CHAPTER 2

CHALLENGES AND OPPORTUNITIES TODAY IN TERAI

CHAPTER 2 CHALLENGES AND OPPORTUNITIES TODAY IN TERAI

After three days walk of steep mountain path with 50kg load of gingers on his/her back, a concrete structure of Chatra intake comes into their sight at the pivot of Koshi River spreading toward the Terai plain. The sight gives them a relief of safe arrival in the plain and at the same time anxiety for their might-be-successful-trade with the people in the plain region. They, who are hill inhabitants, start walking again along the Chatra main canal to reach a market to sell their products. Under their feet, the canal conveys irrigation water quietly to be the source of productive agriculture in the Terai plain and wishes some return to the hills through the trade.

The Ninth Plan (1997-2002) of HMGN has adopted poverty alleviation as its main objective and the utilization of food productive capability in the Terai plain was considered to be the key of economic growth in the region. The economic growth in the Terai plain also implies a strategy of repercussion effect; namely, rising incomes in the Terai plain will generate required income to purchase high valued agriculture products of the hills and raise the economic viability of these products contributing to achieving overall economic growth and maintaining stability of the nation. Development investments in the Terai region, in this sense, imply the challenges and opportunities for overall country.

2.1 National Economy and Development Plan

Nepal has achieved the annual GDP growth rates of 5.7% and 5.9%[1] in recent two years of 1999 and 2000 against the depressed world economy. However, the GDP per capita remains 250US$ and it is said that 42% of the total population live below the poverty line. Subsistence agriculture is the mainstay of the majority of the nation and the sector remains the leading contributor to the GDP with 36% share in 2000. The Country has been, however, in deficit of cereal supply to the nation, either alternating people's diet or requiring some import through and from India. The agriculture is, therefore, cored in the Terai plain fronting the border with India.

HMGN initiated development plans in 1956, and considerable amount of development activities have been executed with the supports of external donors as 56% of the governmental development expenditure was covered by foreign grants and loans in 1990's. Year 2002 is the final year of the Ninth Plan, and the Tenth Plan has been already drafted in preparation for shortly coming official announcement with the review of the last five years development achievements.

The Ninth Plan, in accordance with a long term development plan of Agriculture Perspective Plan (APP), has set the major long-term development objectives as to create a society that is cultured, modern development-oriented and endowed with skills through alleviating the prevailing wide spread poverty. Relatively to agriculture sector, the Plan targets to expand investment in the extensive utilization of water resources and also the target was set to reduce population living below poverty line down to 10% within 20 years. The Plan upholds the APP's premise that one percent growth in agriculture sector will result in 1.5 percent growth

[1] Source: Statistical Year Book of Nepal 2001; All the data in 2.1 are quated from this book.

in non-agricultural sector, which would contribute to achieving the development target.

The Ninth Plan is quite aware of balanced development of the nation. As described above, the Chatra intake as a point of contact and transaction between hill and Terai products embodies the strategy of HMGN, stating that increasing economic growth in the Terai region through the optimum utilization of food-grain production potential will generate the demand for high valued agricultural commodities produced in the hills resulting, in turn, in the increased economic potential of such commodities. It is expected that the effective implementation of this strategy will bring about a balance in the development of both the hills and Terai and will have a positive impact on curbing the present tendency of rapid migration from the hills to the plain.

2.2 Regional Economy of Terai

APP sees the potential of Terai outside Nepal wherein the people enjoyed the effects of green revolution. APP picked up an example of Punjab, in which the green revolution has brought prosperity to millions of farmers who twenty years ago had lived little different from those in Nepal. As compared to the achievement from 1950's to late 1980's in Punjab, which brought doubling irrigated area, cut of rural population in poverty by half, and 27 times of per capita consumption of electricity, the APP evaluates the growth of the Terai region in Nepal in these aspects is conservative, though the region in Nepal has similar potential.

