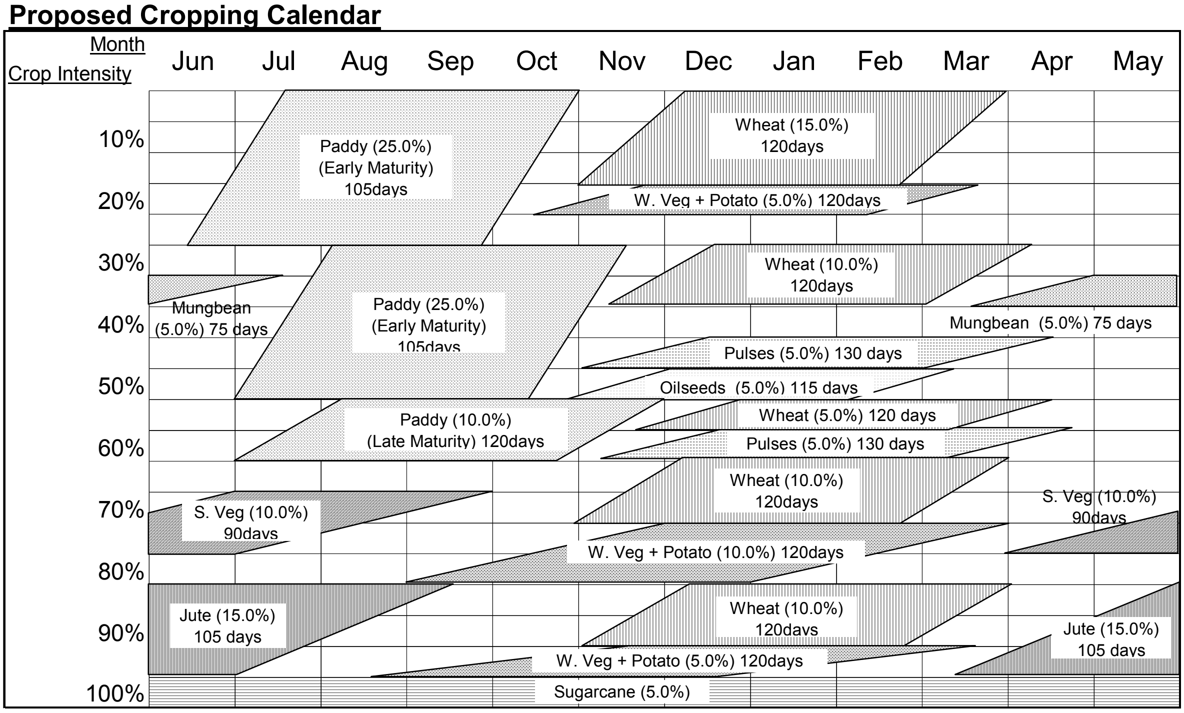
ATTACHMENT 1 PRESENT/PROPOSED CROPPING CALENDAR

Present Cropping Calendar



: Winter Crops (pluses, oilseeds, potato, vegetables), Total Cropping Intensity; less than 15 %
: Spring/Monsoon Crops (mungbean, vegetables), Total Cropping Intensity; less than 5 %
: Sugarcane, Cropping Intensity; less than 5 %

Proposed Cropping Calendar



ATTACHMENT 2 CEREAL REQUIREMENT FOR THE STUDY AREA

1. Cereal Requirement for the Study Area

1.1 Population in 2001				
Sunsari district	(1)	625,633		Population Census 2001 (National Report)
13 VDC	(2)	97,677		Population of Nepal (Eastern Development Region)
Beneficiary ratio	(3)	0.674		Estimation besed on the irrigable area under the Project
Study area	(4)=(2)*(3)	65,834		
Beneficiary ratio	(5)=(4)/(1)	0.105		
1.2 Population in 2012 (projected)				
Sunsari district	(6)	788,987		Estimation based on Statistical Year Book of Nepal 2001
Study area	(7)=(6)*(5)	82,844		
1.3 Cereal requirment for the Study Area				
Annual cereal requiremnt per capita	(8)	182.5	kg/capita	Agricultural statistics in Sunsari district (1999/2000)
Cereal requirment for the Study Area	(9)=(8)*(7)	**15,119**	**ton/year**	

2. Area Planted of Paddy and Wheat to Meet Cereal Requirement

Alternative A; Crop intensity of wheat; 50%, Wheat yield; present level of the Study area (2.0 t/ha)				
Total irrigable aea in the Study Area	(10)	10,147	ha	
Crop intensity of wheat	(11)	50%		
Required area planted of wheat	(12)=(10)*(11)	**5,074**	**ha**	
Anticipated yield of wheat	(13)	2.0	ton/ha	Rural Socio-economic Survey
Production of wheat	(14)=(12)*(13)	10,148	ton/year	
Production cost ratio of wheat	(15)	0.524		Rural Socio-economic Survey
Consumable ratio	(16)	0.75		Agricultural statistics in Sunsari district (1999/2000)
Consumable volume of wheat	(17)=(14)*{1-(15)}*(16)	3,623	ton/year	
Required consumable volume of paddy	(18)=(9)-(17)	11,496	ton/year	
Cunsumable ratio	(19)	0.65		Modified based on Agricultural statistics in Sunsari district (1999/2000)
Anticipated yield of paddy	(20)	4.2	ton/ha	
Production cost ratio of paddy	(21)	0.297		
Required area planted of paddy	(22)=(18)/(19)/(20)/{1-(21)}	**5,990**	ha	
Alternative ;B Crop intensity of wheat; 50%, Wheat yield; present level of SMIP (2.6 t/ha)				
Required area planted of wheat	(23)=(12)	**5,074**	**ha**	
Anticipated yield of wheat	(24)	2.7	ton/ha	Report on survey of crop cut wheat (FY 2001 to 2001)
Production of wheat	(25)=(23)*(24)	13,700	ton/year	
Production cost ratio of wheat	(26)	0.388		
Consumable volume of wheat	(27)=(23)*{1-(26)}*(16)	6,288	ton/year	
Required consumable volume of paddy	(28)=(9)-(27)	8,831	ton/year	
Required area planted of paddy	(29)=(28)/(19)/(20)/{1-(21)}	**4,601**	ha	
Alternative C; Crop intensity of wheat; 50%, Wheat yield; expected level (3.5 t/ha)				
Required area planted of wheat	(30)=(12)	**5,074**	**ha**	
Anticipated yield of wheat	(31)	3.5	ton/ha	
Production of wheat	(32)=(30)*(31)	17,759	ton/year	
Production cost ratio of wheat	(33)	0.365		
Consumable volume of wheat	(34)=(32)*{1-(33)}*(16)	8,458	ton/year	
Required consumable volume of paddy	(35)=(7)-(34)	6,661	ton/year	
Required area planted of paddy	(36)=(35)/(19)/(20)/{1-(21)}	**3,471**	ha	

ATTACHMENT 3 THE RESULT OF SOIL ANALYSIS

Items	Standard	Max.	Min.	Classification		
				Low/ Deficit	Medium/ Adequate	High/ Toxic
(1) Texture		65.8 %[1)]	35.8 %[1)]	2[2)]	6[2)]	11[2)]
(2) pH	6.0 - 8.0	5.7	7.2	5	14	-
(3) Organic Matter	2.5 - 5.0%	9.7 %	0.7%	8	9	2
(4) Major Elements						
Nitrogen (N)	-	0.28 %	0.03%	6	8	5
Phosphorous (P)	28 - 56 kg/ha[3)]	969 kg/ha	189 kg/ha	-	-	19
Potash (K)	112 - 280 kg/ha[4)]	591 kg/ha	836 kg/ha	-	-	19
(5) Micronutrients						
Boron (B)	20 - 60 ppm	80 ppm	44 ppm	-	8	11
Molybdenum (Mo)	0.2 - 1.0 ppm	53.1 ppm	2.3 ppm	-	-	19
Zinc (Zn)	25 - 150 ppm	65.8 ppm	14.0 ppm	11	8	-
Copper (Cu)	5 - 20 ppm	24.5 ppm	4.5 ppm	4	12	3
Iron (Fe)	50 - 250 ppm	153 ppm	63 ppm	-	19	-
Manganese (Mn)	20 - 500 ppm	680 ppm	250 ppm	-	8	11

1) Contents of sand (%)
2) Low/Deficit: silt loam, Medium/Adequate: loam, High/Toxic: sandy loam
3) P_2O_5 basis
4) K_2O basis

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APPENDIX-6 IRRIGATION AND DRAINAGE DEVELOPMENT

ATTACHMENTS

CHAPTER 1 INTRODUCTION

This APPENDIX-6, IRRIGATION AND DRAINAGE DEVELOPMENT, discusses about irrigation and drainage development plan together with the associated issues. In the compilation of this Appendix, inputs have been received from concerned officers such as Department of Irrigation (DOI), Sunsari-Morang Irrigation Project Office (SMIP), Eastern Regional Irrigation Directorate (ERID), Sunsari District Irrigation Office (DIO), as well as field observations and field surveys together with findings and results from other Appendixes.

This Appendix consists of, aside from this CHAPTER 1 INTRODUCTION, 4 chapters; namely, CHAPTER 2 IRRIGATION DEVELOPMENT IN NEPAL TODAY, CHAPTER 3 WATER RELEASE FROM SMIP, CHAPTER 4 IRRIGATION AND DRAINAGE DEVELOPMENT and CHAPTER 5 SYSTEM MANAGEMENT.

CHAPTER 2 IRRIGATION DEVELOPMENT IN NEPAL TODAY describes the brief review of the irrigation sector in this Country as well as lessons learned from previously carried out. Due attention is paid to SMIP where in the area of this JICA Study falls. Following that, CHAPTER 2 discusses the present situation of the Study Area in terms of present irrigation practices though it is limited. Potentials and constraints are fully discussed, which are reflected in formulating the irrigation and drainage development plan.

CHAPTER 3 WATER RELEASE FROM SMIP describes the review, analysis and examination of the water release from CMC basic on the additional irrigation water concepts, such as the intake capacity of CMC, SMIP supply driven mode, SRIP demand driven mode, and conclusion and recommendations.

CHAPTER 4 IRRIGATION AND DRAINAGE DEVELOPMENT describes the review, analysis and examination of the basic irrigation development concepts, such as the gross and net irrigable area, examination of the cropping pattern, calculation of the irrigation water requirement, field investigation and analysis of the percolation losses, set up of the nursery water and pudding water requirement, examination of the effective rainfall, analysis of the irrigation efficiency, calculation of the paddy and upland crops unit water requirements, diversion irrigation water calculation, irrigation canal net work, water distribution and management etc. and describes the review, analysis and examination of the drainage development concepts, such as dual purpose of drainage canal, drainage canal layout.

CHAPTER 5 SYSTEM MANAGEMENT describes the review, analysis and examination of the irrigation system management on SRIP, such as the farmer are collaboration as the government agency and the strategy by which the best management method and to be established for the joint management organization. In addition, the examination of the method of the operation and maintenance of the irrigation facilities, the responsibility system, and the number of staffing were examined in this chapter.

CHAPTER 2 IRRIGATION DEVELOPMENT IN NEPAL TODAY

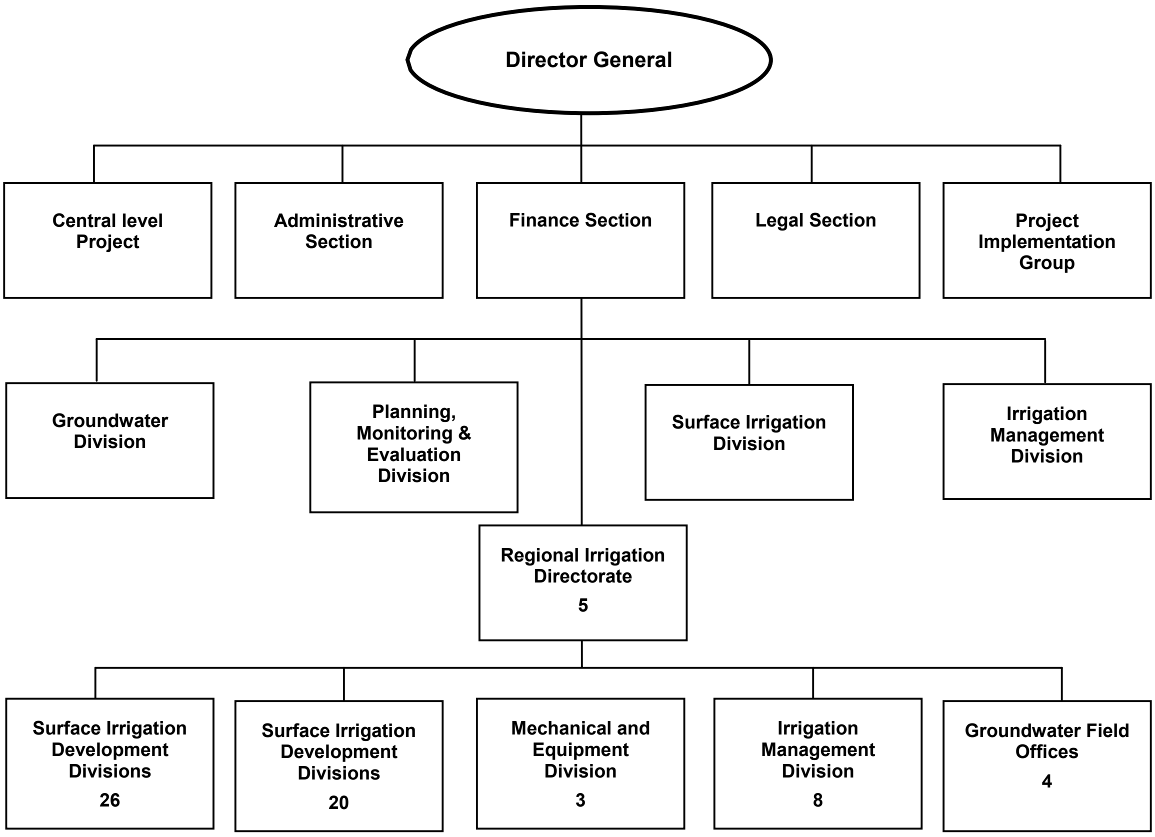
2.1 Authority in Irrigation Development

The Department of Irrigation (DOI), the counterpart agency of this Study, was established in 1951, and has been the principal government organization responsible for the planning, development and management of irrigation schemes in the country. For the first 25 years approximately after its establishment, the DOI had carried out irrigation development through the Division and Sub-division Offices located at key places in the country.

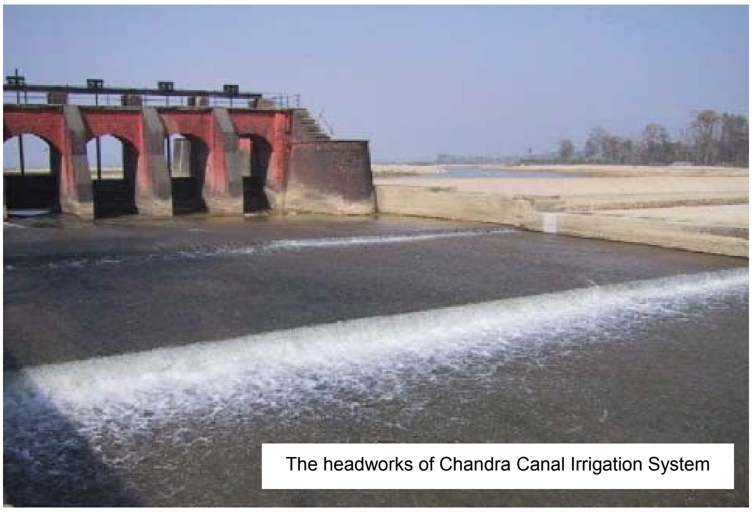
Then, five Regional Irrigation Development Directorates were established during the Fourth National Development Plan period (1975-80), and District Irrigation Offices in all the seventy-five districts were also opened around 1987 to 1988. As of October 2002, a restructuring plan is being carried out, merging some district irrigation offices sometimes jointly with irrigation project offices. The restructuring plan envisages reducing the district and project offices from the present about 90 to 61 in number.

The new organizational structure of DOI is shown below, and there are about 2,400 sanctioned posts of which almost 85 percent are filled. Of the total sanctioned posts, about 9 percent have been sanctioned for the central office, 13 percent for the pool, 8 percent for the five regional directorates, and the remaining 70 percent for the district offices as well as project offices now being under the restructuring:

Figure 2.1.1 The New Organizational Structure of DOI



2.2 Brief History of Irrigation Development in Nepal[1]



The headworks of Chandra Canal Irrigation System

The first effort of the government towards the irrigation development in the Terai can date-back to as early as year 1920 when the first international negotiation and agreement between Nepal and India over the sharing of Mahakali river water for irrigation and power took place. Though the construction of the Mahakali Irrigation Project did not take place until 1971, another large canal irrigation system, the Chandra Canal Irrigation System in the eastern Terai, was realized in the years 1922 to 1928 with the assistance of foreign engineers, which was the first modern canal system having a irrigable area of about 10,000 ha.

International agreements with India were made on the use of the Koshi river water in April 1954 and on the Narayani river water in December 1959. These agreements launched a series of construction of large-scale irrigation systems in the Terai. The government investment in irrigation development, especially in the large-scale irrigation systems in the Terai, had increased tremendously from 1970 onwards as shown in the increase of irrigation development targets in the national development plans. This was made real due to the increase in borrowing international capital in the form of loans and grants.

Until the middle of 1980s, irrigation development by the government had focused largely on the construction of physical infrastructure, and little attention was paid to the effective management of the completed systems. Attention began to be paid on improving the management of government-managed-irrigation-systems from 1985 onwards. This is reflected in the implementation of a number of management-oriented projects: the USAID-funded Irrigation Management Project (IMP) in 1985, the Irrigation Line of Credit (ILC) in 1988 financed by the World Bank, the Irrigation Sector Project (ISP) in 1988 financed by the ADB, the Irrigation Management Transfer Project in 1994 financed by the ADB, etc. All these projects have specifically emphasized the participatory approach.

2.3 Irrigation related Act, Regulation, and Policy in Nepal

2.3.1 The Water Resources Act (2049)

The Water Resources Act (2049) was promulgated in 1992 to make arrangements for the rational utilization, conservation, management and development of the water resources that are available in the Kingdom of Nepal in the form of surface water, underground water or any other forms. The Act states that the ownership of the water resources shall be vested in the

[1] Historical Background of Irrigation Development in Nepal, DOI website: www//doi.gov.np

Kingdom of Nepal and priority order on the utilization of water resources is as follows; placing the priority of irrigation use at the second after the drinking and domestic water:

1. Drinking water and domestic uses
2. Irrigation
3. Agricultural Uses such as animal husbandry and Fisheries
4. Hydroelectricity
5. Cottage Industry, industrial enterprises and mining uses
6. Navigation
7. Recreational uses
8. Other use

Provisions 5 and 6 of the Act clearly recognize Water Users Association (WUA) as a legal entity with perpetual succession. Provision 22 of the Act mentions about turning over of irrigation systems constructed by HMGN to a duly organized farmers association. These provisions together endorse that Water Users Association is duly established as a legal entity and can participate in irrigation O & M even with the ownership over the facilities.

If the government manages an irrigation project partly or wholly, he should have certain income that has to be incurred through irrigation service charge to the user farmers. Provision 13 of the Act specifies the power to fix the terms and conditions of the service charge as "In case where the services generated out of the use of water resources developed by His Majesty's Government is made available to any other person, the service charge may be fixed as prescribed, and may be realized in consideration of services rendered to them". This provision gives the HMGN the authority to charge irrigation service fee to the users.

2.3.2 Irrigation Regulation (2056)

The Irritation Regulation was firstly promulgated in 1993 soon after the Water Resources Act was enacted, and amended in 2000. The Regulation is composed of 7 chapters, under which there are 47 provisions in total, providing rules and regulations all concerned to irrigation development. Chapter 2 with Provisions of 3 to 17 regulates issues relating to WUAs. According to the Provision 3 " Registration of Users Association", the users shall constitute of a Users Association having the Executive Committee of not exceeding nine members including at least two women members. In constituting the Users Association, there should be representation of at least sixty seven percent users of the irrigation area.

Provision 10 rules that a project developed by HMGN or a canal, secondary canal, sub-secondary canal, tertiary or water course of such project may be transferred to Users Association. As for a big project, joint management is also envisaged under the Provision 13. The provision states that big projects, which cannot be fully transferred to the WUA, may be operated jointly by concluding as agreement between the two parties including collection of service charge, share percentage of Users Association, and arrangement for maintenance.

With reference to the Provision 42 "Public Participation", the beneficiaries are required to avail of land to the concerned Irrigation Office until the date of operation of irrigation activities to construct tertiary[2] and watercourse for the purpose of irrigating the land of the users. Further, the Users Association, before developing the Project, has to avail of an amount fixed by Service Charge Fixation Committee[3] not exceeding 0.2% of cost estimate required to construct tertiary and watercourse. The amount received from the users is returned for the repair and maintenance of the tertiary and watercourse after the completion of the project.

2.3.3 Irrigation Policy (2049)

The Irrigation Policy was formulated in 1992 and is amended in every five years. The Irrigation Policy lists nine objectives, of which the 7th objective states the future direction of government involvement in irrigation development as: to gradually decrease the government's responsibility in construction, repair and maintenance and operation by gradually increasing participation of organized users without diminishing the effectiveness in the implementation of irrigation development projects at different stages and to increase the role and responsibility of the organized users in different stages of program implementation.

Provision 2.2.3 states that projects larger than 2,000 hectares in Terai, which cannot be turned over to the Water Users Association for their operation, maintenance and management shall be jointly managed by the concerned Irrigation Office and Water Users Association. Taking into account the project size of about 10,000 ha that this JICA Study undertakes, the irrigation management will fall in the category of joint management.

To pursue the joint management, irrigation system is divided into blocks or various parts on the basis of quantity of water supply and topographical features of the canals, within which the Water Users Association has autonomy for the distribution and management of water. There may be provisions of single Water Users Association for the whole project or separate autonomous legal organizations for separate level and area according to the collective desire of the users. In case of existence of separate autonomous organizations, a coordination committee of such associations at the project level needs to be established.

Provision 2.4.2 accompanies a table specifying a farmers' minimum due which shall be borne by the users as follows. Besides, the Water Users Association has to make an up-front deposit of additional 0.5% their total share before the project starts its work. The amount collected plus interest will be returned to the Water Users Association upon completion of the construction for the purpose of utilizing the amount for future O & M.

Table 2.3.1 Minimum Percentage of the Total Cost Sharing to be Borne by the Users

Users	WUAs	HMGN	In this Study
Water Course up to 10 ha	100	0	Defined as field channel
Tertiary from 10 to 30 ha	25	75	Defined as water course
Sub-secondary from 30 to 500 ha	0	100	Defined as secondary
Headworks, Main, Secondary Canals	0	100	Headworks, headraces, two main canals

Note: In case of rehabilitation. 12 % on the WUAs and the remaining 88% on the HMGN.

[2] The tertiary quoted here is usually defined as a small canal commanding less than 30 ha. Therefore, the tertiary here is same as water course for this Study. Likewise, the water course quoted in the Irrigation Regulation is same as the field channel in this Study.

[3] The committee is composed of Chief of District Irrigation Office as the chairman, representative from District Agricultural Development Office, and Chairperson of the concerned WUA.

The project envisaged in this Study will ask the farmers of 100% burden for so-called on-farm ditches and also 25% for on-farm canals named tertiary in the above table but actually called water course on the ground. In addition to this, the Provision 2.2.3 mentions that the land needed to construct channels irrigating blocks up to 30 ha should be provided by the concerned WUA.

There may be a need to develop groundwater in conjunction with the surface water of Sunsari river for the project envisaged in this Study. The present practice in terms of farmers' due for groundwater development is as follows:

- Deep groundwater development: HMGN 84% WUA 16% (land not included)
- Shallow groundwater development: no subsidy (all on the farmers)

2.4 Relevant Projects and Programs

2.4.1 Sunsari-Morang Irrigation Project (SMIP)

The project started in order to irrigate 68,000 ha of agricultural farmlands of Sunsari and Morang districts, and this JICA Study area falls in a south-western part of the project area. The project has actually a long history, date-backed to the mid of 1950s. The Government of India had constructed the Chatra main canal and its distributaries, and handed over to HMGN in 1975. After the hand over, the World Bank started financing for canal network upgrading and developing on-farm facilities together with institutional development.

In pursuing the development with the assistance from the World Bank, the SMIP area was divided into 3 stages, apart from the construction of a new intake at Koshi river, and the Stage 3 was further divided into 3 phases. The development is still on-going and as of October 2002 the Phase 1 of Stage 3 is about to complete (loan closing extended to June 2003). The development stages and those principal features are glanced as below:

Stage I: Shankarpur canal and its adjacent area (9,750 ha) including the Koshi river control and sediment control devices (April 1978 – June 1986)

Stage II: Stagunji and Ramgunji canals area (16,600 ha) including the improvement of Chatra main canal and related structures (November 1988 – July 1994)

Stage III: Remaining command area (46,000 ha) under 3-phased implementation program including improvement of Chatra main canal, other required works for the Stages I & II and Koshi flood protection, and the current Phase 1 of Stage III covers Biratnagar and Harinagara canals area of 15,100 ha (December 1997 – June 2003)

SMHP: A new intake (Sunsari Morang Headwork Project), a desilting basin, electrically operated dredgers, and micro-hydro power station in the head reach of the main anal (March 1993 – November 1995)

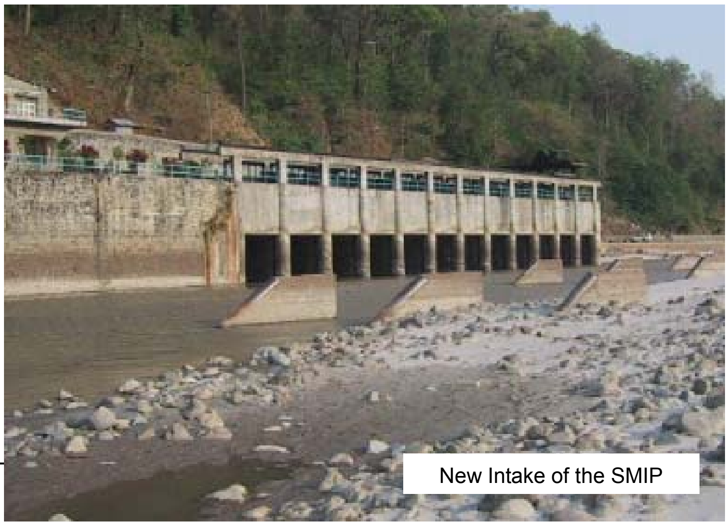
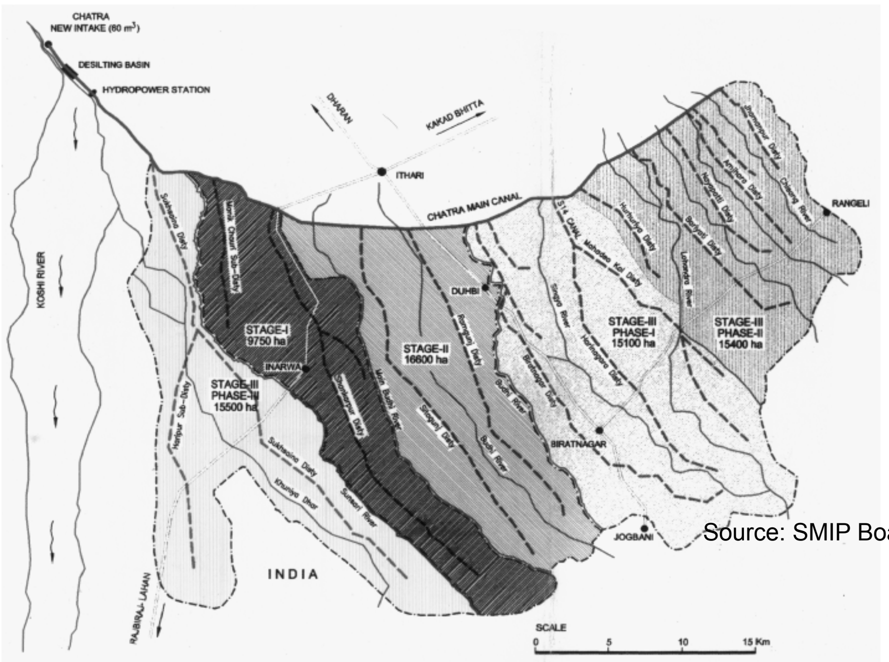

New Intake of the SMIP

Table 2.4.1 Principal Futures of Sunsari Morang Irrigation Project

Work Item	Stage I	Stage II	Phase 1 Stage III	Stage III Total	Total
Chatra MC					
Length, km					53
Year	1978 - 86	1988 - 94	1998 - 02	-	
Command Area, ha	9,750	16,600	15,100	46,000 *1)	73,000 *1)
Irrigation canal					
Secondary, km	31	26	455	165	222
Sub-secondary, km	-	52	40	149	201
Tertiary, km	72	170	166	514	756
Watercourse, km	260	686	634	1,939	2,885
Field Outlet, Nos	-	4,310	3,775	11,634	15,977
Structure, Nos	651	2,566	7,439	7,947	11,164
Drainage canal					
Main drain, km	106	25	-	-	131
Secondary, km	-	63	89	292	355
Sub-secondary, km	-	9	-	15	24
Tertiary, km	-	64	129	351	415
Collector, km	-	125	344	1,070	1,195
Structure, Nos	411	898	986	3,721	5,030

Note: *1 includes extension in command areas of Shankarpur and Haripur canals that were not included in the original 68,000 ha, thus total prospective area became 73,000 ha.



Source: SMIP Board

Figure 2.4.1 Stage-wise Development of Sunsari Morang Irrigation Project

1) Design Duty and System Reliability

The original design intake capacity was 45 m^3/s with an irrigable area of 68,000 ha, giving a design duty per hector of 0.67 l/s/ha, which is very small than the ones usually applied in many Asian countries. The concept of the small duty originates in an idea of preventive irrigation, trying to irrigate as much area as the system can cover with a limited amount of water. In this concept, area coverage is more important than achieving the full level yield.

This has long been practiced in Pakistan and a part of India, however this concept can hardly meet the requirement of paddy irrigation.

When a new intake of SMIP was constructed at 1.3 km upstream from the original one, the intake capacity was also enlarged from the original 45 to 60 m^3/s together with an enlargement of the irrigable area from 68,000 to 73,000 ha. Though the 60 m^3/s is not yet realized simply because Phases 2 & 3 areas of Stage 3 (total 30,900 ha), including a part of Chatra main canal, have not yet been upgraded to accommodate the new design discharge, the expected design discharge is now calculated as follows:

Original: 0.67 l/s/ha (45 / 68,000)

Revised: 0.82 l/s/ha (60 / 73,000; Suksena area 0.85, Others 0.80)

The new design intake capacity of 60 m^3/s (design duty of 0.82 l/s/h) is expected to cover all the 73,000 ha with a system reliability of 70 percent. Design criteria and manuals applied in this country say the system reliability should be set at 80 percent, meaning that probable return of drought is once in every five years. The SMIP took the 70 percent reliability as the system design because: 1) enlargement more than 60 m^3/s was considered not economically feasible since a large amount of excavation should have been carried out for the first 8 km running in a hilly area, and 2) SMIP should cover as much area as reaching to the border with India since local people have long been waiting for irrigation.

2) Design Percolation

In designing paddy irrigation, percolation should be carefully taken into account. The consultants engaged in the design of Stage III area had carried out a series of percolation tests in five places (see Figure right). Most of the test results were below 3 mm/day except the places of No.3 and No. 4. Percolation at No.3 ranged from 10 – 25 mm/day, and at No.4 from 5 – 15 mm/day. The design percolation was decided at 3.0 mm/day for Suksena command area (13,000 ha) and 2.5 mm/day for the remaining area (60,000 ha), thus it could be said the design percolation applied was somewhat conservative specially taking into account very sandy soils one can see at western and south-western parts of SMIP.

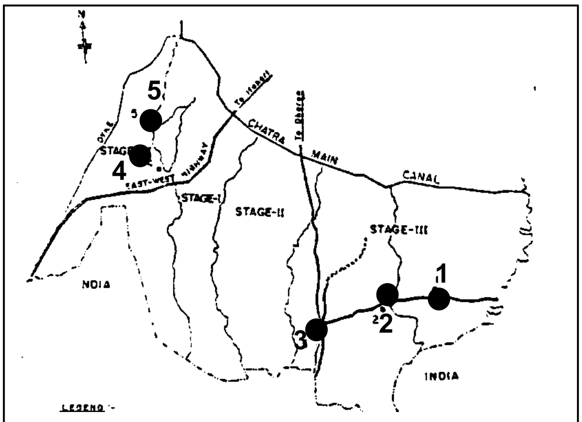


Figure 2.4.2 SMIP Percolation Test

3) Lessons

SMIP has given a number of lessons on the course of development; some have been already incorporated in the successive stages and some should still be further considered in any of the future irrigation development in Nepal. The lessons are summarized as follows;

- Extensive gated network implemented in Stage I did not work. This can be seen not only in Nepal but also in many parts of the world. The farmers had damaged almost all the gates along sub-secondary and tertiary canals just in a couple of years. Especially, gated turnout supplying water onto field had been almost completely damaged. This situation took place in Kankai irrigation system as well, where most check gates in secondary canals (about 400 ha each command) and turnouts had become un-operational within 2 to 3 years after the commissioning. Therefore, Stage II and onwards of SMIP employed un-gated opening type turnout.

- Stage I of SMIP undertook an on-farm development, which had provided a watercourse per about 50 ha each. The watercourse was provided with five field outlets, each of which had served 10 ha. The watercourse, serving 50 ha each, did not work. The gates attached to the watercourse were damaged and tail portion of the watercourse had returned to the paddy field. Stage II reduced the command area of each watercourse from the 50 ha to about 28 ha. The 28 ha block was further divided into 7 (meaning 7 outlets along one watercourse), each of which served 4 ha. This arrangement worked better than the 50 ha system, but still some became un-operational. Further arrangement should be sought.

- In pursuing workable water distribution, a standard was added in designing canal system including watercourse. The length of a canal sub-system, either sub-secondary or tertiary, from the intake to the tail was limited to about 5 km. Likewise, the length of a watercourse was limited to about 1,200 m. This arrangement served better water distribution. However, tail portions of secondary canals still suffer from water shortage because of the long reaches, raging from 10 to as long as 34 km, thereby the arrangement applied does not work in the lower portions of secondary canals.

- Canal arraignment was made taking into account the existing alignment in order to reduce additional land acquisition, and taking into account administrative boundary like ward boundaries and individual land boundaries to facilitate easy formation of WUA and to avoid land fragmentations as much as possible. Also, to limit illegal water intake as well as inundation around a canal, the water level was so designed not to be higher than 60 cm from the adjacent ground.

- Water is substantially reduced as goes to tail end of secondary, sub-secondary and tertiary canals. Though it is natural in any case of gravity irrigation systems, SMIP had hardly delivered water down to latter part of tertiary canals because of small design duty combined with the reliability of 70 percent as well as high amount of percolation that was not undertaken in the design. Therefore, the SMIP introduced rotational irrigation system, with which all the sub-secondary and tertiary canals under a secondary canal are grouped in two, each group of which is given water for 3.5 days alternately.

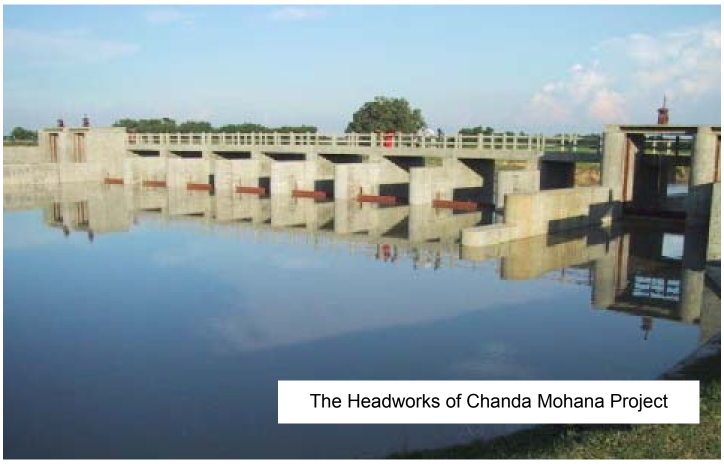
- Water Users Association in SMIP is highly overlaid as blow, and this complicated structure makes very difficult to communicate from the project through the apex of the association all the layers down to the ground. Forming water users association should also take into account to what extent irrigation management should be transferred to the farmers. If a sub-secondary is to be transferred, WUC should be mostly focused and if secondary canal is the case, WUCC be focused. To what extent the irrigation management should be transferred is still in discussion. Some officers think secondary canal should be transferred but others are preferable for sub-secondary.

WUCCC:	Water users central co-ordination committee at project level
WUCC:	Water users coordination committee at secondary canal level
WUC:	Water users committee at sub-secondary canal level
WUSC:	Water users sub-committee at tertiary canal level
WUG:	Water users group at watercourse level

- Cost recovery is still very poor. Actually, this is not a distinct situation only for SMIP but also almost over Nepal. The irrigation service fee, 200 Rs/ha/yr, was firstly introduced in 1993, and the collection efficiency has always been low like less than 20 %. The fee is shared by HMGN and WUA, paying only half, which is 100 Rs/ha, to the HMGN. The gross income from one hector irrigated land is estimated at 76,000 Rs/yr[4]. Therefore the service fee paid to the HMGN is equivalent to only 0.1 percent, which is quite low as compared with other countries; about 6 to 7 percent in Japan, about 2 to 3 percent in the Philippines. The service charge does not meet the O & M requirement, which is estimated at about 700 Rs/ha[5]. A mean to raise the fee as well as the collection efficiency is due sought.

2.4.2 Chanda Mohana Irrigation Project

This project falls in the most south-eastern part of the JICA Study area. The water source of the project is Budhi river which demarcates the Study area at its eastern part. A headwork having 65m long weir cum bridge with a design duty of 1.6 l/s/ha and 500 m^3/s flood for 50 years return period has been constructed to divert the irrigation water to Rajganj, Sinuwari, Amahi and Belaha VDCs. The project has also constructed eastern and western main canals of 15 km (of which 3 km concrete lining), 21 branch canals with total length of 41 km together with other ancillary facilities, and upgraded 15 km gravel access road. The project started irrigating the area in the monsoon season of 2001.



The Headworks of Chanda Mohana Project

Project Duration:	FY 1996/97 to 2000/2001
Command Area:	1,800 ha (1,000 east + 800 west)
Total project Cost:	2.578 million US dollar (1,400 $/ha)
Foreign-OPEC Fund Loan:	2.314 million US dollar

4 Based on the expected paddy production of 3 – 4.2 ton/ha with 9 – 10 Rs/kg and winter crops such as wheat, and vegetables with current prevailing market prices.

5 Irrigation Operation and Maintenance Cost and Water Charge Recovery Study concludes about 660 to 750 Rs/ha is required to sustainably operate large surface irrigation systems in Terai.

Local - HMGN: 0.264 million US dollar

The DOI controls the headwork and the main canals as of February 2002, but later on the main canals' management is to be handed over to the WUAs concerned. There is a WUA, called Chanda Mohana WUA. The Chanda Mohana WUA covers 4 VDCs; Amahi-Belaha, Amadua, Rajgannj-Sinumari (within the Study area), and Sahebganj (with in the Study area). The committee of the WUA consists of 20 members, who are the leaders of water users groups in the tertiary level.

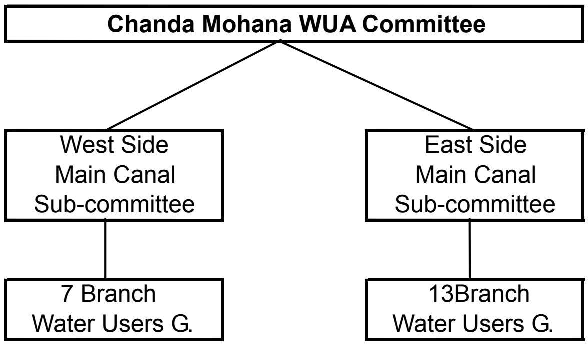


Figure 2.4.3 WUA in Chanda Mohana IP

The WUA does not know the total number of the beneficiaries (equivalent to the general members). They are now identifying the members, reaching to as many as over 2,000. This situation happened due to rushed organizing process for the WUA . The organizing process started with approaching the communities through VDCs. VDC chairmen and some farmer leaders were one day invited to a meeting with the project office and an ad-hoc committee was organized in April-May 1998. The ad-hoc committee prepared draft constitution of WUA and the constitution was ratified by a general assembly, which was formed with about 150 farmers only against the prospective 2,000 members. Then the committee of WUA was formally erected, dissolving the ad-hoc committee.

This rushed organization with limited beneficiaries is now giving the committee a weakness and threatening for the WUA. Their weakness is the fact that they cannot fully use irrigation water due to lack of outlets. If there are enough outlets, they can use irrigation water for nine months per year. Threatening they think is that some parts of branch canals are not completed (lack of outlets). This fact may cause social conflict between farmers who can and cannot use the irrigation water. Few involvements of the beneficiaries resulted in the incompleteness of the facilities and that are their concerned issues to date.

On the other hand, the committee sees some strengths and opportunities for the WUA. For strengths, they feel good coordination has been done among the beneficiaries and this was helped by their historical context; namely, there had been a sort of informal water users association since around 50 years ago. That made them less difficult to organize the WUA. As for the opportunity, they picked up the bridge on Budhi river, built with the headwork, which gives them income by transport charge (10 Rs for tractor, 20 Rs for truck and bus, and 5 Rs for small vehicle). The area near the headwork can also be developed for a picnic field.

The WUA is to collect the first Irrigation Service Fee (ISF) in year 2002. Their plan is to collect 140 to 150 Rs/bigha/year (209 to 224Rs/ha/year). The rate was estimated with reference to the rate of SMIP (200 Rs/ha) and would-be amount required for the O&M. The WUA has already opened a bank account in Nepal Bank limited in Biratnagar.

2.4.3 Second Irrigation Sector Program (SISP)

The program commenced in 1997 as the successor of Irrigation Sector Program (ISP) funded by the ADB, covering Eastern and Central Development Regions. The main objective is to rehabilitate traditional Farmers Managed Irrigation System's (FMIS) as well as construction of few small and medium irrigation projects, seize of which are usually below 500 ha. The program aims to provide irrigation facilities to 32,000 ha for rehabilitation and 9,000 ha for new irrigation development. It is planned to rehabilitate 160 existing irrigation schemes (average 200 ha) and take up 20 new irrigation schemes (average 450 ha).

Project Duration:	FY 1996/97 to FY 2001/2002
Command Area:	41,000 ha (total of 180 system, average 130 ha)
Project Cost:	33.3 million US Dollar (813 $/ha)
Foreign - ADB loan:	25.0 million US Dollar
Local - HMGN:	4.2 million US Dollar
Users Contribution:	4.1 million US Dollar

Though each project is small in size, the principal of the program is demand-driven and farmer-led, and the procedural guidelines have been well prepared for the selection and the implementation. While performance of large irrigation systems often becomes below than the originally expected, this sort of farmer-led program has obviously initiated a new direction in irrigation development in Nepal. Even within the SMIP area, ten projects have so far been implemented; eight under the ISP and two under the SISP. One note is that some projects implemented under these programs show very poor construction workmanship, delaying the commissioning or even remaining almost abandoned (an example is Geruwa project, which was supposed to irrigate a part of the JICA Study area).

2.4.4 Nepal Irrigation Sector Project (NISP)

This is a World Bank assisted project, carried out in districts covering Western, Mid-Western and Far-Western Development Regions. Rehabilitation of user demanded irrigation systems with their active participation has been pursued, providing irrigation to an area of 59,600 ha. Apart from this, the Phase 1 of Stage III of SMIP falls under this project loan. The NISP covers not only DOI but also Department of Hydrology and Meteorology and Department of Agriculture under an institutional development component, and further undertakes policy related studies such as cost recovery and subsidy.

Project duration:	1997/98 to 2001/2002
Command area:	59,600ha (+ 15,100 ha under SMIP)
Total project cost:	103.02 million US Dollar (1,400 $/ha)
Foreign - WB loan:	79.77 million US Dollar
HMGN and User:	23.85 million US Dollar

2.4.5 Community Groundwater Development Project (CGDP)

This project is to provide 110,000 small farmers with irrigation facility by means of constructing shallow tube-wells in Eastern and Central Development Regions. Construction of 15,000 shallow tube-wells in 12 Terai districts is programmed, thereby covering 300 VDCs with a total of 60,000 ha irrigation area. The project also deals with construction and upgrading of village access road in all the VDCs with an average of 2.8 km per VDC totaling to 840 km. The preparation works have been completed for eight pilot sub-projects and these are to be implemented in year 2002 and onwards.

Project Period:	FY 1997/98 to 2003/04
Prospective Area:	60,000 ha
Project Total cost:	42.8 Million US dollar (71 $/ha)
Foreign ADB Loan:	32.8 Million US dollar
Local - HMGN:	5.3 Million US dollar
Users:	3.0 Million US dollar
Institutional:	1.7 Million US dollar

This project entailed a policy reform concerning subsidy in constructing shallow tube-wells. The policy reform was a reduction of capital cost subsidies for shallow tube-well investment from 80 % to 60 % for group based and from 40 % to 30 % for individual shallow tube-well on September 2, 1997, and was a complete elimination of the subsidies by July 1999. The subsidy was actually reduced and finally eliminated as agreed with the ADB. Now, no subsidy is available for the farmers eager to install shallow tube-well.