The country of Nepal is geographically demarcated with five categories, which are High Himalayas, High Mountain region, Middle Mountain region, Siwarik region and Terai plain region. Terai plain is of the most residential area in the country. The total population in Nepal in 2001 is estimated at 23.2 million[2], out of which 9.8 million people (42% of the total population) reside in the districts which major lands are located in the Terai plain despite the fact that the total area of the districts is 26,700km^2, 18% of the total Nepal area of 147,200km^2. Accordingly the population density of 366 people per km^2 is the highest among the five regions, reaching 2.3 times of the national rate of 158 people per sq. km. Figure 2.2.1 shows the shares of area and population by the defined regions.

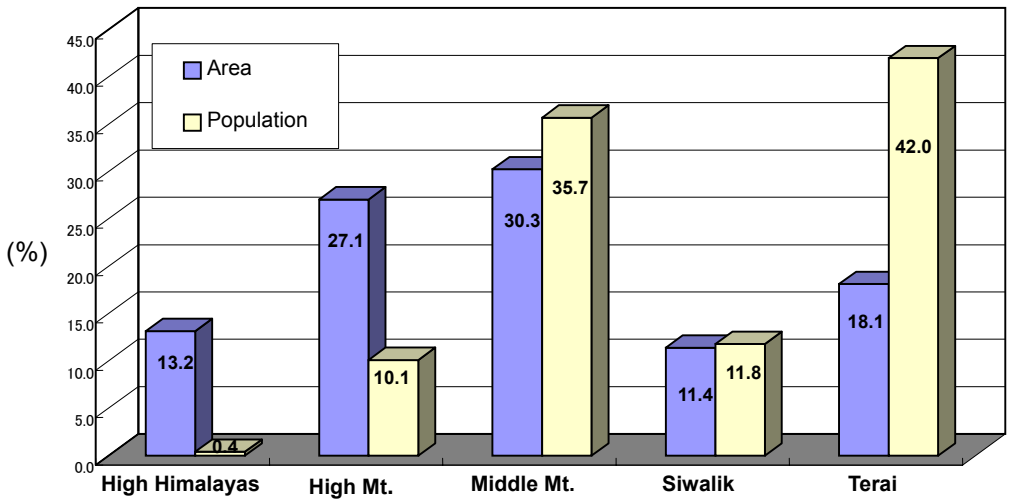


Figure 2.2.1 Share of Area and Population by Region

[2] Source: Results of Population Census 2001

Population Growth is also rapid in the Terai plain due to the migration from hills and mountains as one of the reasons. The average annual growth rate from 1991 to 2001 in Nepal is 2.3%[3], while the rate in Terai counts at 2.7%. The average annual growth rate in the High Himalayas, High Mountain and Middle Mountain during the same period are 1.8%, 1.6% and 2.0% respectively, fairly proving the climbing down of the people in the mountains to the Terai plain.

The Terai plain, as its nature, has been developed as agriculture sector pulling force. Having been described as an eligible granary of the country, the Terai plain has a role of supplying staple food to the nation, especially to those mountain regions. Cereal production in the Terai plain is so significant that 65%[4] and 54% of paddy and wheat, the staple grains of the nation, in 1998/99 respectively were produced. The cereal production is enough to feed the population in the plain and the surplus is transferred to other regions by either export or the mountain inhabitants coming down to the plain to exchange their high valued hilly products with the rice and wheat.

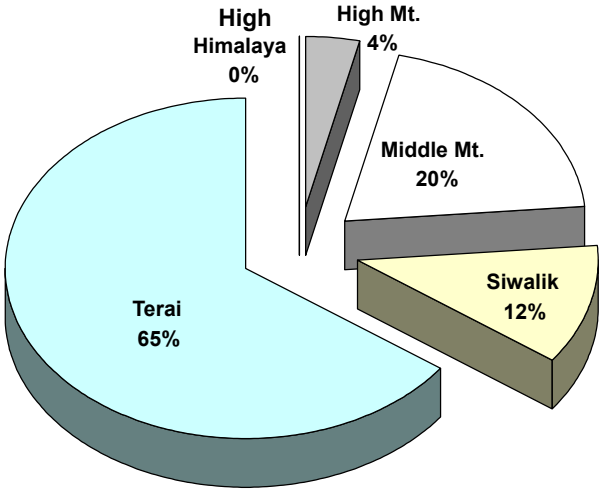


Figure 2.2.2 Share of Paddy Production by Region (1997/98)

However, as it has been mentioned, total food balance of the country has been in deficit. Cereal supply and demand balance in 1997/98 is estimated at a deficit of 123,600 metric ton in total and by region only Siwalik and Terai were estimated at surpluses of 34,000 metric ton (13.3kg per capita) and 167,000 metric ton (18.6kg per capita) respectively. As the Figure 2.2.3 shows, deficit per capita in High Himalayas, High Mountains and Middle Mountains are estimated at 109.7kg, 46.9kg and 26.5kg respectively. Irrigation development as of 1999/2000 has covered 1.1 million ha, about 63%[5] of the total irrigable area of 1.77 million ha in the country, and, 0.9 million ha in the Terai plain (66% of the irrigable area in Terai) has been actually irrigated leaving still potential of higher target of

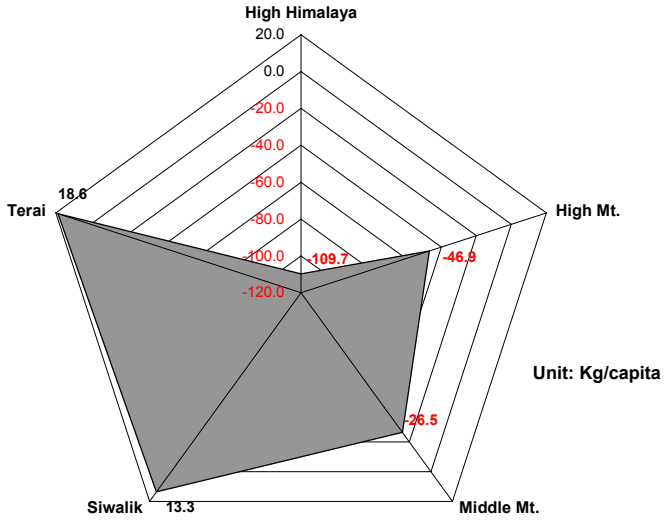


Figure 2.2.3 Cereal Balance per Capita by Region (1997/98 estimate)

[3] Population growth rates are derived from the Population Census data of 1991 and 2001.
[4] Source: District Development Profile of Nepal 2001 (Informal Sector Research & Study Center)
[5] Source: Water Resources Strategy Nepal, HMGN Oct. 2001

agricultural productivity.

Population pressure has given the necessity of public investment in the Terai plain as well as in line with the government development strategy. The budget allocated for development program in 1997/98, however, reveals that the development program budget per capita in Terai is the lowest among the five regions as it is calculated at 627Rs/capita[6], though the gross amount occupies 31% of the total budget of 19.7billion Rs. It is, therefore, envisaged that, with the potential and the priority given to agriculture including water resource development for irrigation, the needs of investment in the Terai plain is still in line with the balanced development.