The project, in turn, provides credit to a group of the farmers who want to construct shallow tube-well. The credit is provided without any individual collateral but the members of the group should be guarantor each other. This arrangement has been tried in Grameen Bank in Bangladesh. The project also provides agricultural extension services and rehabilitation and upgrading of village access road so that the farmers get easy access to marketing. In summary, this project does not construct the project itself, that is shallow tube well, but to create enabling environment with which the farmers embark on the irrigation development by means of shallow tube well.

2.4.6 Irrigation Management Transfer Project (IMTP)

This is an ADB assisted project, objective of which is to hand over the irrigation management partially or wholly of 11 large and medium irrigation projects constructed by DOI to the relevant Water Users Associations. The irrigation systems, which fall under this project, are Panchakanya, Khageri, West Gandak, Banganga, Patharaiya, Mohana, Chaurjahari, Manushmara, Hardinath, Kamala and Chandra Canal, total command area of which is 67,800 ha. The first three projects are under Phase 1 and the remaining under Phase 2.

Project period:	FY 1994/95 to 2000/2001
Total project cost:	21.43 million US Dollar (316 $/ha)
Foreign - ADB loan:	12.91 million US Dollar
Loan effectiveness:	June 14, 1995
Loan closing:	June 30, 2002
USAID grant:	3.00 million US Dollar
Local - HMGN:	5.52 million US Dollar

Management transfer of Khageri (3,900 ha), Panchakanya (600 ha) in Chitwan district and West Gandak (10,300 ha) in Nawalparasi district under Phase 1 has been completed as of February 2002 upon completion of necessary rehabilitation for those projects. The remaining 8 irrigation systems under the Phase 2 are behind the original schedule, so that loan extension is to be made.

Of the three completed project, Khageri (3,900 ha) transferred all the branch canals (average about 400 ha/branch) but the headwork and the main canal still remain under DOI's control; Panchakanya (600 ha) has been fully transferred to the WUAs; and the West Gandak has, to a surprise, transferred even main canal, commanding as much as 10,300 ha, and below thereof to the respective WUAs. The West Gandak is now in question if the WUAs could well manage the vast area by themselves and some officers feel the main canal needs to come back under the control of DOI.

The process of transferring the management is well established by step, including walk-through to identify which facilities should be rehabilitated before the transfer, prioritization on the facilities to be rehabilitated taking into account the available fund which is roughly 15,000 Rs/ha, a series of training given to both DOI staff and the representatives of the farmers, etc. Difficulties that the project is facing are; limited budget available for the rehabilitation because farmers usually request not only rehabilitation but also a sort of improvement, and limited time available for the rehabilitation work which should usually be completed within two to three months of dry season.

2.5 Relevant Studies and Policy Implications

The NISP undertakes not only physical irrigation development but also policy relevant studies. These are: 1) Irrigation Operation and Maintenance Cost and Water Charge Recovery Study and 2) Irrigation Subsidy Study. The former presented the latest report in February 2001, and the latter in September 2001. Both reports will be thoroughly discussed with HMGN, and the outcome is to be incorporated in the Irrigation Policy as well as in the Irrigation Regulation.

The former study finds that the current recovery of O & M cost from the irrigation service fee, presently set at 60 Rs/crop/ha to 200 Rs/ha/year, ranges from 0.1 % to 15 % only, leaving the irrigation systems very much dependent on heavy government support actually by a form of subsidy. The study also says the ISF collection efficiency is less than 19 % in SMIP and less than 50 % in Kankai irrigation project. This pitfall may be attributed to lack of sense of ownership, lack of incentives to pay, weak institutional mechanism, low level of irrigation impact, water as a free good, poor post construction project management, free riders, land tenure system and absentee landlords, etc. The study is now proposing 660 Rs/ha to 750 Rs/ha to fully recover the O & M cost of irrigation systems in the Terai plain.

The latter study, Irrigation Subsidy Study, presents a very ambitious irrigation policy in terms of beneficiaries' burden in both capital investment and O & M. The study concluded that the beneficiaries could bear as high as 79 percent of the capital cost in case of large irrigation systems in Terai and 85 percent in case of medium irrigation systems in Terai. With the percentage for the large systems, the beneficiaries are required to make an up-front payment of 8,592 Rs/ha and also an annual cost recovery of 4,817 Rs/ha for the capital over 19 years with a concessional interest of 7.5 %. Besides, the beneficiaries are asked to pay the ISF to fully recover the O & M cost, which is almost same amount suggested in the Irrigation Operation and Maintenance Cost and Water Charge Recovery Study.

The implication of the Irrigation Subsidy Study is somewhat too beyond what the actual practices are taking place on the ground. The study assumed that the capital investment per hectare is 72,000 Rs, which seems relatively low than actually incurred, and incremental benefit is 4.3 ton/ha, which in turn seems too ambitious. Low investment cost and high incremental benefit applied in the study may have led to the idea that the farmers could bear 79 percent of the capital cost aside from full recovery cost of O & M.

CHAPTER 3 WATER RELEASE FROM SMIP

3.1 Examination of Water Release form SMIP Chatra MC (CMC)

3.1.1 Rationale

The JICA Study, so far, revealed that there would be an extending water shortage during winter as well as early monsoon season because the demand exceeded the discharge of Sunsari river. As a result, it became necessary to come up with appropriate measures that can technically and economically cope with the water shortage. It is also necessary to take into account the impact of the water diversion on the bio-diversity in the Sunsari river for clearance of EIA.

There are several alternatives for the project formulation in overcoming the water shortage such as: 1) development of STW, 2) adjustment of cropping patterns and/or cropping seasons, 3) compromise of irrigation system reliability, 4) reduction of command area, and 5) release of supplemental water from the CMC. As it seems that the possible consequences of the alternatives except the last one could have some constraints, it was agreed between DOI and the JICA Study Team at the central level meeting on June 20, 2002 to carry out a study on the water release from CMC to Sunsari River Irrigation Project (SRIP).

3.1.2 Approach of the Study

The approach is divided into two steps; namely, 1) examination of Chatra intake capacity according to the water level in Koshi river (just in front of the intake), and 2) within which, how much water SMIP can release or otherwise how much water the SRIP should be entitled to receive. The second step, as mentioned, encompasses two sub-approaches, and these can be defined: as 1) SMIP supply driven mode and 2) SRIP demand driven mode.

3.2 Intake Capacity

As the first step, the study will examine the performance of the intake of the CMC; namely, how much water the intake can withdraw according to the water level. Though the original design tells us that the intake can withdraw 60 cum/s of water all the season year-round, there might be a difficulty to withdraw that amount of water especially during lean season. The first step will examine the intake performance by using a broad-crest weir formula shown below together with the water levels (WLs) observed at Chatra intake point from 1996 to June 2002 and WLs observed at Koshi gauging station No.695 from 1990 to June 2002.

Broad-crest weir formula:

$Q = C\,L\,(H - 107.00)^{1.5}$

Where: Q; Flow volume, cum/s
C; Coefficient (1.5 applied)
L; Crest length (48 m, pier contraction loss not considered), m
H; Total head on the crest in elevation (WL + velocity head), m
107; Crest sill level in elevation, m

3.3 SMIP Supply Driven Mode

This is to investigate the water release from CMC to SRIP on basis of surplus water in CMC upon covering the whole SMIP area except the SRIP command area. This investigation will have to estimate water requirement of SMIP with reference to the present and future SMIP command areas together with present and proposed cropping patters.

The present command area can be estimated by dropping some areas from SMIP command area. The areas, which should be dropped, are urbanized areas, high-elevated areas that cannot be irrigated by the SMIP canal network, and already irrigated areas by other existing projects such as Chanda Mohana, ISP and SISP. The future command area of SMIP will further take into account future development areas by using drainage water and also existing rivers.

The cropping patterns to be referred in estimating water requirement are the present pattern given by SMIP's seasonal crop coverage report of 1999/00 and also proposed patterns in the Detailed FS III dated on June 1995. There are three proposed cropping patterns in the Detailed FS, so that a total of four cropping patters will be referred to in the estimation of the SMIP water requirement. Also, considered additionally in this estimation is a high percolation area reaching to 15mm/day for paddy.

3.4 SRIP Demand Driven Mode

This mode will examine the water release on basis of SRIP demand driven for which the water release from CMC to SRIP will be made according to the legitimate area proportion of SRIP to SMIP. As the water is to be released from CMC to SRIP based on the legitimacy of SRIP, this mode entails a concept of water right given to SRIP against whole SMIP command area. It is, therefore, essential to establish a judicial proportion of SRIP to SMIP from several aspects.

This mode will examine the judicial portion from the planning viewpoint and also from the present SMIP operational point of view. As per planning point of view, the planned SRIP command area will be delineated within the SMIP whole command area (not all the SRIP area is in the SMIP). For operational point of view, present cultivable command area (CCA) of SMIP which falls in SRIP command area will be identified. The SMIP command area will therefore refer to two cases; 1) planned SMIP command area including future command area development (CAD) but excluding areas already covered by other project like Chanda Mohana and ISP & SISP, and 2) current operationally covered CCA of SMIP.

3.5 Examination and Findings

3.5.1 Available Data (WL & Q)

Data for Koshi river's water level and discharge were collected from Department of Hydrology and Meteorology. The data is at Station No.695, located 975m upstream from the Chatra intake, and covers a period of January 1990 to June 2002. Data relative to Chatra were collected from SMIP, and it covers from June 1996 to date. The data are water level at the Chatra intake and also discharge at the hydro power station that is the discharge into

Chatra main canal. The Chatra data are not completed as shown in the Table 1, having some missing periods.

The Koshi river's data intend to supplement the missing data at Chatra intake by using a linear correlation and also serve as a basic data to forecast long-term trend of water level change at Chatra intake. The correlation between the two data, Koshi WL and Chatra intake WL, is given as follows by season:

December to April: Chatra intake WL = 0.7352 x Koshi WL + 28.185 (R = 0.707)
May to November: Chatra intake WL = 0.7429 x Koshi WL + 27.269 (R = 0.984)

3.5.2 Koshi River's WL and Chatra Intake's WL

Figure 1 shows the Koshi river's water level for the last 13 years. The water level varies from as low as 107.7m to as high as over 114.0m. The lowest water level shows up in March, and the water level starts rising up towards August. Figure 2 shows the trend of water level change during lean period for the last 13 years. The figure shows a clear trend that the water level has been continuously lowering. The water level in the beginning of 1990s was about 109.4m, but now it is around 107.7m. The Koshi river's water level was lowered by bout 1.7m for the last 13 years (13cm/year).

Figure 3 shows the water level observed just in front of Chatra intake. The water level varies from about 107m to over 112m, and during the lean season from December to April, the water level hovers in between 107 and 108m (crest elevation of the intake is 107.0m). The lowest water level ever observed is 107.05m[6] which was recorded in late March and early April of year 2002. As the data of 1999 is missing, it may be difficult to identify the trend of water level change at the Chatra intake from 1996 to date. However, Figure 4 tells us the water level during lean season has a tendency of lowering at least for the last three years (2000 – 2002)

3.5.3 Capacity of Chatra Intake

Chatra intake capacity is examined on basis of water levels observed and plus velocity head calculated. In doing the examination, missing data of Chatra WL were supplemented by using the linear correlation with the Koshi river's WL. The capacity examination considered the velocity head (hv) which is given below:

Critical velocity: Vc = sqroot (g x hc)
Velocity head: hv = Vc x Vc /2g
Where: g: gravity (9.8 m/s/s)
hc: overflowing depth (critical flow depth, m)

Figure 5 shows the calculated capacity based on such data as; 1) 80% probability[7], 2) last 3

[6] The water level is not static level since the intake was withdrawing water so that velocity head was already subtracted. If the velocity head of 5cm, estimated by using critical flow theory, is considered, the static total water level will be 107.10m.
[7] Since a continuous lowering trend is observed for the water level, this probability does not make sense and is

years average, 3) last 2 years average, and 4) latest year 2002 data. Also, Figure 6 shows the capacity trend during lean season from 1996 to 2002. As these figures show, the capacity was over 30 cum/s even during lean season until year 2000 except some short periods. However, because of the trend of the water level getting down, the intake capacity has lowered to less than 10 cum/s according to the latest data (data of year 2002).

A forecast analysis is made on an assumption if the trend of water level getting down would continue onward. The future water level at the Chatra intake was regressed with reference to the water level at Koshi river. The capacity of the Chatra intake can be estimated according to the water level regressed. ATTACHMENT 1 Table 2 and Figure 7 shows the probable year that the capacity becomes certain limit, say 30, 20, 10, and 0 cum/s, on the assumption that the trend would continue onward. The table and figure imply that the Chatra intake may cease functioning in year around 2005 to 2008 during lean period.

As per monsoon season, no noticeable problem takes place. The Chatra intake capacity will not be any problem after around May 10 since the water level in the Koshi river starts rising up from end of April toward August very sharply. Figure 7 implies sufficient water will be available in Chatra main canal after May 10, giving possibility for SRIP to have some water from SMIP.

3.5.4 SMIP Supply Driven

Taking into account urbanized area, high elevated area, areas already covered by other project, and so on, SMIP's command area is estimated in ATTACHMENT 1 Table 3. In examining the SMIP demand driven, the present probable command area and also future command area are considered. Given the Table 3, it can be said that the present SMIP command area is 68,980 ha, and future command area could be 64,675 ha. The former figure, 68,980ha, excludes urbanized area, high elevated area, areas covered by Chanda Mohana and ISP & SISP. The latter figure, 64,675ha, further excludes drainage re-use areas as well as future development area like development of Lohandra Khola.

Within the SMIP command area defined above, there exists most part of SRIP command area. The part of SRIP within SMIP is 9,050[8]ha. Leaving the area of 9,050ha from the SMIP, how much water SMIP requires is estimated and the water requirement is compared with the capacity estimated at the Chatra intake[9]. In estimating water requirement, the crop requirements mentioned in the Detailed FS were applied. The Chatra capacity is estimated on basis of average water level from 1996 to 2002 (If the latest water level is applied, the capacity is obviously less than the requirement). Table 4 and Figure 8 reveal the following:

- With the SMIP area of 59,900ha (68,980 – 9,050), there is a positive balance between the

given as a reference only.

[8] *The total command area of SRIP is 105,00ha, out of which 1,450ha (tail portion of Shankarpur canal) is not included in SMIP, giving the overlapped area of 9,059ha.*

[9] *Comparison with actually withdrawn volume is not made because the Chatra operation is done according to the demand given by respective WUCCs. The volume is small as compared to the expected volume under full development. Also, Water actually supplied during winter season intends to irrigate only wheat which occupies about half of the whole SMIP area, so that the water is about half amount as compared to the planned water requirement during the detail FS III.*

crop water requirement and the Chatra capacity; ranging from 3.5 cum/s to as much as the Chatra maximum capacity of 60 cum/s. This implies if the Chatra capacity remains same as the average of the past operating years, SMIP could provide at least 3.5 cum/s or more to the SRIP (in April, more than 50 cum/s positive balance already available).

- With the SMIP area of 55,625ha (64,675 – 9,050), there is a positive balance ranging from 5.5 cum/s to as much as the Chatra maximum capacity. This means if future development is done within SMIP and the Chatra capacity remains same as the average of the past operating years, SMIP could provide at least 5.5 cum/s or more to SRIP during lean period (in April, more than 50 cum/s positive balance already available).

3.5.5 SRIP Demand Driven Mode

As mentioned in the "SMIP demand driven mode", the SRIP area falling within SMIP is 9,050ha. If the SMIP command area takes the acreage of 68,980ha which is the present command area excluding urbanized, high-elevated, and other project coverage areas, the ratio of SRIP to SMIP is given below, and the ratio can be regarded as the SRIP demand portion from the planning point of view:

Ratio = 9,050 / 68,980 = 13.1 % (from planning point of view)

In estimating water volume, the 13.1% should be applied to the probable discharge at Chatra intake. If the Chatra intake discharge is estimated on basis of the past average water level from 1996 to 2002, the monthly basis water volume that the SRIP is entitled is at least 3.7 cum/s and more (7.5 or more available after April) as shown in Table 5 & Figure 9 (Note: if the latest water level is applied, the volume becomes negligible).

As per CMC operational plan of year 2001, the SMIP intends to irrigate 62,099ha. The operationally intended area covers a part of SRIP command area. Under Shankarpur command area of 6,687ha, DOI is responsible up to Gautampur VDC which already falls in SRIP command area. For Suksena canal, SMIP operates on 8,146 ha. The area of 8,147 ha covers up to 2 – 3 kilometers downstream from the siphon crossing Sunsari river. These areas within SRIP and covered by SMIP operational plan are; 3,170ha and 3,713ha for Shankarpur and Suksena respectively, totaling to 6,883ha. Therefore, the SRIP ratio to SMIP from the operational point of view is given of the following:

Ratio = 6,883 / 62,099 = 11.1 % (from operational point of view)

In estimating water volume, the 11.1% should be applied to the actually withdrawn discharge at the Chatra intake since this 11.1% refers to the actual operation. If the average for the past 1996 to 2002 is applied as the actually withdrawn discharge, the water volume that the SRIP is entitled is 0.8 to about 2 cum/s during lean period (see ATTACHMENT 1 Table 5 & Figure 10). As per early monsoon season like May and June, about 1.2 to 2.9 cum/s will be available for SRIP.

3.6 Summary, Conclusion and Recommendation

Above examinations are summarized as below:

- Should the lowering trend of water level in Koshi continue, the Chatra intake would become unable to withdraw water during winter season at around year 2005 to 2008. This situation would not take place after May 10, meaning that the Chatra intake remains functional to withdraw as much water as the designed after May 10 even if the lowering trend would continue in a long run.
- As per SMIP supply driven with the present command area of 59,900ha, if the Chatra capacity remains same as the average of the past operating years (1996 – 2002), SMIP could provide at least 3.5 cum/s or more to the SRIP.
- With the SMIP area of 55,625ha (future development done within SMIP), SMIP could provide at least 5.5 cum/s to SRIP during lean period on condition that the Chatra capacity remains same as the average of the past operating years (1996 – 2002).
- As for SRIP demand driven mode, the water to be released to SRIP should be based on 13.1% or 11.1%. 13.1% entails planning point of view; giving an amount of 3.7 cum/s at least. 11.1% is based on present operation of SMIP, and this gives about 0.8 to 2 cum/s during lean period. The volume estimated here was also based on the average of the past operating years (1996 – 2002).

Faced with the continuous lowering trend of water level of Koshi river, this study recommends that no supplemental water should be taken into account in planning irrigation development of the Sunsari river during lean period, say up to May 10. After May 10, there is a possibility that the Chatra MC could provide water reaching to the capacity of the Vortex tubes.

Note: One Vortex tube(downstream) capacity is said to be 5.0 cum/s and the other (upstream) to be 3.5 cum/s. The upstream Vortex tube is not functional at present, so that the present capacity of the Vortex is 5.0 cum/s.

DOI is requested to pay cautious attention to the water level of Koshi river. Should the trend of the water level reverses, there will be a possibility of getting water from SMIP even during lean period. Referring to the past operating years' average, there would be available water of 1 to 5 cum/s or even more than that depending on the future trend as well as on which mode DOI chooses. This should be reserved for future.

Note:

To conserve the Sunsari river's environment during lean period, the Study Team is to explore rotational irrigation between Shankarpur and Suksena canals (say, irrigate Shankarpur this year, and irrigate Suksena in next year). Likewise, preventive irrigation is explored for which minimum amount of water is applied which is maybe equal to the amount currently applied by STW. In this case, project benefit will be the saving cost of STW operation.

CHAPTER 4 IRRIGATION AND DRAINAGE DEVELOPMENT

4.1 Irrigation Development

4.1.1 Issues to be considered

Issues this Study has to take into account, aside from conventional ones, are; 1) priority use of surface water with groundwater being the supplemental, 2) disparities in water supply, 3) useless extensive network of gate/turnout, 4) irrigation system management jointly by the Government and the WUAs, 5) sustainable O & M and water management, 6) institutional development, 7) cost recovery mechanism, etc. This sub-chapter undertakes the irrigation planning with due attention to the issues of 1) to 3). Issues of 4) – 6) are discussed in Chapter 7 and issue of 7) cost recovery is in Chapter 9.

1) Priority Use of Surface Water

There are three water sources available for the Sunsari River Irrigation Project (SRIP); surface water, shallow groundwater and deep groundwater. In terms of economic return, shallow groundwater development usually shows higher benefit as compared to surface water development and deep groundwater development. EIRR [10] for shallow groundwater development usually shows at least 30 % to as much as over 50%, while surface water development and deep groundwater development 15 to 30 %.

Turning to the water cost borne by the farmers, the cheapest one is obviously the surface water. Prevailing water charge is 200 Rs/ha but this is not justified because the charge does not reflect cost recovery. Therefore 700 Rs/ha, which could make cost recovery for large irrigation systems in Terai according to the NISP Cost Recovery study, is applied here to estimate water charge per cubic meter. Given this water charge of 700 Rs/ha, the unit water cost is calculated as low as 0.04 Rs/cum in case that 1,600mm for paddy plus 300mm for winter crop are provided and still low as 0.23 Rs/cum even in case that only 300 mm water is given as a worst case.

Shallow tubewell needs diesel oil and deep tubewell requires electric power to operate. One litter diesel is 27 Rs and unit cost of electricity is 3.5 Rs/kw/hr[11] (plus 200 Rs monthly base case). Given this condition, water price produced by shallow tubewell ranges 0.56 to 0.80 Rs/cum according to the yield usually ranging from 20 to 14 l/s while the price by deep tubewell comes to around 0.45 to 0.50 Rs/cum (yield 50 to 40 l/s). As these costs show, operating tubewells requires at least double cost to as high as 10 times more cost as compared to the one required for surface irrigation system.

This Study, therefore, puts the highest priority on Sunsari river for its irrigation development. The initial cost required for Sunsari river development may be the highest or almost same as deep groundwater development. However, surface irrigation system requires least operation

[10] The EIRRs referred to available reports such as ADB funded Community Shallow Tubewells Groundwater Development, Nepal Irrigation Sector Project, SMIP report, Detail FS for Mahakali Irrigation Project (latest FS study as of February 2002).

[11] The electricity fee for irrigation purpose is 50% subsidized at present. Therefore economic price is 7.0 Rs/kw/hr. If this cost is applied, the water charge will be double of 0.45 to 0.50 Rs/cum, say about 1 Rs/cum.

and maintenance cost as mentioned above. Though shallow tubewell usually shows the highest economic return, it requires diesel which is imported. It is also justified that the Nepal's own resource, surface water, shall be put higher priority than the one dependent on the imported material.