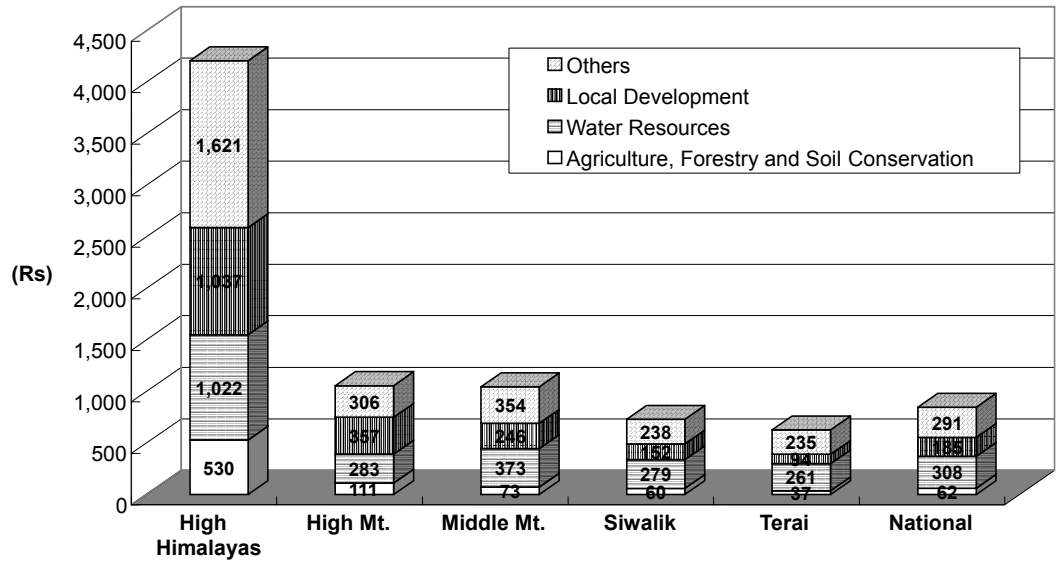


Figure 2.2.4 Development Program Budget per Capita by Region (1997/98)

2.3 Positioning of Sunsari District

Sunsari District is located in the eastern Terai plain with an area of 1,257 sq. km and the population of 625,600, occupying 4.7% and 6.4% of the Terai plain respectively. The population density reaches 498 people per sq. km and the average annual population growth rate from 1991 to 2001 is 3.0% ranked at 6th highest out of all the 75 districts in the country or 4th highest out of 16 districts whose major lands belong to the Terai plain.

Major mother tongue of the people in the eastern Terai is Maithali, the second biggest population in Nepal following to Nepali. In Sunsari District, the population whose mother tongue is Maithali and Nepali occupy 30% each according to 1991 population Census. Also Tharu, an ethnic group ever lived in the Terai plain, is significant as 16% of the population in Sunsari district belong to the group against only 5% in proportion to the total Nepal. Another aspect is religion. In Sunsari district, the population who follows Islam is relatively higher as it occupies 10% of the district population, while the nation-wide Islam population consists of only 3%.

[6] Data is derived from District Development Profile of Nepal 2001.

The eastern Terai region consists of five districts, namely Jhapa, Morang, Sunsari, Saptari, and Siraha located from east to west. It is roughly estimated that the Gross Regional Domestic Product (GRDP)[7] of agriculture, livestock and industry in Sunari District in 1998/99 is 3.8 billion Rs, of which 3.1 billion Rs or 80% is born to agriculture and livestock. Of the share of agriculture and livestock compared to industry in the other eastern districts are 96% in Jhapa, 74% in Morang, 99% in Saptari and 96% in Siraha. The share of agriculture and livestock to GRDP is relatively low in Morang and Sunsari district. This is because there is an industrial zone along the Biratnagar – Dharan road running southern border of India to the north hills comprising of about one hundred industrial factories. The industrial zone is located along the border of Sunsari and Moran Districts (Figure 2.3.1).

GRDP per capita in Sunsari District is 6,120Rs, of which agriculture and livestock occupies 4,900 Rs. GRDP of agriculture and livestock per capita in Sunsari District is the second lowest[8] among five districts of the eastern Terai region (Figure 2.3.2). It would indicate that there would still be some potential for agricultural development in Sunsari Distirct regarding the level of the vicinity districts.