2) Disparities in Water Supply

Disparities in the water supply to the farmers along a canal are not only due to the physical problems of reaching the tail of long canals but also may be caused by a relentless behavior. Upstream users have no incentive to use less water in the absence of strong local organizations responsible for the management of the system and established water rights. Thus, they leave turnout gates fully open to withdraw as much water as possible at all times. System design, especially gate and turnout design that are to fall under the WUA's responsibility, should take into account a measure of rectifying the situation below.

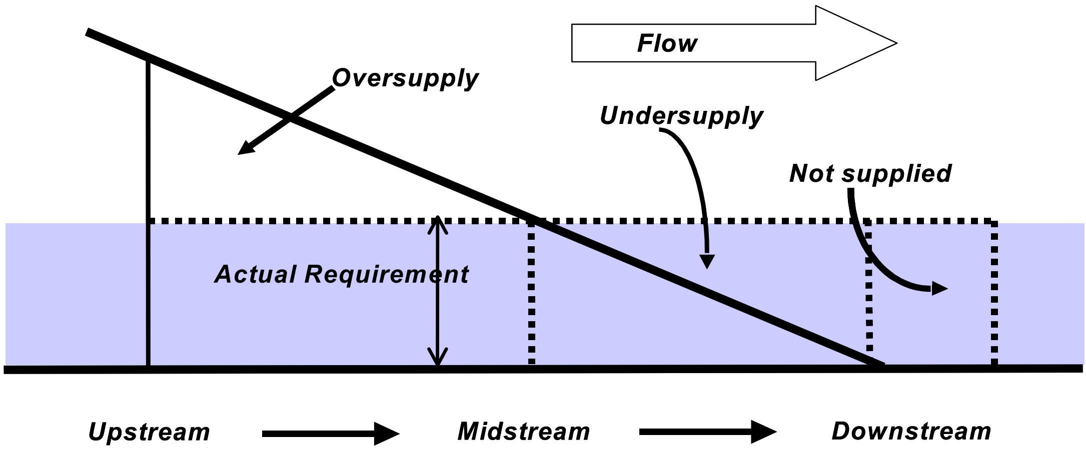


Figure 4.1.1 Typical Inequitable Water Supply along a Canal

When the farmers are responsible of operating the system, this situation would improve, because under user own management responsibility, tampering with water distribution becomes very difficult. While other farmers might tolerate thefts of 'government' water, when the water supply is allocated to the collectivity of the farmers, any theft of water implies stealing from fellow farmers. The responsibility of system O&M would implant the sense of water being allocated to the collectivity, as a farmers' common property and not the government water, thus overuse by the fellow farmers becomes very difficult.

If the water availability is inadequate, simply because there is inadequate supply, then there is clear limit to satisfy the farmers. However, even if the quantity is not enough, the farmers would have no way, but agree and share as far as the scarce water is equitably distributed. The responsibility of O&M of the system can create good will to realize equitable distribution. From the farmers' viewpoints, their own water shall be secured, and the share be agreed in a stable and reliable ways.

3) Useless Gate/Turnout

Lessons from SMIP, Kankai Irrigation Project and others clearly tell us gate and turnout do not serve those primary objective or at worse they are removed out by the users just within a couple of years after the commission. Farmers tend to leave gate and turnout fully open to make water available at any time and as much as possible beyond the allocated amount.

If a gatekeeper employed by the government tries to regulate those gate and turnout strictly, the aftermath is so simple that the gate/turnout are just destroyed and wiped out. In addition, regulating many number of gate/turnout is not easy task, resulting in a simple operation; either full open or full close. Affordable number of gatekeepers does not meet with the task regulating so many gate/turnout either.

Though main and other big canals, which are to be under the responsibility of the government, should be equipped with check and regulating gate, water distribution system within a block that is to be managed by the farmers should not be of extensive gate network. Rather, simple opening type (un-gated) turnout should be designed. An opening type (un-gated) turnout has been already employed in SMIP, and this Study is to follow the same concept. Un-gated system entails less operation and maintenance, and also inequitable water distribution along a canal aforementioned could be rectified.

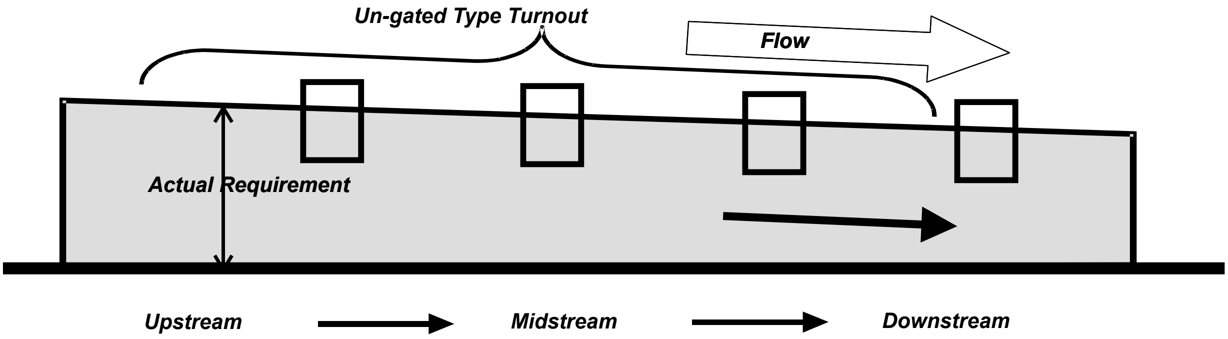


Figure 4.1.2 Concept of Un-gated Type Turnout

4.1.2 Development Strategy

Taking into account above issues together with the issues to be discussed in Chapters 7 & 8, this Study refers the following as the irrigation development strategy:

- To develop Sunsari river as the primary water source and then groundwater as a supplemental source,
- To pursue equitable water distribution over the irrigation system as well as within an irrigation block,
- To establish WUAs fully functional to assume O & M of hydraulically decentralized irrigation block(s),
- To establish sound irrigation system management, by a form of joint management, taking into account the HMGN's recent restructuring as well as WUAs' manageability, and
- To establish sustainable O & M particularly based on cost recover mechanism.

4.1.3 Delineation of Irrigable Area

This Study deals with 13 VDCs, total gross land area of which is 16,800 ha. In estimating irrigable area, this Study primarily refers to the taxation area given by Inaruwa Census Office. The total taxable area is 12,530[12] ha, and this is considered to be equal to the gross irrigable area in most cases. To estimate net cultivated land only, homestead areas and levees have to be deducted. This Study applies 7% deduction to estimate net cultivated land from the gross irrigable area.

Some parts of the cultivated land cannot be covered by a gravity canal network starting with a diversion barrage to be constructed in the Sunsari river simply because of; 1) some areas like northern tip of the Study area are located out of the canal network, 2) topographic condition does not allow the gravity distribution, and also 3) the most south-eastern part of the Study area has been already provided with another irrigation project.

Northern areas that will not be covered by the canal network are located in Narsimha and Babiya VDCs. There is a little elevated area in Kaptanganj VDC, which is the most southern part of the Study area. The area is about 397 ha in net (455 ha in gross), and this cannot be gravity fed by the canal. Sahebganj VDC, located at the most south-eastern part of the Study area, is now provided with irrigation water by Chanda Mohana system, so that the area falling in this VDC is no longer counted. Taking into account these areas, the net irrigable area which can be covered by the barrage planned is now 10,147 ha (see Table 4.1.1).

Table 4.1.1 Maximum Irrigable Area by Sunsari River Irrigation Project

No.	Nome of VDC	Total Land, ha	Taxation, ha	Gross Irrigable, ha	Net Irrigable, ha
1	Sahebganj	1346.3	1242.6	0.0	0.0
2	Kaptanganj	1469.0	1362.4	1111.6	636.8
3	Dewanganj	373.9	333.9	333.9	310.5
4	Ghuski	1450.5	1299.3	1299.3	1208.3
5	Rajganj-Sinuwari	1969.1	1852.7	1100.9	1023.8
6	Madhya Harsahi	627.5	589.0	589.0	547.8
7	Basantapur	983.0	793.8	793.8	738.2
8	Harinagara	1089.9	988.8	988.8	919.6
9	Ramnagar Bhutaha	1317.0	877.0	877.0	815.6
10	Jalpapur	599.9	543.2	448.2	416.8
11	Narsimha	3548.9	767.2	2651.7	2466.1
12	Gautampur	817.6	768.3	637.7	593.1
13	Babiya	1226.2	1112.2	506.1	470.7
Total of the Study Area, ha		**16,819**	**12,530**		
Gravity Irrigable Area, ha				**11,338**	**10,147**
Elevated area in Kaptanganji		to be irrigated by pump		455	397
Total Irrigable Area, ha					**10,544**

4.1.4 Water Requirement

This Study employs two methods of estimating draft crop water requirement; 1) Modified Penman method and 2) preventive irrigation method. Modified Penman is the most conventional way, and this Study takes the estimated water volume as the base requirement. As to paddy, additional water such as peroration, puddling, nursery should be considered

12 Some areas are not counted as taxable land in spite of the area being cultivated (Narsimha VDC). In this case, the area of the cultivated lands was measured on a map with scale of 1:25000 and counted as irrigable area. Likewise, some areas are counted as taxable land though it cannot be cultivated due to the barrenness or being located in Old Sunsari river. In this case, the practical irrigable area was measured on the map of 1:25000.

aside from the draft requirement. The meteorological data required for the Modified Penman method were collected from the Biratnagar Airport for a period of 1971 to 2000 (Station No.1319).

Though water requirement estimated by the Penman method applies to the base requirement, this Study undertakes, as a case study, preventive irrigation requirement for winter crops. Since water requirement during lean period is obviously not enough to cover all the 10,147 ha, this preventive requirement should be examined. As no method of estimating preventive irrigation requirement exists, this Study considers water provided by shallow well (STW) as the water of the preventive irrigation because farmers usually apply minimum amount of water due to high diesel cost.

Net irrigation water is estimated, based on the draft crop water requirement, by undertaking an amount of effective rainfall. The effective rainfall refers to the same data from the Airport and its probability is considered. The net irrigation water will then be converted into gross requirement taking into account the losses incurred in delivering and distributing irrigation water and in applying the water to on-farm.

1) Crop Evapotranspiration (ETo)

Crop water consumption is estimated as a product of the Potential Evapotranspiration (ETo) and crop coefficient (Kc), which varies according to the crop growth stage. The Potential Evapotranspiration is calculated by the following Modified Penman Method recommended in "Crop Water Requirements, FAO Irrigation and Drainage Paper No.24, 1977", a method generally accepted worldwide as most accurate.

$$ETo = C [W \times Rn + (1-W) \times f(u) \times (ea-ed)]$$

Where:
- ETo = reference crop evapotranspiration, mm/day
- W = temperature related weighting factor
- Rn = net radiation in an equivalent evaporation, mm/day
- f(u) = wind related function
- (ea-ed) = difference between the saturation vapour pressure and the mean actual vapour pressure, mbar
- C = adjustment factor for day/night weather condition

Table below shows the calculated potential evapotranspiration; the minimum of 2.3 mm-day shows up in December, the maximum of 7.2 mm/day in April and the annual total is 1,679 mm.

Table 4.1.2 Potential Evapotranspiration (ETo) Unit: mm/day

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
2.4	3.6	5.6	7.2	7.0	5.8	4.7	4.9	4.2	4.0	3.3	2.3	1,679

2) Crop Coefficients

The proposed cropping pattern consists of monsoon paddy and upland crops. The crop coefficient varies according to the crop, time of planting or sowing, and stage of crop development. The crop coefficient is determined based on the said FAO paper and also the coefficients employed in the SMIP. The estimated crop coefficients are shown on the table below, varying from 1.00 to 1.15 for the monsoon season paddy, and 0.40 to 1.15 for upland crops.

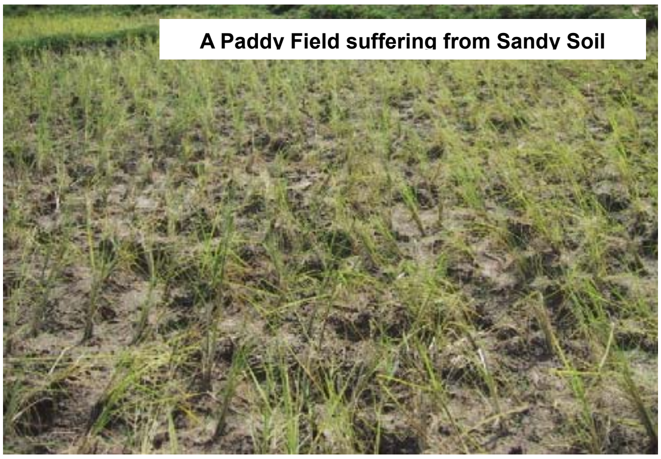
Table 4.1.3 Crop Coefficient (Kc)

Crop	1	2	3	4	5	6	7	8	9	10	11	12
Paddy(105days)	1.00	1.00	1.00	1.05	1.10	1.13	1.15	1.10	1.10	1.00		
Paddy(120days)	1.00	1.00	1.00	1.00	1.05	1.10	1.13	1.15	1.10	1.05	1.03	1.00
Wheat	0.43	0.54	0.75	1.00	1.10	1.15	1.15	1.15	1.00	0.80	0.60	0.40
Oilseeds	0.40	0.44	0.55	0.75	0.90	1.00	1.00	0.90	0.70	0.50	0.20	
Pulses	0.40	0.44	0.52	0.70	0.86	1.00	1.05	1.05	1.00	0.96	0.40	0.20
Mungbeen	0.40	0.50	0.65	0.75	1.00	1.00	0.70					
Vegetable(W)	0.45	0.49	0.55	0.65	0.85	0.95	0.95	0.95	0.95	0.95	0.80	0.60
Vegetable(S)	0.45	0.60	0.70	0.85	0.95	0.95	0.95	0.80	0.60			
Potato	0.42	0.48	0.55	0.79	0.90	1.01	1.13	1.13	1.13	1.08	1.01	0.94
W. Vegetable + Potato	0.44	0.49	0.55	0.72	0.88	0.98	1.04	1.04	1.04	1.02	0.91	0.77
Jute	0.41	0.49	0.85	0.85	0.85	1.10	1.10	1.10	0.85	0.85		
	0.55	0.55	0.55	0.65	0.80	0.88	0.93	0.97	0.99	1.00	1.01	1.02
Sugercane	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
	1.05	1.05	1.05	1.05	1.00	0.90	0.90	0.90	0.80	0.70	0.65	0.60

Note: One growing stage = 10 days

3) Percolation Losses

In estimating paddy water requirement, percolation losses accompanied with puddling should be considered. A total of 42 field tests of water depth measurement (percolation test) has been carried out from April to August of 2001 and from July to August of 2002. N-type water requirement test in depth measurement (240×480 mm no bottom box) was carried out with pan evaporation kit and the rainfall-gauging kit.


A Paddy Field suffering from Sandy Soil

The result ranges from 9.9 mm/day to as much as 38.7 mm/day. No test has shown the percolation less than or close to the SMIP design peroration that is 3.00 mm/day in Suksena area. As we go southward, the soil is getting sandy. The percolation test results are very correlative to the observation. If the one divides the Study area into three parts; northern, mid and southern, those average percolations are 14.4 mm/day, 17.0 mm/day and 20.8 mm/day from the north to south respectively. Taking into account area coverage corresponding to the averages, the overall average percolation arrives at 17.26 mm/day.

Table 4.1.4 Design Percolation Rate; mm/day

Zone	Area, ha	Excluded, ha	Area, ha	Sample No.	Avrg Percor'n	Weighted Avrg
Upstream	2,926		2,926	14	14.4	17.26 mm/day
Midstream	4,518		4,518	14	17.0	
Downstream	3,100	397	2,703	14	20.8	
Total Area	10,544	397	10,147	42	mm/day	

4) Puddling Water Requirement and Nursery Water Requirement

Puddling water requirement consists of water equivalent to soil moisture difference before and after the puddling, standing water required on soil surface, and evaporation and percolation losses from paddy field, etc. The puddling water requirement is estimated as follows and the design requirement is 180 mm:

1. Depth of soil porosity		
	Surface soil (15cm):	50 %
	Subsoil (15cm):	50 %
2. Soil vapor phase after puddling:		5 %
3. Soil moisture before water supply:		20 %
4. Water to be supplied		
	Water to be supplied to soil profile:	85 mm
	Evaporation:	10 mm
	Percolation:	34 mm
	Standing water depth after puddling:	45 mm
Total		174 mm, say 180 mm

Nursery water requirement refers to water needed for preparation of nursery bed, and evapotranspiration and percolation during the nursery period. The nursery is assumed to occupy 5 % of the total paddy. The nursery water requirement is estimated as follows, giving an amount of 840 mm which is equivalent to 42 mm with the area 5 %.

1. Nursery bed:		1/20 of paddy field (5%)
2. Nursery period:		30 days
3. Required water 30 days		
	Preparation of nursery bed:	180 mm
	Evapotranspiration (about 5 mm/day):	150 mm
	Percolation (16.8 mm/day):	504 mm
Total		834 mm, say 840 mm×0.05 = 42mm

5) Raw Rainfall and Effective Rainfall

The water, needed for the crops proposed, is partially provided by rainfall. The rainfall this Study refers to is the one recorded at Biratnagar Airport. The mean 10-day rainfall from 1971 to 2000 is graphically shown below, and the annual average rainfall is 1,948 mm.

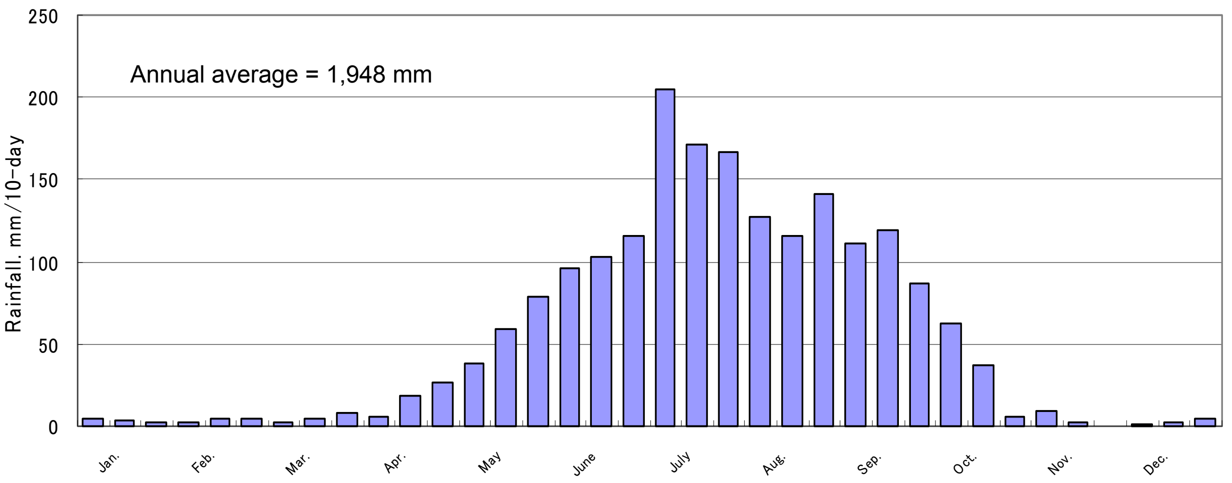


Figure 4.1.3 Mean 10-day Rainfall at Biratnagar Airport based on 1971 - 2000

The crops consume not all the rainfall provided since part of the rainfalls become surface runoff and infiltrate down below the root zone. The rainfall, consumed by the crops, is therefore called effective rainfall. There are several methods estimating the effective rainfall, and also differs between paddy and upland crops.

5.1) Paddy Field

In estimating effective rainfall for paddy, a relationship between 10-days rainfall and the 10-days effective rainfall is referred. SMIP Stage III F/S identified the relationship as follows based on the daily rainfall data recorded at Biratnagar Airport for 24 years from 1970 to 1993.

In case of R10<10mm: ER = 0 mm,
In case of R10mm < R10 < 150mm: ER = 0.80×R10, and
In case of R10> 150mm: ER = 120 mm
Where: ER: 10-days effective rainfall in mm, and
R10: 10-day rainfall in mm

This Study refers to the above relationship to estimate 10-day probable effective rainfalls. The estimated effective rainfall is shown below according to the probability, giving 1,394 mm as the annual average and 1,161 mm as probability 80%.

Table.4.1.5 10-day Effective Rainfall for Paddy by Probability

Probability, %	May			Jun.			Jul.			Aug.			Sep.			Oct.			Annual
	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	
Average	30	48	63	77	82	92	120	120	120	102	92	113	89	95	70	50	30	0	1,394
50	30	47	62	76	81	90	120	120	120	100	91	111	87	94	68	49	29	0	1,374
60	28	44	58	71	75	84	120	120	120	93	85	103	82	87	64	46	27	0	1,307
70	26	41	54	66	70	79	120	117	114	87	79	97	76	82	60	43	26	0	1,235
80	24	38	51	62	66	74	120	110	106	81	74	90	71	76	56	40	24	0	1,161
90	23	36	47	58	61	69	120	102	99	76	69	84	66	71	52	37	22	0	1,092

5.2) Upland Field

The US Department of Agriculture, Soil Conservation Service, has developed a procedure for estimating effective rainfall by processing long term climatic and soil moisture data from 50 years of rainfall data at 22 experimental stations. A daily water balance in the soil profile was carried out and the following relationship came out between monthly rainfall and crop consumptive use. This Study refers to the following equation with a modification that is if 10-day rainfall is less than 10mm/day, it is not counted as any effective rainfall.

$$ER = 0.2 \times R^{0.95} \times Cu^{0.31}$$

Where: ER: Effective rainfall (mm),
R: Rainfall (mm), and
Cu: Crop water requirement (mm)

Table 4.1.6 Effective Rainfall for Upland Crops by Probability

Probability, %	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Average	0	0	0	23	100	172	276	187	145	47	0	0	951
50	0	0	0	23	98	169	271	184	143	46	0	0	934
60	0	0	0	22	92	158	254	172	134	44	0	0	875
70	0	0	0	20	86	148	238	161	125	41	0	0	820
80	0	0	0	19	81	139	223	151	117	38	0	0	768
90	0	0	0	18	76	130	209	142	110	36	0	0	720

6) Irrigation Efficiency

The irrigation efficiency refers to farm application, distribution and conveyance. The farm application loss in paddy field is considered to be small but that in the field of upland crop irrigation is more since it includes percolation, surface run-off, etc. Taking into account the soil characteristics, topography, climate, irrigation practices and experience etc., the farm application efficiency is assumed to be 90% for paddy field irrigation and 70 % for upland crop irrigation.

Distribution efficiency is defined as the ratio between water received at the inlet of a service unit and that received at the outlet of an irrigation block (on-farm field channel block); namely, efficiency subject to distribution canal network composed of secondary, tertiary, water course and field channel in a service unit. According to the actual results measured in the irrigated paddy field of South Asian countries, it ranges from 85 to 95%. Considering the example, the distribution efficiency is assumed to be 85%.

Conveyance efficiency is the ratio between water received at the inlet of a service unit and that in-taken at the Project headwork; namely, conveyance efficiency subject to main canals of Suksena and Shankarpur. The Study Team measured a canal conveyance loss on the existing Suksena and Shankarpur canals in August 2001. An average conveyance loss of about 14% was measured. When this value is applied to the irrigation canal, a conveyance loss of about 15% of diversion water may be expected even if the main canal is concrete-lined. The conveyance efficiency is therefore assumed to be 85%.

Overall irrigation efficiency is estimated by multiplying the three efficiencies; application, operation and conveyance. The overall efficiencies are 65% for paddy irrigation and 50% for upland field irrigation as shown below:

Table 4.1.7 Irrigation Efficiency

Efficiency	Paddy field	Upland field
Application efficiency	90%	70%
Operation efficiency	85%	85%
Conveyance efficiency	85%	85%
Overall efficiency	65%	50%

7) Water Requirement

Following the discussions above, net and gross water requirements are calculated by using the formula below.

Paddy: GR = NR / OE

NR = CU + P – ER + NW + PW

where GR: Gross water requirement,

NR: Net water requirement,

OE: Overall irrigation efficiency

CU: Paddy rice water consumption from potential evapotranspiration calculated by using the climatic data and crop coefficients (Kc) varying with growth stage.

P: Percolation rate, ER: Effective rainfall, NW: Nursery water, and

PW: Puddling water requirement

Upland crop: GR = NR / OE

NR = CU- ER where: GR: Gross water requirement, NR:Net water requirement, OE: Overall irrigation efficiency, CU: Crop water consumption, and ER: Effective rainfall

4.1.5 System Reliability on Sunsari River Potential

Design irrigation system reliability varies from country to country and also sometimes differs from system to system even in a country. The system reliability in Nepal is usually designed at 80 %. However, should water available for an irrigation system be not enough to cover all the prospective irrigable area under the system reliability 80 %, there should be two ways to cope with; namely, 1) reducing the irrigable area to meet with the water available under the reliability, or otherwise 2) reduce the system reliability itself so that more area could be covered though water shortage takes place more often.

In case of available water being not able to cover all the prospective irrigable area, it is not just an engineering issue but also highly political one to decide if the irrigable area should be reduced or the system reliability be lowered. One example is SMIP; the system reliability is not 80 % but 70 %. The design intake discharge of 60 m^3/s cannot cover all the prospective irrigable area of 73,000[13] ha with 80 % reliability, so that the system design was made with 70 % reliability and thereby no prospective irrigable area was excluded in the design.

To design the system reliability of Sunsari River Irrigation System, monsoon paddy is firstly examined since the monsoon paddy is the present dominant crop as well as would-be a major crop in future too and requires the biggest amount of irrigation water. The table below summarizes the water balance on Sunsari river with different paddy area and different system reliability taking into regulatory downstream release of 1.8 cum/s:

Table 4.1.8 Water Balance on Sunsari River for Paddy (D/S release 1.8 cum/s considered), cum/s

Paddy Area		Reliability %	Water Balance on Sunsari River (deficit/surplus), cum/s																		Max Requirement	Irrigation Duty
			June			July			August			September			October			November				
%	ha		F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	cum/s	l/s/ha
100%	10,147	P50%	13.18	14.82	10.41	20.02	13.02	16.52	7.03	9.19	7.06	0.88	10.21	1.92	-1.40	-0.52	-0.89	1.81	2.59	3.09	25.06	2.4696
		P60%	11.58	12.23	7.64	16.15	9.47	12.36	2.70	4.57	2.84	-2.82	6.02	-1.02	-3.50	-2.16	-1.76	1.15	2.01	2.61	26.14	2.5763
		P70%	10.84	10.99	6.23	14.37	7.49	9.46	0.14	1.92	0.26	-5.03	3.59	-2.67	-4.63	-2.99	-2.16	0.84	1.74	2.39	27.15	2.6760
		P80%	10.42	10.26	5.32	13.34	5.61	7.17	-1.74	0.03	-1.66	-6.64	1.85	-3.82	-5.39	-3.51	-2.39	0.66	1.58	2.26	28.10	2.7690
		P90%	9.61	8.91	3.83	11.37	2.93	3.94	-4.30	-2.65	-4.21	-8.84	-0.60	-5.50	-6.56	-4.39	-2.83	0.33	1.29	2.01	28.98	2.8559
90%	9,132	P50%	13.30	15.72	11.74	21.78	15.16	18.91	9.34	11.69	9.12	3.31	12.24	3.91	0.35	0.88	-0.09	2.12	2.75	3.09	22.55	2.4696
		P60%	11.71	13.13	8.99	17.91	11.61	14.76	5.13	7.18	5.03	-0.28	8.15	1.04	-1.71	-0.75	-0.96	1.46	2.16	2.61	23.53	2.5763
		P70%	10.97	11.90	7.61	16.12	9.66	11.96	2.68	4.63	2.58	-2.39	5.82	-0.55	-2.81	-1.56	-1.36	1.15	1.89	2.39	24.44	2.6760
		P80%	10.55	11.17	6.73	15.09	7.88	9.78	0.91	2.84	0.77	-3.91	4.17	-1.65	-3.55	-2.08	-1.60	0.98	1.74	2.26	25.29	2.7690
		P90%	9.73	9.84	5.26	13.13	5.28	6.67	-1.56	0.25	-1.67	-6.03	1.80	-3.28	-4.69	-2.94	-2.04	0.64	1.44	2.01	26.08	2.8559
80%	8,118	**P50%**	**13.43**	**16.61**	**13.07**	**23.54**	**17.30**	**21.31**	**11.65**	**14.20**	**11.18**	**5.75**	**14.27**	**5.91**	**2.10**	**2.27**	**0.70**	**2.44**	**2.90**	**3.09**	**20.05**	2.4696
		P60%	11.83	14.04	10.35	19.67	13.74	17.16	7.56	9.79	7.23	2.26	10.28	3.09	0.07	0.66	-0.17	1.77	2.32	2.61	20.91	2.5763
		P70%	11.10	12.81	8.99	17.88	11.84	14.46	5.22	7.35	4.90	0.25	8.04	1.56	-0.99	-0.14	-0.57	1.47	2.05	2.39	21.72	2.6760
		P80%	10.67	12.09	8.13	16.85	10.14	12.40	3.55	5.65	3.20	-1.19	6.48	0.51	-1.70	-0.64	-0.80	1.29	1.89	2.26	22.48	2.7690
		P90%	9.86	10.76	6.68	14.88	7.64	9.40	1.18	3.14	0.87	-3.22	4.20	-1.07	-2.82	-1.50	-1.24	0.95	1.60	2.01	23.18	2.8559
70%	7,103	P50%	13.56	17.51	14.40	25.29	19.44	23.71	13.96	16.71	13.24	8.18	16.30	7.90	3.85	3.67	1.50	2.75	3.05	3.09	17.54	2.4696
		P60%	11.96	14.94	11.71	21.42	15.88	19.56	9.99	12.41	9.42	4.80	12.41	5.15	1.86	2.07	0.63	2.09	2.47	2.61	18.30	2.5763
		P70%	11.22	13.72	10.37	19.64	14.01	16.95	7.76	10.06	7.22	2.89	10.27	3.67	0.82	1.28	0.23	1.78	2.20	2.39	19.01	2.6760
		P80%	10.80	13.01	9.54	18.61	12.41	15.01	6.20	8.46	5.64	1.54	8.80	2.68	0.15	0.79	-0.01	1.60	2.05	2.26	19.67	2.7690
		P90%	9.99	11.68	8.11	16.64	9.99	12.12	3.92	6.04	3.41	-0.40	6.60	1.15	-0.94	-0.05	-0.45	1.27	1.75	2.01	20.29	2.8559
60%	6,088	P50%	13.68	18.40	15.73	27.05	21.58	26.11	16.27	19.21	15.30	10.62	18.32	9.90	5.61	5.06	2.29	3.06	3.21	3.09	15.04	2.4696
		P60%	12.09	15.84	13.07	23.18	18.02	21.96	12.42	15.02	11.61	7.34	14.54	7.20	3.64	3.48	1.42	2.40	2.63	2.61	15.69	2.5763
		P70%	11.35	14.63	11.76	21.39	16.18	19.45	10.30	12.78	9.53	5.53	12.50	5.79	2.64	2.70	1.02	2.09	2.36	2.39	16.29	2.6760
		P80%	**10.93**	**13.92**	**10.95**	**20.36**	**14.67**	**17.63**	**8.84**	**11.27**	**8.07**	**4.27**	**11.11**	**4.85**	**1.99**	**2.23**	**0.79**	**1.92**	**2.20**	**2.26**	**16.86**	2.7690
		P90%	10.11	12.61	9.54	18.40	12.34	14.85	6.67	8.94	5.95	2.41	9.00	3.37	0.93	1.40	0.35	1.58	1.90	2.01	17.39	2.8559
50%	5,074	P50%	13.81	19.29	17.06	28.81	23.72	28.51	18.58	21.72	17.36	13.06	20.35	11.89	7.36	6.45	3.09	3.38	3.36	3.09	12.53	2.4696
		P60%	12.21	16.74	14.42	24.94	20.16	24.36	14.85	17.64	13.81	9.88	16.67	9.26	5.43	4.89	2.22	2.71	2.78	2.61	13.07	2.5763
		P70%	11.48	15.54	13.14	23.15	18.35	21.95	12.84	15.49	11.85	8.16	14.72	7.90	4.46	4.13	1.81	2.41	2.51	2.39	13.58	2.6760
		P80%	11.05	14.84	12.35	22.12	16.94	20.24	11.49	14.08	10.50	7.00	13.43	7.01	3.84	3.66	1.58	2.23	2.36	2.26	14.05	2.7690
		P90%	10.24	13.53	10.97	20.15	14.69	17.58	9.41	11.84	8.49	5.23	11.40	5.58	2.81	2.84	1.14	1.89	2.06	2.01	14.49	2.8559

[13] The original irrigable area is 68,000 ha with 45 cum/s, but the design of Stage III enlarged to 73,000 ha with a new intake capacity of 60 cum/s.

The calculation summarized in the above table deals with paddy areas raging from 100 % to 50 % of the Study area, corresponding to 10,147 ha to 5,074 ha, with different system reliability ranging from 50 % to 90 %. The table tells us:

- The water available from August to October cannot support 100 % paddy area even under 50 % system reliability. In case of system reliability 80 % which is the standard in Nepal, the water deficit reaches to around 7 cum/s in early September.
- The available water cannot support 80 % paddy area (8,118 ha) except the case of system reliability 50 %. If the system is designed with system reliability of 50 %, the system can narrowly manage the paddy planted over the area of 8,118 ha. The surplus water in October is about 0.7 to 2.3 cum/s, which could be utilized for upland crop cultivation.
- In case of 70 % paddy area, water deficit does not take place under reliabilities of 50, 60 and 70 %. However, in case that the system reliability needs to be increased more than 70%, the system starts encountering a water deficit though the deficit is meager.
- If the paddy area is reduced to 60 % which is 6,088 ha, there is in all the cases water surplus. Looking at reliability 80 %, 0.79 cum/s surplus is still in the river which can be utilized for upland crop promotion.
- In case of 50 % paddy, no water deficit takes place. Under system reliability 80 %, the minimum surplus is 1.58 cum/s taking place in late October.

One thing very clear is that the water available in the Sunsari river cannot support full 10,147 hector of paddy, leading to a discussion; 1) whether the project area should be reduced, or 2) less water consumptive crops like summer vegetable should be promoted, or otherwise 3) the system reliability should be lowered. Likewise, conjunctive approach among the three may be an option taking into the development term of short (5 yrs), mid (5 yrs) and long (10 yrs).

There is a disparity between northern part and southern part within the Study area. The southern part is relatively poor than the northern part. Should the local people living in the southern part be excluded from the project, the disparity would definitely increase and also they might feel further segregated from ordinary Nepalese. The place they are living is already very close to India, therefore no more feeling of isolation from Nepalese side should be given to them. This leads us to an idea of not reducing the project area but either lowering system reliability or promoting upland crops or otherwise undertaking the both.

There may be difficulties to rapidly change the present dominant paddy to upland crops. In this regard, paddy should be allowed as much as possible even with lower system reliability at least for some time. On the other hand, the Study area is dominated by sandy soil which is not suitable for paddy cultivation but for upland crop. Practically saying, large paddy area, say more than 80%, can hardly be realized due to the high porous sandy soil. In this sense, future development vision should consider upland crop promotion while keeping cereal food sufficiency. These two contradictory issues give us the following term-wise development strategy:

- As to short term development, 80 % paddy area can be tried with system reliability of 50 % and the remaining 20 % could serve upland crop promotion. According to the aforementioned table, the case of 80% paddy with 50% reliability leaves meager surplus of 0.7 m^3/s at the leanest period. Except the leanest period, there are about more than 2 cum/s surplus, which can be used for upland crop promotion.

- As for mid and long term development, paddy area should be reduced to 60 % and the remaining 40 % should serve upland crop cultivation. This case gives 80 % system reliability to the irrigation system. The case of 60% paddy with 80% reliability leaves about 0.79 m^3/s surplus at the leanest period.

- Design discharge for the short-term development is bigger than the one for the mid and long term development. Referring to the above table, about 20 m^3/s and 17 m^3/s are required for short term and mid & long terms development respectively (requirement for upland crop not counted). However, canal design should not necessary be made based on the bigger amount of 20 cum/s since there is free board section in all the canals. As about 20% more can be conveyed with this free board, the canal design can be made on basis of future requirement.

According to the estimated self sufficiency done in Chapter 6.3 “Agriculture Development”, 60 % area of paddy can support the local people’s cereal sufficiency together with present wheat production (about 50% area with the present yield). Table 4.1.9 shows the gross water requirement by the proposed cropping pattern in Chapter 6.3, 60 % paddy and the rest being upland during summer, together with surplus or deficit on Sunsari river under system reliability 80%. Figure 4.1.4 illustrates the gross water requirement, and Figure 4.1.5 shows the balance on Sunsari river after subtracting 1.8 cum/s for the downstream regulatory release.

Though the cropping pattern raises meager water deficit of 0.25 cum/s in late October, this deficit would not affect any the yield of the paddy. Therefore, it is concluded that during monsoon season the Sunsari river can support the proposed cropping pattern; 60% paddy + upland crops. However, during winter season, many water shortages take place. The water available in Sunsari river becomes small during winter season to as little as less than 4 cum/s.

According to the table, even if whole amount of water is extracted for the project, the water cannot support full area of 10,147 ha. The area that the available water can support is 6,600ha in case all water extracted and 3,500ha in case 1.8 cum/s released to downstream. Therefore, measures to cope with the water deficit should be sought; those are introduction of preventive irrigation, introduction of rotational irrigation between the main canals of Suksena and Shankarpur, and groundwater development. Next sub-chapter discusses preventive irrigation together with the rotational irrigation.

Table 4.1.9 Estimation of Crop Water Requirement under the Propoased Cropping Pattern with System Reliability of 80 %

		Jan			Feb			Mar			Apr			May			June			July			Aug			Sep			Oct			Nov			Dec			Remarks	
		F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L		
Paddy Net WR, P80%ER, mm/10days	105days																8.4	60.9	90.6	96.7	124.4	144.4	147.5	156.3	134.6	150.6	124.6	111.3	87.3	57.0	21.1							1,516	
Paddy Net WR, P80%ER, mm/10days	120days																		14.0	100.1	129.9	146.8	141.0	151.3	134.6	152.2	145.0	163.2	176.7	191.4	158.3	104.1	51.3					1,980	
AF x Upland Crop Net WR, P80%ER, mm/10days																																						Net WR, mm	
Wheat		27.4	29.1	32.2	35.4	33.5	33.3	24.6	15.5	12.5	8.9	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	4.6	6.4	9.7	15.0	24.5	319	
Pulses		21.4	25.3	29.4	32.3	33.5	39.9	19.9	9.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	4.3	6.0	7.9	10.4	17.2	260	
Oilseed		24.9	25.3	25.2	21.5	16.8	6.2	5.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	6.5	9.6	14.8	18.1	22.1	203	
W.Vegetable+Potato		20.7	16.8	13.7	12.9	11.7	11.7	10.4	8.1	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	13.5	18.6	23.3	26.5	26.0	25.1	23.2	271	
Mungbean		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	10.8	13.0	19.8	30.3	27.2	31.4	15.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	153	
S.Vegetable		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	5.1	8.3	6.3	2.7	2.5	0.5	3.2	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32	
Jute		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	4.1	7.3	9.1	11.7	25.9	18.6	10.2	18.6	10.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	118	
Sugarcane		13.7	13.9	15.4	20.0	26.8	36.6	46.2	56.1	62.1	67.6	65.9	62.4	59.4	49.1	34.8	22.8	15.7	7.7	0.0	0.0	0.0	1.0	5.8	0.0	5.1	1.1	12.1	20.1	26.8	34.6	32.0	29.3	23.6	18.9	15.7	14.7	917	
Average		21.7	22.0	23.0	24.2	24.3	24.7	20.8	17.2	12.6	12.1	10.9	17.5	23.6	23.6	19.9	11.6	7.2	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	12.5	22.6	9.4	11.7	13.3	15.3	16.7	20.4	448	
Gross Water Requirment, cum/s	ha																																					Max. cum/s	Max. l/s/ha
Paddy(105days)	5,074	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	5.50	8.18	8.73	11.24	13.04	13.32	14.12	12.16	13.62	11.27	10.05	7.89	5.16	1.91	0.00	0.00	0.00	0.00	0.00	0.00	14.12	2.7639
Paddy(120days)	1,015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	1.81	2.35	2.65	2.55	2.73	2.43	2.75	2.62	2.95	3.19	3.46	2.86	1.86	0.93	0.00	0.00	0.00	0.00	3.46	3.4077
Wheat	5,074	3.22	3.42	3.79	4.16	3.93	3.91	2.91	1.82	1.47	1.05	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.54	0.75	1.14	1.76	2.88	4.16	0.8190
Pulses	1,015	0.50	0.59	0.69	0.76	0.79	0.94	0.47	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.10	0.14	0.19	0.24	0.40	0.94	0.9244
Oilseed	507	0.28	0.30	0.30	0.25	0.20	0.07	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.12	0.17	0.21	0.28	0.30	0.5856
W.Vegetable+Potato	2,029	0.97	0.78	0.64	0.81	0.55	0.55	0.49	0.38	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.63	0.87	1.10	1.25	1.32	1.18	1.09	1.32	0.6484
Mungbean	507	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.13	0.15	0.23	0.36	0.32	0.37	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.7270
S.Vegetable	1,015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.12	0.15	0.15	0.08	0.06	0.01	0.08	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.1464
Jute	1,522	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.14	0.28	0.32	0.41	0.91	0.65	0.36	0.65	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91	0.5981
Sugarcane	507	0.18	0.16	0.18	0.23	0.31	0.43	0.54	0.66	0.73	0.79	0.77	0.73	0.70	0.56	0.41	0.27	0.16	0.09	0.00	0.00	0.00	0.01	0.07	0.00	0.06	0.01	0.14	0.24	0.32	0.41	0.38	0.34	0.28	0.22	0.18	0.17	0.79	1.5648
Total Gross, cum/s	**18,265**	**5.14**	**5.25**	**5.60**	**6.01**	**5.78**	**5.90**	**4.47**	**3.12**	**2.53**	**2.18**	**1.73**	**1.43**	**1.62**	**1.87**	**1.49**	**1.58**	**6.42**	**8.84**	**10.54**	**13.59**	**15.69**	**15.88**	**16.93**	**14.59**	**16.43**	**13.91**	**13.14**	**11.31**	**9.07**	**5.81**	**3.53**	**3.09**	**2.53**	**3.04**	**3.58**	**4.80**	**16.928**	**1.6881**
																																						Min. cum/s	
Sunsari Discharge, P80%, cum/s	cum/s	4.05	4.19	3.84	3.90	3.95	3.84	3.69	3.72	4.09	4.14	4.38	5.79	6.46	8.69	10.12	13.48	21.23	21.18	32.70	30.06	35.12	26.51	29.93	24.46	22.44	26.81	19.85	14.87	12.64	7.36	5.60	4.93	4.06	4.28	3.98	4.08	3.69	
Sunsari Discharge, P80% - 1.8cum/s(50%)		2.25	2.39	2.04	2.10	2.15	2.04	1.89	1.92	2.29	2.34	2.58	3.99	4.66	6.89	8.32	11.66	19.43	19.38	30.90	28.26	33.32	24.71	28.13	22.66	20.64	25.01	17.85	13.07	10.84	5.56	3.80	3.13	2.28	2.48	2.16	2.28	1.89	
Sunsari Discharge, P80% - 0.7cum/s(20%)		3.35	3.49	3.14	3.20	3.25	3.14	2.99	3.02	3.39	3.44	3.68	5.09	5.76	7.99	9.42	12.76	20.53	20.48	32.00	29.36	34.42	25.81	29.23	23.76	21.74	26.11	18.95	14.17	11.94	6.66	4.90	4.23	3.36	3.58	3.26	3.38	2.99	
																																						Min. Bal., cum/s	
Balance, P80%, cum/s	cum/s	-1.10	-1.06	-1.76	-2.11	-1.83	-2.05	-0.77	0.60	1.56	1.95	2.65	4.36	4.85	6.82	8.63	11.90	14.81	12.24	22.16	16.47	19.43	10.63	13.00	9.87	6.01	12.90	6.51	3.56	3.57	1.55	2.06	1.84	1.53	1.24	0.38	-0.72	-2.11	
Balance, P80% - 1.8cum/s(50%)		**-2.90**	**-2.86**	**-3.56**	**-3.91**	**-3.63**	**-3.85**	**-2.57**	**-1.20**	**-0.24**	**0.15**	**0.85**	**2.56**	**3.05**	**5.02**	**6.83**	**10.10**	**13.01**	**10.44**	**20.36**	**14.67**	**17.63**	**8.83**	**11.20**	**8.07**	**4.21**	**11.10**	**4.71**	**1.76**	**1.77**	**-0.25**	**0.26**	**0.04**	**-0.27**	**-0.86**	**-1.42**	**-2.52**	**-3.91**	
Balance, P80% - 0.7cum/s(20%)		-1.80	-1.76	-2.46	-2.81	-2.53	-2.75	-1.47	-0.10	0.86	1.25	1.95	3.66	4.15	6.12	7.93	11.20	14.11	11.54	21.46	15.77	18.73	9.93	12.30	9.17	5.31	12.20	5.81	2.86	2.87	0.85	1.36	1.14	0.83	0.54	-0.32	-1.42	-2.81	
																																						Min. in %	
% covered by P80%	%	79	80	68	65	68	65	83	119	162	189	253	404	400	464	679	853	331	237	310	221	224	167	177	168	137	193	149	131	139	127	158	160	160	141	111	85	65	
% covered by (P80% - 1.8cum/s(50%))		44	46	36	35	37	35	42	62	90	107	149	279	289	368	558	739	303	217	293	208	212	156	166	155	126	180	136	116	120	98	107	101	89	82	60	48	35	
% covered by (P80% - 0.7cum/s(20%))		65	68	56	53	56	53	67	97	134	157	212	355	357	427	632	809	320	229	304	216	219	163	173	163	132	188	144	125	132	115	139	137	133	118	91	71	53	
																																						Min. in ha	
Area covered by P80%	ha	7,985	8,095	6,950	6,589	6,937	6,615	8,393	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	8,635	6,589	
Area covered by (P80% - 1.8cum/s(50%))		4,435	4,619	3,686	3,549	3,780	3,518	4,303	6,245	9,183	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	9,709	all	all	9,053	8,273	6,126	4,629	3,518	
Area covered by (P80% - 0.7cum/s(20%))		6,604	6,743	5,681	5,407	5,709	5,411	6,802	9,825	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	9,246	7,155	5,407	