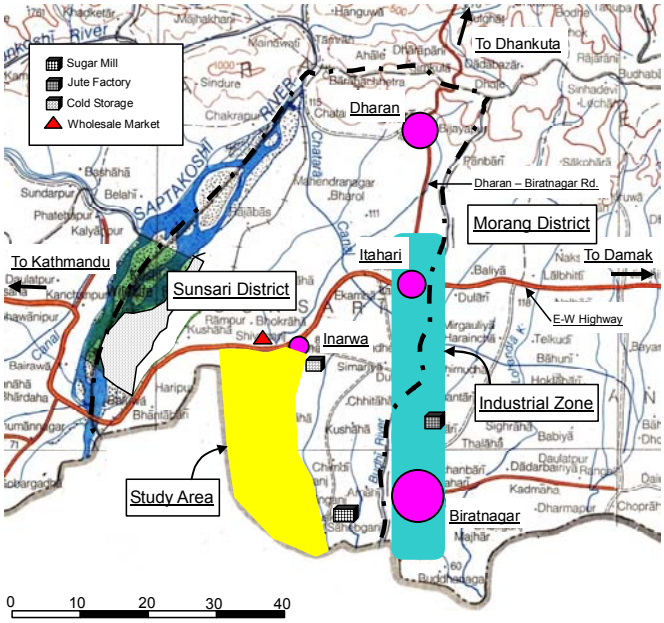


Figure 2.3.1 Regional Map of Sunsari District

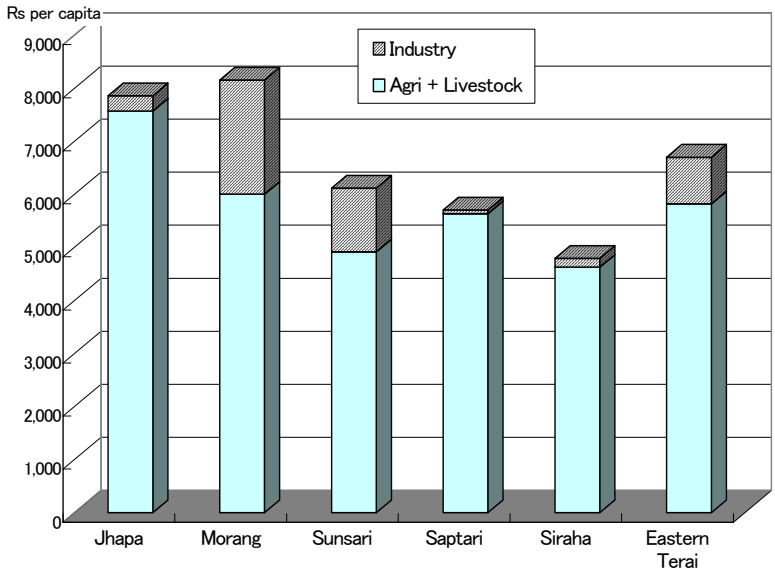


Figure 2.3.2 GRDP per Capita

[7] Due to lack of data, other sectors like service industry were not estimated.

[8] Though population density of Sunsari (498 people/km2) is the highest among five districts, it is not far from the average population density of the five districts (454 people/km2) and considering the population working for industry, the estimation of agriculture production per capita would nor be affected by the scale of population.

Major agricultural production in the district is paddy, wheat, jute, sugarcane and pulses. The production of these crops is ranked among 75 districts as rice in fifth, wheat in twelfth, jute in second, sugarcane in ninth and grass pea in second. Food balance is also surplus with 14,500 metric ton in 1997/98, giving the district a role of supplying food grain to the deficit areas of the country. Paddy production per capita in 1997/98 is estimated at 254kg/capita. This is over the required amount of cereals for per person and the per-capita production is ranked at 10th out of 75 districts.