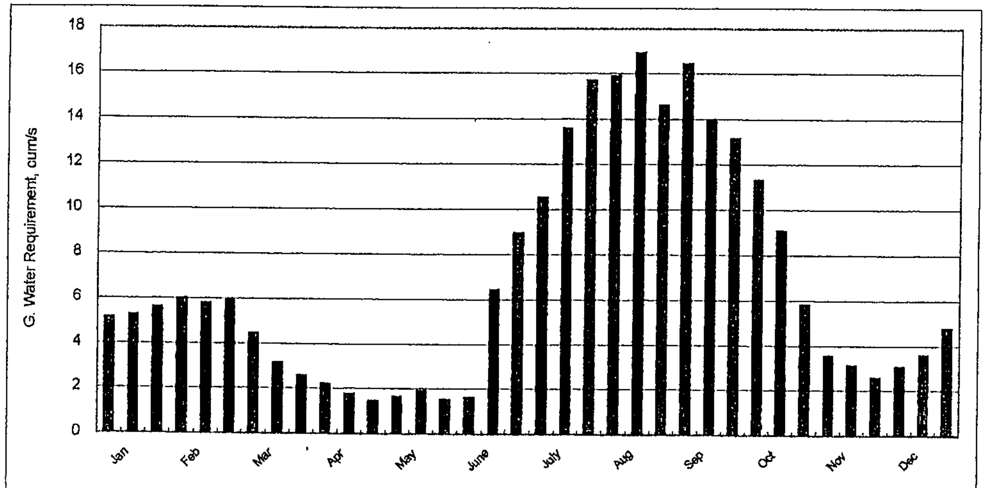


Figure 4.1.4 Gross Water Requirment of 60% Paddy and Upland Crops

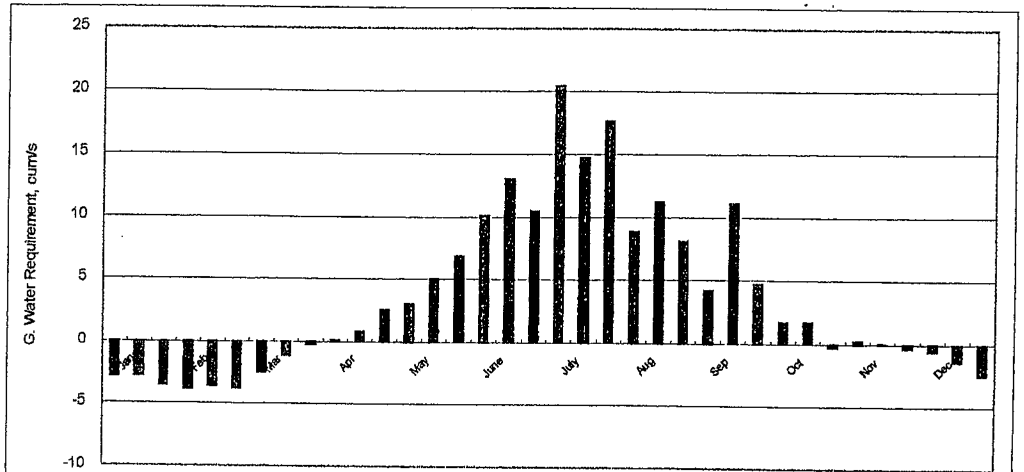


Figure 4.1.5 Surplus/Deficit on Sunsari River, 60% Paddy and Upland Crops (DS Rise 1.8 cum/s)

4.1.6 Preventive Irrigation

The concept of preventive irrigation, sometimes called supplemental irrigation, can be seen in the original SMIP irrigation duty of 0.66 l/s/ha. The preventive irrigation has been carried out in countries where vast cultivable land is available while water resources are so limited that cannot cover whole the prospective land. No formula has been established to estimate preventive irrigation requirement, but we can refer to actual examples practiced in the field. The example is STW irrigation. The farmers, in most cases, apply a minimum amount of water to save diesel cost[14].

This Study carried out a survey of STW operation to a total of 60 farmers. The result summarized below shows that they are applying about 33 cm for wheat and 25 cm for other upland crops like potato, cauliflower, cabbage, etc. If these volumes are converted at the place of the proposed headwork taking into account a conveyance efficiency of 0.85, they are to be 39 cm and 30 cm respectively. The estimated amounts count to about 60 % of the one estimated by Penman method. Therefore, this Study undertakes 60% volume of Penman requirement as the preventive irrigation requirement.

Table 4.1.10 Preventive Irrigation Requirement

Crop	Water Applied (cm)	Gross at HW Effi.=0.85	Gross by Penman (cm)	Ratio %	Remarks
Wheat	32.8	38.6	63.9	60.4	say 60%
Others	25.0	29.4	51.7	56.9	

Note: STW capacity assumed at 20l/s

Table 4.1.11 below shows: 1) coverage area based on Penman requirement, and 2) coverage area by preventive water requirement, with three cases each depending upon how much water should be released to the downstream. The first case is no downstream release, second is release 50% of minimum probability 80% volume (1.8 cum/s release), and the third one is release 20 % of minimum probability 80% (0.7 cum/s release). The table tells us:

- Under the Penman requirement, the coverage area is only 35% of the total 10,147 ha in case of 1.8 cum/s release and 53 % in case of 0.7 cum/s release. Even in case that the available volume after 1.8 cum/s release is applied to only either Suksena or Shankarpur, implying rotational irrigation between the two canals by year, the coverage is still 64 % and 76 % only. If downstream is reduced to 0.7 cum/s, both canals can narrowly have 100% coverage under the rotation by year.

- Under the preventive requirement, the coverage area is 58% in case of 1.8 cum/s release. If the water is applied to one of the two canals alternately by year, the coverage will be more than 100 %; 106% for Suksena and 127% for Shankarpur.

How much water the Project should release to downstream is very much dependent on how the paper mills located just downstream of the proposed headwork site proceed in terms of establishing an effluent treatment plant (ETP). Though it is very difficult to forecast how much the paper mills can deal with, this Study considers 50% downstream release, 1.8 cum/s release, as the base case still requiring the factories to establish ETP that reduces the effluent

[14] One litter diesel cost is 27 Rs/l as of October 2002, and this incurs on the farmers about 0.6 Rs per cubic meter pumped water in case of yield about 20 l/s.

by 80% (at present DANIDA intervention is on-going). Then, 20% release, 0.7 cum/s, is also considered as an expecting future scenario on condition that the factories meet the Nepalese Industry Effluent Standard (for detail downstream release, see Chapter 11) and also fishermen's compensation is met. Based on this, this Study proposes the following irrigation development:

Monsoon: Proposed cropping pattern; namely, 60% paddy and upland crops

Winter: Base case: proposed cropping pattern under rotational irrigation between Suksena and Shankarpur by year with preventive irrigation (downstream release is minimum 1.8 cum/s, 50% of minimum P80% flow)

Winter: Expecting case: proposed cropping pattern under rotational irrigation between Suksena and Shankarpur by year with conventional irrigation, requirement of which is estimated by Penman method (downstream release is minimum 0.7 cum/s, 20% of minimum P80% flow)

Condition 1: Effluent treatment plant envisaged now under a DANIDA program should be constructed even for the base case, which reduces the effluent to 20% of the present. Otherwise water extraction from Sunsari river during winter should not be done.

Condition 2: Expecting case is realized on condition that; 1) the paper factories meet the Nepalese standard of industry effluent and also 2) compensation for fishermen is met maybe by promoting inland fish culture in Old Sunsari river.

Table 4.1. 11 Conventional and Preventive Irrigations during Dry Season

Case	DS Release	Area covered	% ag. 10,147	% ag. Suksena	% ag. Shank.
	cum/s	ha		5,529ha	4,618ha
Penman WR					
Covered by P80% (no DS release)	No	6,589	65	119	143
DS release 1.8 cum/s	50% of minimum P80%	3,518	35	64	76
DS release 0.7 cum/s	20% of minimum P80%	**5,407**	**53**	**98**	**117**
Preventive WR					
Covered by P80% (no DS release)	No	10,982	108	199	238
DS release 1.8 cum/s	50% of minimum P80%	**5,863**	**58**	**106**	**127**
DS release 0.7 cum/s	20% of minimum P80%	9,012	89	163	195

4.1.7 SMIP Water Release

Tough SMIP seems not able to provide any water during lean period for SRIP due to the trend of water level getting down, this sub-chapter, as a case study, examines how much irrigable area during lean period can be realized if SMIP could provide some water according to the past operating years' average water level at the Chatra intake. The water provided by SMIP is assumed at 3.8 cum/s in January, 4.4 cum/s in February, 5.00 cum/s in March and so on according to the SMIP supply driven mode with 59,900 ha under the present cropping pattern (refer to 5.3.3 Possibility of Water Release from SMIP

Following table shows the result how much area the SRIP can cover with the supplemental water of 3.8 to 5.0 cm/s from SMIP. With the supplemental water, the SRIP can cover as much as 70 % of the whole irrigable area even after 100% of minimum probability 80% water, 3.7cum/s, is released to the downstream (irrigation requirement is based on Penman). In case of 50 % water release, 1.8 cum/s release, it can cover all the irrigable area.

Table 4.1.12 SRIP Area Coverage with SMIP Supplemental Water Release

Case	DS Release	Area covered	% ag. 10,147	% ag. Suksena	% ag. Shank.
	cum/s	ha		5,529ha	4,618ha
Suppl't from SMIP (3.8 to 5.0 cum/s)					
Covered by P80%	No	10,147	100	184	220
DS release 3.7 cum/s	100% of minimum P80%	**7,131**	**70**	129	154
DS release 1.8 cum/s	50% of minimum P80%	10,147	100	184	220
DS release 0.7 cum/s	20% of minimum P80%	10,147	100	184	220

4.1.8 Major Facilities' Design

Major facilities are headwork, conveyance canals, distributary canals, and control and regulating gates. The design criteria used in this Study are based on DOI's criteria, which are given in the "Planning and Design Strengthening Project" (PDSP) manuals. For the design of headworks, this Study refers to "Hydrology and Agro-meteorology Manual (M.3)" and "Headworks, River training Works and Sedimentation Manual (M.7). Also, considered were Japanese standard design criteria for headworks as well as the views and the experiences of the DOI staff including SMIP.

The siting of the headworks is proposed at 600 m downstream from the E-W highway. Though Sunsari river flows in meandering almost all the way, there is a straight and stable reach starting at about 100 m downstream from the E-W Highway. The stable reach is about 700 m and at a downstream mid of the stable reach is designed for siting the headworks. The site set on the straight reach can well divert the Sunsari river's water into both east and west conveyance canals leading to Shankarpur and Suksena canals.

The site can also evade from the industrial effluent by two paper factories. There are two paper factories located right beside Sunsari river at about 700 m downstream from E-W highway, discharging effluent into Sunsari river. The headwork site is so designed that the effluent cannot enter the irrigation network. The dimensions of the proposed headworks are as followed:

- Position of headworks — 600m downstream from E-W High Way
- Type of headworks — Barrage (fully movable type using gates)
- Catchment Area — 300 km^2
- Design High Flood Discharge — 650 m^3/sec
- Width of headworks — 72 m
- No. of Spillways — 5 Nos.
- No. of Under Sluices — 4Nos. (on both sides of the headworks)
- Size of Under Sluice Gates — 6.2m x 3.85m
- Size of Spillway Gates — 6.2m x 3.60m
- Design Water Intake Discharge — 16.93 m^3/sec
- River Maintenance Flow — about 1.8 m^3/s (50% of minimum P80%)
- Related Structure — Fish Pass (on both sides of the headworks)

As per design flood discharge, this Study refers to empirical formulas employed in Nepal under 50 years probability, probable passing flow under the E-W highway bridge, and a recorded discharge. The recorded discharge is at Sunsari crossing point at Eastern Koshi main canal in India having catchment area of 500 sqkm (Sunsari CA is 300 sqkm). As shown in the table below, discharge based on empirical formulas is less than the probable passing flow at the E-W highway bridge estimated by Manning formula (WL = 82.4m). Though the recorded discharge is 680 cum/s, the biggest value, this was augmented due to the bigger catchment area of about 70% more than the Sunsari catchment area. This Study takes 650 cum/s as the design flood discharge taking into account the probable passing flow.

Table 4.1.13 Design Flood Discharge

Method	Particular	Discharge, cum/s	Remarks
1. Modified Dickens Formula	Empirical	568～610	
2. WECS Method	Empirical	488	
4. Area Velocity Method (EW Bridge)	Manning	647	= 500 cum/s (design flood)
5. Sunsari crossing at Eastern Koshi Main Canal (In India)	Recorded	680	CA=500 km^2(70% more than the Sunsari CA of 300 sqkm)

Type of the weir is fully movable type (all gate type). As headworks are so-called river structures, they need to be stable enough to withstand floods while at the same time not being a serious obstacle disturbing the flow of the floods. Fully movable type can pass the high flood through to downstream safely by its full open operation. Therefore, this Study designs all gate type weir as the headwork type.

In addition to above, fixed type weir may give unbalance of supply and demand of the river bed materials between upstream and downstream across the headworks. Actually, such kind of cases can be found in some existing irrigation systems. River bed materials have deposited in front of a fixed weir, and then the supply of bed material has been forced to stop going to downstream. Consequently, retrogression of the downstream river bed has taken place. Adopting the fully movable type (all gate type) can head off this problem.

Relative to the foundation design, this Study carried out two core borings at the prospective headworks site. When the foundation is classified by the size of grain, unconsolidated deposits in much of the proposed headworks site can be divided into two layers which in ascending order are the lower layer and the upper layer. The upper layer can be divided into the alternating beds (U1) of sand and silt, and sand bed (U2). The lower layer can be divided into three beds which in ascending order are gravel (L3), sand (L2), and silty bed (L1). Those beds are well layered each other in both the upper layer and the lower layer.

The foundation structure at the proposed headworks site is illustrated in Figure 6.4.6 together with the result of standard penetration test. The result of the SPT is that: alternating beds (U1; silt and very fine to medium-grained sand) recorded a range of 9 to 16 with an average of about 13, fine to medium-grained sand beds (U2) recorded a range of 27 to 35 with an average of about 31, silt bed (L1; occasional thin beds of clay) recorded 17 only, fine to course-grained sorted sand beds (L2) recorded a rage of 18 to 62 with an average of about 34, and sand and gravel beds (L3; pebble and fine to medium sand) were dense and hard with N values from 39 to over 50 and rebounded.

Taking into account the results above, this Study designs tree foundation levels for the proposed headworks site as: the bank foundation level (a intake bed level) is located at about 2 m below surface in both the banks of Sunsari river, the riverbed foundation level (a pile cap level) is located at 6 to 7 m below surface in the Sunsari river bed where the concrete floor of the headworks is designed, and the sheet pile foundation level is located at between 7 to 15 m below surface. The riverbed foundation on which the headworks' concrete floor is placed was designed to have about 10 or more SPT N values.

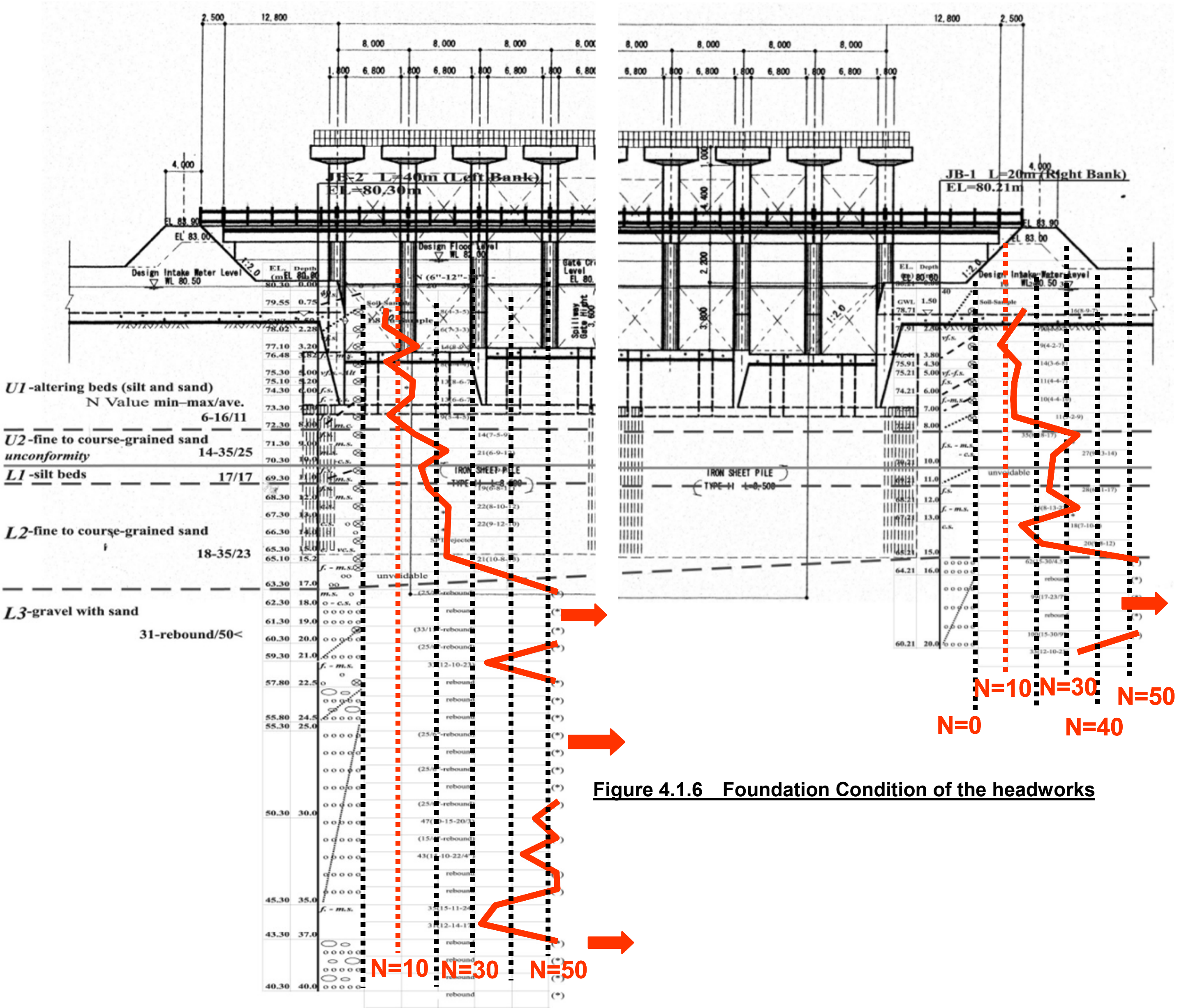


Figure 4.1.6 Foundation Condition of the headworks

4.1.9 Canal Design and Irrigation Network

Canal design refers to the said manual, SMIP experiences and the existing conditions of the present canal network in the Study area. To meet with the present cross section of the canals, the new design section basically follows the existing cross section so that additional excavation/embankment as well as land acquisition can be minimized. Though the present canals are all unlined, the main canals of Suksena and Shankarpur plus the biggest secondary of 4SRR are concrete-lined since the embankment material available around the site is very much sandy dominated.

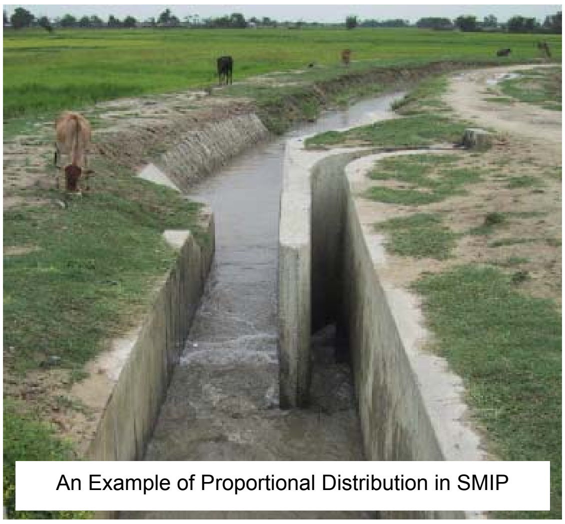
SMIP standardized length from the beginning point of secondary to the end of tertiary to be limited at about 5 km from the viewpoint of proper water distribution. This Study flows this standard, thereby no canal longer than 5 km is allowed. The canal network follows the present irrigation network, taking into account the 5 km limit, so as to minimize the land acquisition. In case the density of canal network is found not enough from the viewpoint of system management and equal water distribution or a canal is longer than 5 km limit, some additional canals are arranged as discussed in “Chapter 7.1 Irrigation System Management (Joint Management)”.

As per water course, this Study designs much shorter unit than SMIP. SMIP standard limits the length to about 1.2 km covering 28 ha each. This Study envisages all the water course should be constructed by the concerned farmers as their contribution to the Project. Also, taking into account is the sandy soil. The soil will shorten the durability of such small canal, asking the farmers frequent maintenance and repair. Once a portion of the canal is breached, the longer watercourse is, the more difficulty the farmers will face. Therefore this Study proposes about 300 m length only as the limit of the water course together with about 20 ha command area. This arrangement was discussed in Farmers Consultation Workshops, and most farmers were very preferable to this and some raised even smaller unit.


A Water Course constructed by sandy soil, requiring frequent maintenance

4.1.10 Distribution System

As per distribution system, while main canal adapts conventional check regulating system together with drops as required according to the topographic condition, distribution once after the water gets into secondary canal block is designed to be proportionally and free. No gated regulation within secondary canal block wherever is applied. This concept has been well verified in SMIP. Though the distribution system requires almost full water level even during lean period, the system lowers the construction cost and maintenance cost, and eliminates manipulation by delinquent users.


An Example of Proportional Distribution in SMIP

4.2 Drainage Development

4.2.1 Conventional Drainage

Drainage network in the Study area has not been well developed, giving damages to paddy and also causing inundation problem in many residential areas. Though meager drainage systems are often found along canal maintenance roads and village roads, there is a difficulty to drain out the water to lower areas leading finally to existing rivers. The drainage system is designed based on the need to take away excess irrigation and rainfall water from the paddy fields as well as upland fields within the irrigated area and also surface runoff in the village areas during periods of extreme storms in the monsoon season.

In order to determine allowable period for draining excess water from paddy field, the frequency of the rainfall that has occurred right before and after the annual maximum daily rainfall was examined, using daily rainfall data recorded at Biratnagar Airport meteorological station during the past 30 years (year from 1970 to 2000). The examination tells us that a 3-day continuous storm with more than 50 mm/day rainfall has hardly occurred. Therefore, this Study undertakes the daily maximum rainfall with 10-year return period as the design rainfall.

A part of the design rainfall is stored in paddy fields, and their effects to the yield of the paddy cultivation is often quoted as: 1) submergence at the growing stage of young panicles formation seriously damages the paddy, while that at the maturing stage does not seriously damage the paddy, and 2) duration of submergence within 1 to 3 days is insignificant, but the damage to paddy remarkably increases if the submergence lasts for more than 3 days. Based on the quotation, it is concluded that 3-days duration for draining excess water from the paddy field will not much damage the yield. The period for draining excessive water from paddy is thus determined to be 3 days.

The probable annual maximum daily rainfall is analyzed by using the Log-Peason III method. The annual maximum daily rainfall with 10-year return period is estimated at 194 mm, which is the design rainfall for paddy field drainage. The annual maximum daily rainfall with different return periods is as follows:

Table 4.2.1 Annual Maximum Daily Rainfall (Unit: mm/day)

10-year	20-year	50-eyar
194	207	230

Based on the conditions mentioned above, the drainage water requirement is estimated at 4.3 l/sec/ha as shown below:

Assumptions: Design rainfall is 194 mm/day

Effective water depth in the paddy field is 110 mm

Standing water depth in the paddy field is 30 mm

Calculations: $Q = q \times A$

$q = RE24 \times 10\ m^2/(3{,}600\ sec \times 72\ hours) = 114 \times 10/(3{,}600 \times 72) = 4.3$ l/sec/ha

$RE24 = R24 - (D1 - D2) = 194 - (110 - 30) = 114$ mm

Q = Design drainage water requirement (m^3/sec)
q = Unit drainage water requirement per ha
A = Drainage area
R24 = Design rainfall, 194 mm/day
D1 = Effective water depth in the paddy field, 110 mm (assumption)
D2 = Standing water depth in the paddy field, 30 mm (assumption)
RE24 = Excess rainfall to be drained, 114 mm

The proposed drainage system consists of collector, tertiary or secondary, major existing streams and drain to the Sunsari river, Old Sunsari river and Budhi river. The function of a collector drainage canal is to receive excess rainwater from the irrigated areas. It will then carry the excess water to the tertiary, secondary drain or in some cases directory natural stream. The smallest unit of on-farm, about 20 ha each under water course, will have at least one access point to the either collector or tertiary. The tertiary drainage canal will then be connected to secondary or existing streams. The tertiary and secondary drains are as far as possible designed to run along irrigation tertiary and secondary canals.

4.2.2 Mariya Dhar (Old Sunsari River) Utilization

Mariya Dhar running along almost center of the Study area will collect the drainage water coming from right bank of Shankarpur and left bank of Suksena canal after the Project commences the operation. There is a road improvement plan proposed in this Study, connecting Harinagar and Basantapur (see Sub-chapter 6-7 Rural Infrastructure Improvement for the detail). This road crosses Mariya Dhar, where requiring a causeway type bridge.

The causeway can work as a weir to store the drainage water coming from the Project area. Then, the drainage water can be diverted into a tertiary canal downstream. Taking into account topographic condition, the drainage water can be provided to TC3 of 11 SLR of Suksena canal, irrigable area of which is about 500 ha. This Study proposes the development of Mariya Dhar to be done as a mid term development, say 6 – 7th years after the Project commences the operation.

CHAPTER 5 SYSTEM MANAGEMENT

5.1 Irrigation System Management (Joint Management)

What form of irrigation management have we devised? One lists up three types of irrigation system management. These are: 1) user management (in Nepal called farmer managed irrigation system; FMIS); 2) government management (in Nepal called agency managed irrigation system; AMIS); and 3) joint management (sometimes referred to as participatory irrigation management; PIM).

Easily distinguished are between the systems that are managed by local user organizations and systems that are managed by the government agencies. The general tendency in countries having both types of irrigation systems is: for user-managed systems to be relatively small and for government-managed systems to be relatively large. In this country of Nepal, user management usually applies to small scale irrigation systems such developed under ADB assisted ISP and SISP while government management applies to big national irrigation systems usually more than 2,000 ha command area.

The third management style that is Joint Management is a form wherein the water users association and the government share the management responsibilities. In most cases, the government manages principal facilities such as dams, reservoirs, diversion weirs, and large canals while the water users association manages downstream past of a system such as secondary canals, sub-secondary canals, tertiary canals, on-farm facilities and in all the cases the water users association is responsible for irrigation service fee (ISF) collection.

Having seen the trend in irrigation management all over the world, many governments are reducing their roles in irrigation management while farmers associations are taking them over. The governments are now transferring a part of irrigation management to the water users associations. This is referred to as Irrigation Management Transfer; so called IMT[15], resulting in a Joint Management that has become a widespread practice all over the world.

Especially for the last two decades, many countries around the world have been turning over the management authority from the government to the farmers organization. Nepal is not an exception but is pursuing management transfer either under IMTP or with its own internal fund. The logic why

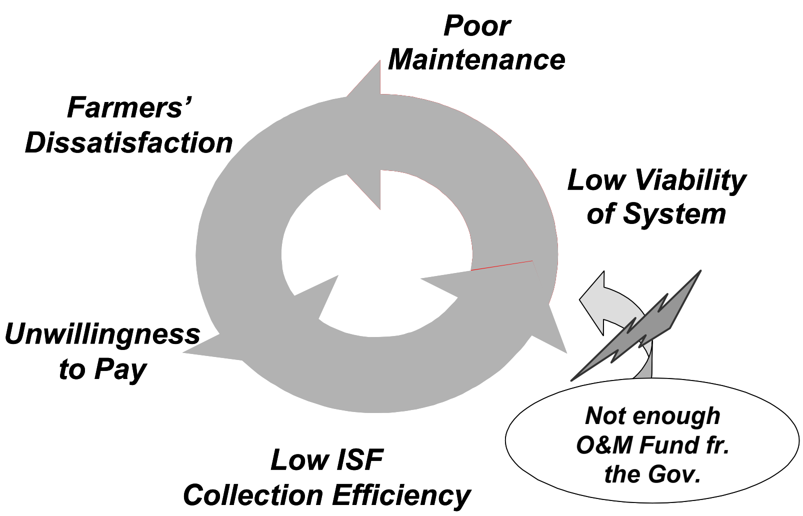


Figure 5.1.1 An Irrigation System in a Vicious Circle

[15] Irrigation Management Transfer early occurred from the 1950s through 1970s in: the USA, France, Colombia, and Taiwan. Then, in the 1980s and 1990s, Latin American Countries, African Countries, Middle Eastern Countries, Asian Countries such as Pakistan, India, Sri Lanka, Bangladesh, Lao PDR, Vietnam, China, Indonesia, the Philippines have introduced IMT, and so is the Nepal.

the management transfer, resulting in a joint management, is needed is shown in Figure 7.1.1.

ISF collection efficiency and also the fee itself are very low, an example of which is SMIP; namely, less than 20% efficiency with 200 Rs/ha (half goes to the government). Supplementing O&M by the government budget is not easy task taking into account the budgetary constraint as well as from the viewpoint of equity aspect (capital is subsidized and any rationale to further subsidize O&M ?). System viability becomes low because the system does not have enough funds, leading to poor operation and maintenance.

Thus, the government becomes no longer able to operate and maintain the irrigation system at a level with which the farmers are satisfied. Farmers' dissatisfaction creates unwillingness to pay irrigation service fee. Then, return again to the low ISF collection efficiency, which is the vicious circle wherein most government managed irrigation systems are now struggling.

What mentioned above leads us to concluding rationale why we should promote Joint Management. Government bureaucracies in one way may lack the incentives and responsiveness to optimize the irrigation management performance. Specially given the situation HMGN is now facing under staff curtailment, DOI alone can no longer increase the performance level of the irrigation system. On the other hand, farmers must have a direct interest in enhancing and sustaining the quality and cost-efficiency of irrigation management because agriculture is their primary occupation.

From the viewpoint of government side, joint management will reduce the government expenditures for O&M and allow reallocation of the fund to new construction within the sector. In many countries, the governments are running shortage of fund while many projects are lining up, waiting for the implementation, and Nepal is not an exception in that way. Joint management would contribute to rectifying the situation to certain extent.

The joint management is already legalized in Nepal as Provision 13 of Irrigation Regulation (2056) says that "big projects, which cannot be fully transferred to the WUA, may be operated jointly by concluding as agreement between the two parties including collection of service charge, share percentage of users' association, and arrangement for maintenance." The issue now is how and in what way the joint management be introduced in the Sunsari river Irrigation Project.

There are variations in how far upstream the role of WUAs is extended and the extent to which the Government, DOI, should be still in place. There are also variations in what tasks and responsibilities should be transferred to WUAs. The most frequent pattern in Asia is that the government retains overall ownership of the irrigation system and control over the water resource, and main and other big canals. Then, WUAs take the responsibility of operation & maintenance of lower-level canals and ISF collection.

In Nepal, the responsibility of ISF collection is in no doubt on the farmers' side under the joint management. However, to what level of canal network the WUAs should undertake the responsibility of operating and maintaining is not yet standardized and is still under try & error as one can see in the transfer program of IMTP. To demarcate the responsible line between the government and WUAs should taking into account hydraulic decentralization, farmers' manageability of operating and maintaining the system, solidarity of the member farmers of a WUAs, system hardware design, government limited and would-be curtailed workforce, etc.

5.1.1 Hydraulic Decentralization

There will be 13 WUAs, named Water Users Committee (WUC) same as SMIP, along Suksena canal and 9 WUCs along Shankarpur canal, totaling to 22 WUCs under the Sunsari River Irrigation Project. The WUCs are the organ dealing with the irrigation water, which is an economic good. To deal with an economic good, perceived right for the use in exchange of paying the service fee should well be established. In this sense, WUCs should be hydraulically decentralized by being established in conformity with any head gate that regulates the flow going into their irrigation area. The WUCs may be stratified as the organization becomes big, starting in all the cases with on-farm irrigation groups. At every level of the organization, hydraulic decentralization should always be pursued in conformity with turn-out, head gate, check regulator, etc.

5.1.2 Farmers Manageability

The example of West Gandak, where the main canal commanding 10,300 ha was transferred, tells clearly us farmers would face very difficulty in managing such big canals covering several thousand hector. A canal commanding thousands hector usually entails almost same number of member farmers or more in the WUA (say, 10,000 ha means about. 10,000 member farmers or more). Too many members definitely make it difficult to act collectively in operating and maintaining their canal system even if the WUAs is well stratified.

In case of Sunsari River Irrigation Project, Shankarpur and Suksena canals should not be transferred to the farmers. The command areas are about 5,000 ha each, which are so big in size that the canals should be operated and maintained under the jurisdiction of the DOI. Therefore, the management transfer should take place at the level of secondary[16] canals that branch off from the Shankarpur and Suksena.

5.1.3 Solidarity of the Member Farmers

The more members a WUA has, the more difficulty the WUA would face in discharging collective task. One may say even big number of members could well be organized in a stratified organization. However, practices on the ground have hardly proved it as shown in SMIP and according to a lesson gained from IMTP. The lesson[17] says; "The organizational structure of some IMT WUAs, particularly in the larger projects, may be overly complex, with too many layers of bureaucracy. IMTP should stress leaner WUAs and help identify key leaders and mangers……."

Generally speaking from human attitude point of view, a number of 15 to 20 is considered to a certain extent to be a limit in organizing well cohesive group. 15 to 20 members entail about

[16] In Sunsari River Irrigation Project, Shankarpur and Suksena canals are regarded as the main, though these are secondary in SMIP, and canals branching off from the two canals are called secondary.

[17] Irrigation Management Transfer Project, Contract Completion Report, May 30, 1996 – November 20, 1999, prepared by Aomputer Assisted Development Inc., and APTEC Consultancy P. Ltd.

20 to 30 ha that, however, is too small if the group were given identical irrigation management authority from the view point of overall system management. If a WUA is envisaged with 2 layers with the same limit in number in the organizational structure, it could cover 200 to 400 members (15 x 15 to 20 x 20). This would entail about 200 to 400 ha which is usually corresponding to the range of command area by a secondary canal. Therefore, the WUAs should be principally established at secondary canal level.

5.1.4 System Hardware Design

Taking into account the farmers manageability and also solidarity among the member farmers, any secondary canal covering more than 400 members (or about 400 ha) should be divided into smaller blocks by providing additional secondary between the main (Shankarpur or Suksena) and around mid point of the concerned secondary (see Figure 5.1.2). If topographic condition does not allow this arrangement, the government should go down to the point below which the command area is less than 400 ha (see Figure 5.1.3). In this case, the upstream of the concerned canal is regarded as a part of main canal from the viewpoint of system management.

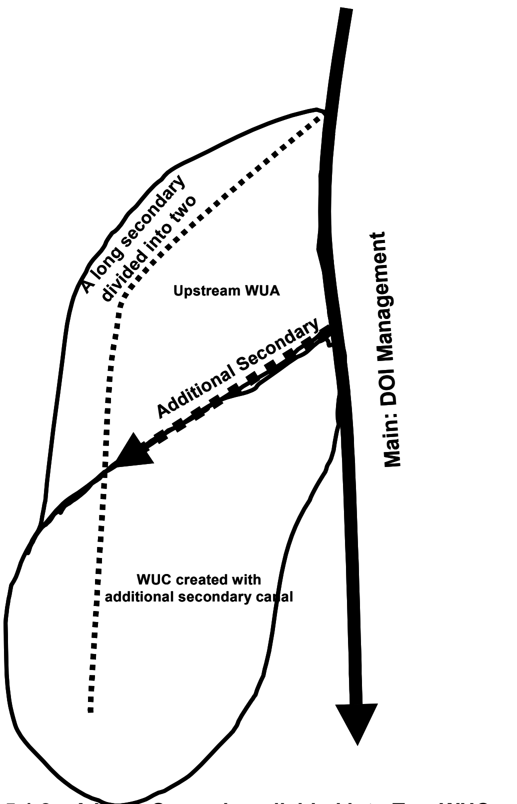


Figure 5.1.2 A Long Secondary divided into Two WUCs

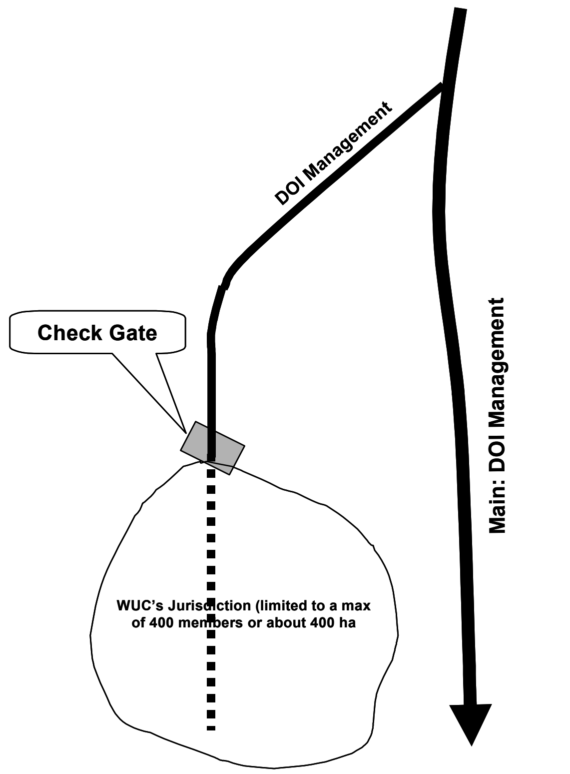


Figure 5.1.3 A Long Secondary partly covered by DOI

The case left shown in Figure 5.1.2 took place in case of lower part of Shankarpur canal, and the case shown in Figure 5.1.3 occurred in the biggest secondary canal of Suksena named 4SRR (command area is 1051 ha). Given the arrangement, now Suksena canal has 26 WUCs ranging from 115 ha to 388 ha with an average of 213 ha and Shankarpur canal has 18 WUC ranging from 131 ha to 402 ha with an average of 257 ha.

5.1.5 System Management

In summary, the main canals, Shankarpur and Suksena, and 4SRR will be managed by DOI, and secondary canals and below thereof are managed by the relevant WUCs. The gates attached to the main canals of Suksena and Shankarpur and secondary 4SRR will be operated and maintained by DOI with consultation of relevant WUCs. The demarcation of joint management is illustrated below:

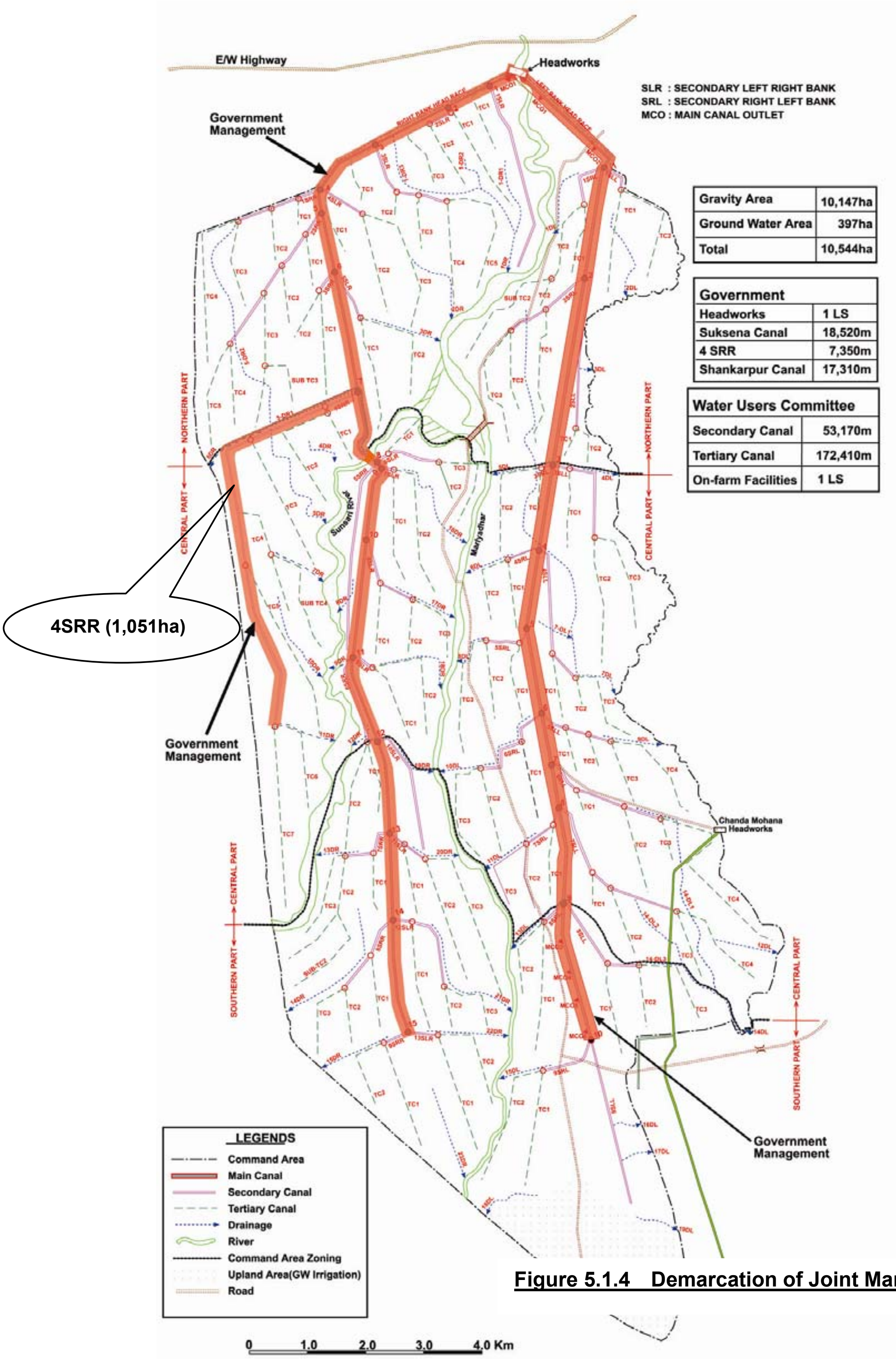


Figure 5.1.4 Demarcation of Joint Management

5.2 Water Management

Water management discussed here is how to convey the irrigation water by season, either continuous or rotation, and how to carry out the rotational irrigation whether it is by main canal and/or by a cluster of secondary canals or otherwise the combination of main canal and the cluster.

The conveyance of water during monsoon is done under continuous flow same as most of the irrigation systems over the world. However, as discussed earlier in Sub-chapter 4.1.6 "Preventive Irrigation", water during lean period is not enough to cover whole irrigable area, thereby requiring the rotational irrigation between main canals by year. Sub-chapter 4.1.6 says that rotational irrigation between Suksena and Shankarpur by year should be done in both cases of 50% and 20% water downstream releases (50% release with preventive irrigation requirement and 20% release with conventional requirement by Penman).

In any case of either preventive or conventional irrigation, rotational irrigation between the Suksena and Shankarpur by year cannot be avoided taking into account the area that can be covered by the limited water source during the lean period. Further, rotational irrigation by a cluster of secondary canals is required due to the introduction of un-gated opening type field inlet serving water courses. The un-gated inlet serves to realize automatic equal water distribution among water courses; namely, among water users groups (WUGs). However, to let the water getting into the inlet as required, always nearly about full design water level should be kept.

To keep such water level at the un-gated inlet, water volume going into each secondary canal should always be almost equal to the design discharge corresponding to each canal. This is realized by carrying out rotational irrigation among clusters of secondary canals during lean period. With some trials, this Study proposes three blocks rotation along each main canal taking into account a limit in terms of water duty not less than 70 % of the design duty (water duty is always kept more than 1.168 l/s/ha, otherwise water cannot get into the inlet).

Tables 5.2.1 shows the particulars for planning the rotational irrigation and Table 5.2.2 show the canal operation composed of rotation between main canals, rotation among clusters of secondary canals, and continuous flow (See Figure 5.2.1 for Rotation Block). The operation plan is:

From Nov. 1 to Feb. 28:
    Rotation between the main canals by year under which further rotation among 3 clusters of secondaries with 3 days each

From Mar. 21 to Apr. 30:
    1 cluster rotation among total 6 clusters of secondaries with 2 days each

From May 1 to Jun, 10 & Oct. 11 to 31:
    2 clusters rotation among 6 clusters of secondaries with 3 days each

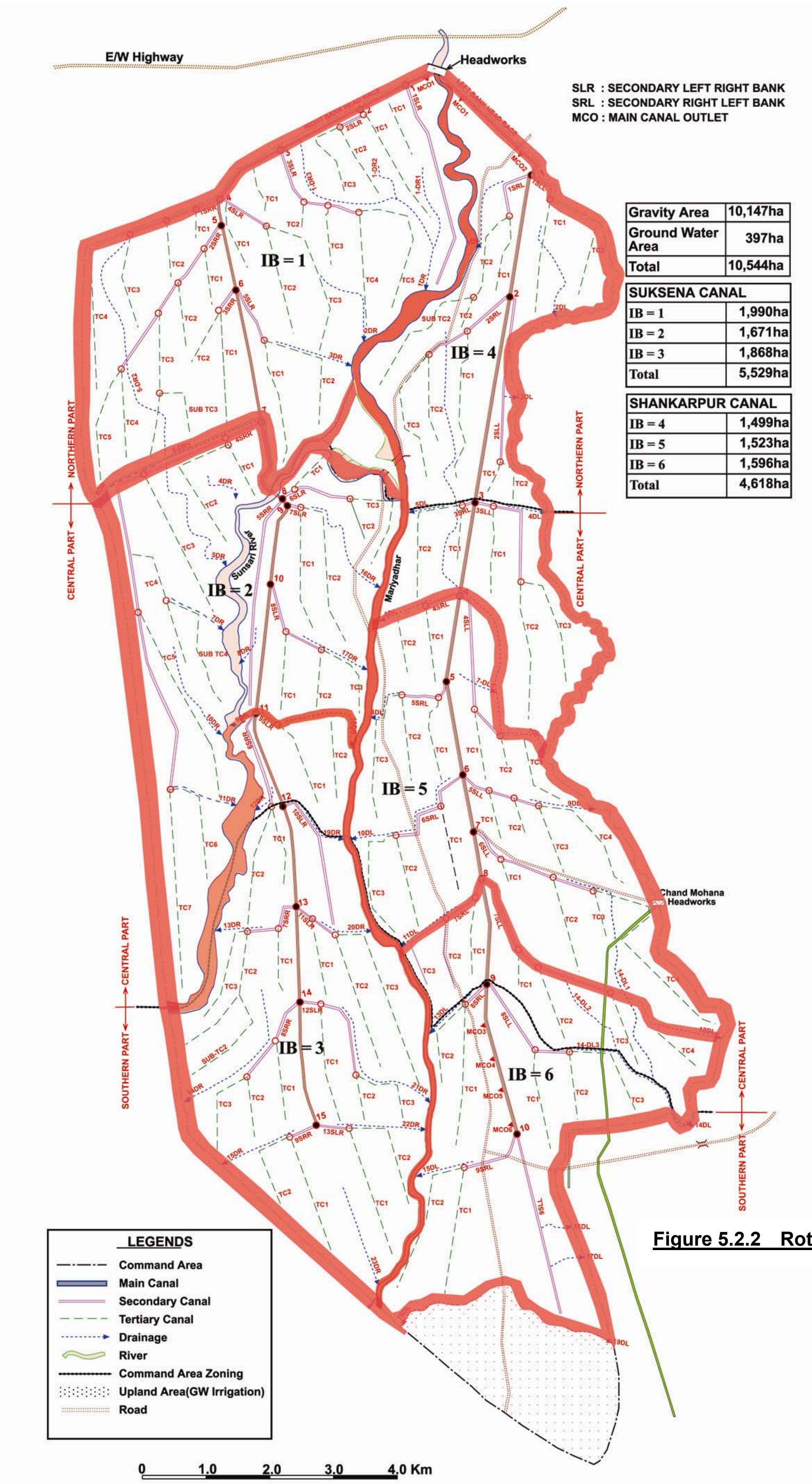
From June 11 to June 30 & October 1 to October 20:
    4 clusters rotation among 6 clusters of secondaries with 3 days each

Table 5.2.1 Paticulars for Planning Rotation Irrigation

Particulars	Area	Q Max	Duty	1.2 x Q Max	0.7 x Q max	1.2 x Duty	0.7 x Duty
	ha	cum/s	l/s/ha	cum/s	cum/s	l/s/ha	l/s/ha
Whole Command Area	10,147	16.926	1.668	20.311	11.848	2.002	1.168
Shankarpur CA	4,618	7.703		9.244	5.392		
Suksena CA	5,529	9.223		11.067	6.456		

Table 5.2.2 Rotation Irrigation Plan

Particulars	Jan.			Feb.			Mar.			Apr.			May			Jun.			Jul.			Aug.			Sep.			Oct.			Nov.			Dec.		
	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L
Required Gross WR, cum/s	5.14	5.25	5.60	6.01	5.78	5.90	4.47	3.12	2.53	2.18	1.73	1.43	1.62	1.87	1.49	1.58	6.42	8.94	10.54	13.59	15.69	15.88	16.93	14.59	16.43	13.91	13.14	11.31	9.07	5.81	3.53	3.09	2.53	3.04	3.58	4.80
Preventive G. WR, cum/s	3.09	3.15	3.36	3.61	3.47	3.54	2.68	1.87																							2.12	1.85	1.52	1.83	2.15	2.88
Shankarpur CA G. WR, cum/s	2.34	2.39	2.55	2.73	2.63	2.68	2.03	1.42	1.15	0.99	0.79	0.65	0.74	0.85	0.68	0.72	2.92	4.07	4.80	6.18	7.14	7.23	7.70	6.64	7.48	6.33	5.98	5.15	4.13	2.64	1.61	1.41	1.15	1.38	1.63	2.18
Suksena CA G. WR, cum/s	2.80	2.86	3.05	3.27	3.15	3.21	2.43	1.70	1.38	1.19	0.95	0.78	0.88	1.02	0.81	0.86	3.50	4.87	5.74	7.40	8.55	8.65	9.22	7.95	8.95	7.58	7.16	6.17	4.94	3.16	1.93	1.68	1.38	1.66	1.95	2.62
Shankarpur CA Preventive WR, cum/s	1.40	1.43	1.53	1.64	1.58	1.61	1.22	0.85																							0.96	0.84	0.69	0.83	0.98	1.31
Suksena CA Preventive WR, cum/s	1.68	1.72	1.83	1.96	1.89	1.93	1.46	1.02																							1.16	1.01	0.83	0.99	1.17	1.57
Available Water (P80 - 1.8cum/s)	2.25	2.39	2.04	2.10	2.15	2.04	1.89	1.92	2.29	2.34	2.58	3.99	4.66	6.89	8.32	11.68	19.43	19.38	30.90	28.26	33.32	24.71	28.13	22.66	20.64	25.01	17.85	13.07	10.84	5.56	3.80	3.13	2.26	2.48	2.16	2.28
Available Water (P80 - 0.7cum/s)	3.35	3.49	3.14	3.20	3.25	3.14	2.99	3.02	3.39	3.44	3.68	5.09	5.76	7.99	9.42	12.78	20.53	20.48	32.00	29.36	34.42	25.81	29.23	23.76	21.74	26.11	18.95	14.17	11.94	6.66	4.90	4.23	3.36	3.58	3.26	3.38
Whole Command Area, 10,147ha																																				
No. of Rotation Blocks	[illegible]						Canal Close for Maintenance		6				3				3		Continuous Flow									3		3	[illegible]					
No. of Irrigated Blocks simultaneous									1				1				2											2		1						
Days of each Rotation, days									2				3				3											3		3						
Headwork Discharge, cum/s									2.29				4.50				10.00		14.00		16.93					14.00		11.40	10.00	5.56						
Rotated Irrigation Module, l/s/ha									1.35				1.33				1.48		1.38		1.67					1.38		1.69	1.48	1.64						
Preventive Irrigation																																				
Shankarpur Area, 4,618ha																																				
No. of Rotation Blocks	3						Canal Close for Maintenance			Preventive Irrigation	Short Term Development																				3					
No. of Irrigated Blocks simultaneous	1																														1					
Days of each Rotation, days	3																														3					
Headwork Discharge, cum/s	1.80																														1.80					
Rotated Irrigation Module, l/s/ha	1.17																														1.17					
Suksena Area, 5,529ha																																				
No. of Rotation Blocks	3						Canal Close for Maintenance																								3					
No. of Irrigated Blocks simultaneous	1																														1					
Days of each Rotation, days	3																														3					
Headwork Discharge, cum/s	2.04																														2.20					
Rotated Irrigation Module, l/s/ha	1.11																														1.19					
Conventional Irrigation																																				
Shankarpur Area, 4,618ha																																				
No. of Rotation Blocks	3						Canal Close for Maintenance			Conventional Irrigation	Mid/Long Term Development																				3					
No. of Irrigated Blocks simultaneous	1																														1					
Days of each Rotation, days	3																														3					
Headwork Discharge, cum/s	2.80																														2.20					
Rotated Irrigation Module, l/s/ha	1.82																														1.43					
Suksena Area, 5,529ha																																				
No. of Rotation Blocks	3						Canal Close for Maintenance																								3					
No. of Irrigated Blocks simultaneous	1																														1					
Days of each Rotation, days	3																														3					
Headwork Discharge, cum/s	3.00		3.14																												2.20					3.00
Rotated Irrigation Module, l/s/ha	1.63		1.70																												1.19					1.63
	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L
	Jan.			Feb.			Mar.			Apr.			May			Jun.			Jul.			Aug.			Sep.			Oct.			Nov.			Dec.		
Area Ratio covered by each Irrigation																																				
Rotation Rule	Rotation between main canals by year						Canal Close		Whole Irrigable area to be covered																						Rotation between main Canals by year					
	Rotation among secondary canals								Rotation among secondary canals										Continuous Flow									Rotation among secondary canals			Rotation among secondary canals					



Gravity Area	10,147ha
Ground Water Area	397ha
Total	10,544ha

SUKSENA CANAL	
IB = 1	1,990ha
IB = 2	1,671ha
IB = 3	1,868ha
Total	5,529ha

SHANKARPUR CANAL	
IB = 4	1,499ha
IB = 5	1,523ha
IB = 6	1,596ha
Total	4,618ha

Figure 5.2.2 Rotation Block

5.3 Operation and Maintenance

In terms of operating and maintaining the Sunsari River Irrigation Project (SRIP), there are three options; namely, 1) stand-alone project operated and maintained by an independent project office, 2) stand-alone project but operated and maintained by Sunsari Division Office[18] (Sunsari District Irrigation Office as of October, 2002), and 3) as a part of SMIP irrigation system for which the O&M will be placed under the responsibility of SMIP office. Of them, the first option, stand-alone project with independent O&M office, may be out of consideration since DOI is now downsizing the whole administrative structure. Below is the discussion how the SRIP be operated and maintained in terms of administrative as well as staffing structure:

5.3.1 Administrative Responsibility

Chanda Mohana project, covering 1,800ha, is located within SMIP. However, the O&M is undertaken by Eastern Regional Irrigation Directorate (ERID) as the project construction was done under the responsibility of the Director of ERID. The O&M responsibility is supposed to go under the Sunsari Division Office but not under the SMIP, yet to be finalized. This may reflect a decentralization policy of DOI. An example that a division office undertakes responsibility of a large irrigation project is Kankai. Kankai irrigation project, covering about 10,000ha, once had the independent project office, but now is placed under the responsibility of Jhapa Division Office that is now merging with Ilam DOI.

In case that Chatra main canal could provide supplemental water to SRIP, the operation should have very established coordination with SMIP. In this sense, if the SRIP is placed under SMIP, the O&M may be well done. However, faced with the difficulty of receiving water from SMIP, O&M either under SMIP or as an independent system under Sunsari DO may have both merits and demerits. Table 5.3.1 shows the comparison between SRIP under Sunsari DO and SRIP under SMIP in terms of operation and maintenance.

The table shows the O&M under SMIP may have advantages in terms of engineering, staffing and office setting up. On the other hand, O&M under Sunsari DO may have advantages from the viewpoint of decentralized responsibility, WUA's cohesiveness/solidarity, and future cost recover aspect. Especially taking into account the aspect of WUA and responsibility decentralization, if SRIP WUAs are merged into the many stratified SMIP WUAs, their functionality may not come up to the expected level.

Though WUAs in SRIP basically follows the structure of the SMIP, the major responsible level for the WUAs is one stratum down from the secondary (main in case of SRIP) to sub-secondary (secondary in case of SRIP). As well, farmers overall apex like WUCCC in SMIP is not foreseen in SRIP, but planned is a coordination committee having equal authority and power among all the concerned WUCs. To pursue the one-step down decentralized functionality with less pyramidical power structure, this Study proposes the SRIP should be operated and maintained by Sunsari Division Office in coordination with SMIP.

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[18] Sunsari District Irrigation Office (DIO) is to merge with Morang DOI, and the office is to be at the present Sunsari DIO in Inaruwa according to the on-going restructuring plan.

Table 5.3.1 Comparison between under Sunsari DO and under SMIP

Particular	Sunsari Division Office	SMIP
Engineering	SRIP may need advices from SMIP to operate/maintain the headwork as well as carry out rotational irrigation.	SMIP has long been engaged in O&M of the Chatra intake as well as big canals, so that the experience would help to well manage the SRIP.
O & M Staffing	In case of smaller system, Government recurrent cost will usually increase as compared to bigger system.	As system becomes bigger, usually scale of economy works so that less number of staff engaged in O&M can be arranged, contributing to reducing the O&M cost.
O & M Office	The present Sunsari DIO is small, so that may need expansion, or otherwise headwork site operation office should be constructed enough to accommodate the additional staff.	The Inaruwa sub-divisional office can accommodate the additional staff with a little renovation.
Decentralization	SRIP is in principal hydraulically decentralized; so that administrative decentralization from SMIP can easily be set up.	SMIP is very big, covering about 68,000ha. In terms of manageability, the big system might still fall behind the expected level.
WUA	Primary responsibility is placed at secondary canal (defined as sub-secondary canal in SMIP) level covering 200 to 400 ha corresponding to Water Users Committee, smaller unit than SMIP arrangement. This would contribute to raising cohesiveness among the farmers and make easy to discharge collective task.	Primary responsibility is placed at secondary canal from the Chatra main canal, covering more than 10,000ha in cases, corresponding to WUCC. This arrangement raises difficulty for the farmers to be well consolidated and organized from the bottom to the apex of the WUCC.
Cost recovery on the government side	At present, the national treasury pays DOI staff salary. However, should the HMGN introduce full cost recovery system at each office, the division office needs incomes that come mostly from irrigation service fee (and amortization of initial investment though this is not yet practiced in Nepal[19]).	SMIP is a project office, so that ISF could be the income for the full cost recovery.

5.3.2 Staffing of Operation and Maintenance

To operate and maintain the SRIP, there should be engineers, overseers, institutional development officer, association organizer, administrative and assistant staff, etc. The staffing proposed here basically refers to the structure of the forthcoming division office but has new staff alignment that is not allocated under the present structure. New staff alignment is for: 1) institutional development officer, 2) association organizer (some project office already have), 3) agriculture engineer, and 4) strengthening of accounting section.

WUAs foreseen in SRIP will have much greater role and responsibility than before. Therefore, an officer in charge of institutional development should be aligned, under whom association organizer and field surveyor (*Amin* in local language who knows cadastrals) are posted. An agriculture engineer together with junior technician is also proposed in order to increase the agriculture production as expected, and he is to work in collaboration with

[19] In Philippines, the recurrent cost inclusive of staff salary of National Irrigation Administration (NIA), same as DOI in Nepal, comes from ISF in case of national irrigation project jointly managed by the NIA and WUA and from amortization in case of small scale irrigation project like FMIS. ISF supports the recurrent cost of the O&M project staff, and amortization supports the recurrent cost of provincial offices. Offices regardless of being project or provincial are supposed to be cost center that has to be financially variable and sustainable.

District Agriculture Development Office. Accounting section has to be strengthened from ordinary setting up because the section will have to deal with irrigation service fee billing, collection and its monitoring. Therefore an account officer, an assistant accountant and a computer operator are proposed in addition to accountant usually posted.

The proposed organizational set-up is shown below. The staff, total 15, in the shaded zone serves not only for SRIP but also for whole divisional office. The right side, rectangulared by dotted line, is the staff exclusively devoted for SRIP operation and maintenance. There are total 22 staff including 14 gate keepers, and it consists of two sub-sections; namely, institutional section devoted for WUAs and technical sections. The technical section has one engineer under whom there are four overseers composed of 2 civil, one mechanical and one electrical.

One civil overseer takes case of one of the main canals together with 7 gatekeepers (total 14 gate keepers in SRIP). Out of the total 14 gate keepers, 6 gate keepers are posted at the headwork site since there have to be 24 hours stand-by under 3-shift a day (2 gate keepers x 3 sifts a day). Along the main canal, this Study proposes minimum number of gate keepers; namely 4 each (about 5 km reach per gate keeper).

Figure 5.3.1 Proposed Organizational Structure at O&M Stage

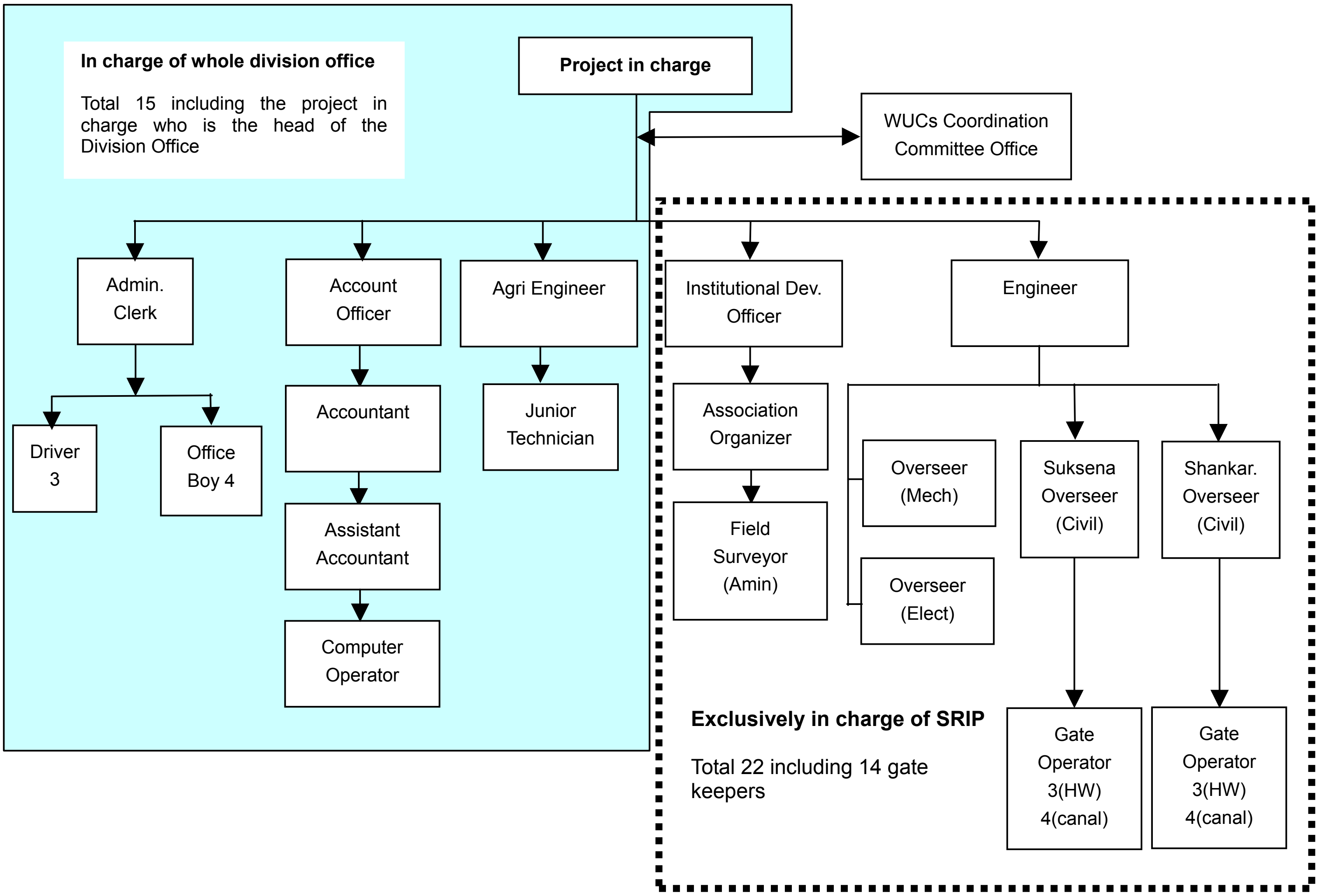

Table 5.3.2 SRIP Staffing at O&M Stage

S Nr	Description	Number	Excusively in charge of SRIP
1	Project in Charge: Senior Divisional Engineer (SDE)	1	
2	Engineer	1	O
3	Agriculture Engineer	1	
4	Institutional Development Officer	1	O
5	Account Officer	1	
6	Administrative Clerk	1	
7	Junior Technician (JT)	1	
8	Association Organizer (AO)	1	O
9	Field Surveyor	1	O
10	Overseer	4	O
11	Accountant	1	
12	Assistant Account	1	
13	Computer Operator	1	
14	Gate Operator	14	O
15	Driver	3	
16	Watchman/Officeboy	4	
Total		37	22

5.3.3 Maintenance Arrangement

Once large irrigation projects used to equip heavy equipment machines such as track, crane, loader, bulldozer, etc. for maintenance. However, most of those irrigation projects have faced difficulty to maintain the equipment due to not enough maintenance cost either from national coffer or from irrigation service fee. There are many cases that the equipment have deteriorated and became out-of-function even before the expected depreciation age. Two options can be found over the world if those equipment are well utilized; one is shared use among projects and the other is to rent out those equipment to local private civil contractors[20].

The re-structuring plan in Irrigation Sector of Nepal is to establish three mechanical divisions in such places; Jhumka of Sunsari District, Birganj and Nepalganj. The division at Jhumka will look after eastern region, and likewise Birganj looks after central & western regions and Nepalganji looks after mid & far western regions. Equipment and heavy machineries presently owned by project base will be collected to these 3 divisions and shared by concerned projects falling under their respective development region.

The plan to set up the mechanical division is following the first option mentioned above, and Jhumka is located only 10km north-eastward from Inaruwa. Therefore, the maintenance arrangement for SRIP is not to have own equipment but to ask the division at Jhumka to provide necessary equipment as need arises. The cost required to operate machines should always be born by the irrigation service fee (for detail cost recovery discussion, see the Chapter 9).

[20] The biggest irrigation system, UPRIIS, in the Philippine is now renting out heavy equipment, and the income consists of more than 30% of their total income (the rest mostly comes from ISF)