Paddy Harvesting in the Study Area

To date, several development programs have been carried out with assistance from donors. Those are Local Governance Program (LGP) funded by UNDP for capacity building of District Development Committee (DDC) and implementing Village Development Program, Decentralized Planning for Child Program (DPCP) by UNICEF, Sunsari-Morang Program by PLAN International, an international NGO, for health, education, income generation etc., fostering vulnerable families, Nepal Participatory Learning and Advisory Project (NPLAP) funded by DFID for capacity building of local NGOs, Park and People for mitigating those who had adverse impact from establishment of the Koshi Tappu natural reserve, etc.

2.4 Positioning of the Study Area

The Study area is located southern most part of Sunsari district bounded by India to the south and west. Total area of the Study area covers 16,800 ha, occupying about 13% of the district and agricultural area is estimated at about 125,700 ha, 74% of the total Study area. Total population of the Study area according to year 2001 Census is 97,700, which is about 16% of the whole population in Sunsari district. The population density counts at 581 people per sq. km, higher than that of Sunsari district, which is 498.

The average annual population growth rate from 1991 to 2001 is 2.5%, slower growth than the whole district of 3.0%. Although the population growth of Sunsari district is relatively rapid due to migration from hilly areas as one of the factors, it seems that the migration movement has not reached influentially to the Study area due to the location furthest from the hillside. Instead, the migrant workers have got its movement to India as well as Arabic countries. According to interviews to farmers in the Study area, some 10% of the villagers in a VDC are now in India and Arabic countries to work.

Generally people residing near the border have based their living cross the border. However, due to recent insurgency of Maoist, Indian security force has been bolstering for security and preventing even their daily trade. Although India near the national border is traditionally in the economic block of Nepalese, the national border could be an iron curtain to shut all the transactions down. Therefore, the development concept should be formulated primarily on self-sufficiency in Nepalese side as much as possible.

Given the position of Sunsari district above, the Study area can also be considered to be a piece of the granary of the Terai plain. However, a sample household survey in the Study area conducted by Local Governance Program funded by UNDP in 1998 reports that 53% of farm households of the 13 VDCs in the Study area answered that they can only support their food consumption from their land for not more than three months.

The Study area, while located in the fertile granary of the Terai plain, is placed in a spot of food shortage due mainly to the shortfall of irrigation water, although the Koshi river water was supposed to wet the Study area through the two branch canals of SMIP, Shankarpur and Suksena. It is, therefore, envisaged that the development in the Study area, as a spot left behind the natural blessing of Terai, should be based on the self-sufficiency of food as the primary target in harmony with the issue of border above.

If we go up along the Suksena canal toward the intake of Chatra main canal, the cropping pattern in winter season drastically changes from the lands occupied almost all with wheat and mustard in mixed cropping in the Study area to the lands which such vegetables as tomato, potato, green pea, radish, and cauliflower are grown more than wheat.


Cauliflower at Upper Reach of Suksena Canal

The reason for much vegetable cultivation in the upper stream reaches could be attributable to high yield of paddy including the spring paddy production thanks to enough irrigation water. The paddy yield in the upper stream reaches allows farmers to challenge to grow risky but profitable vegetables during winter. As for the Study area, paddy yield is not so high due to insufficient irrigation water that the farmers may have to grow wheat to be self-cereal sufficient. The present agricultural practice in the upper reaches of SMIP could be an outlook of the Study area when irrigation water becomes available.

The Study area is dominated with sandy solids especially at its southern part. This is one of the major causes of the shortfall of irrigation water, but it implies high potential for vegetable cultivation. Actually farmers in the downstream reaches like Dewanganji and Kaptanganji VDCs are advancing in vegetable crop such as potato. With improvement of infrastructure such as roads for marketing as well as irrigation and the adequate agricultural extension services incorporated, the area could enjoy their given natural potential leading to raising their living standard and eventually the linkage with other regions of the country will be well built with strengthened people's purchasing capacity of the high-valued hill products.

CHAPTER 3

CHALLENGES IN NEPAL'S IRRIGATION DEVELOPMENT TODAY

CHAPTER 3 CHALLENGES IN NEPAL'S IRRIGATION DEVELOPMENT TODAY

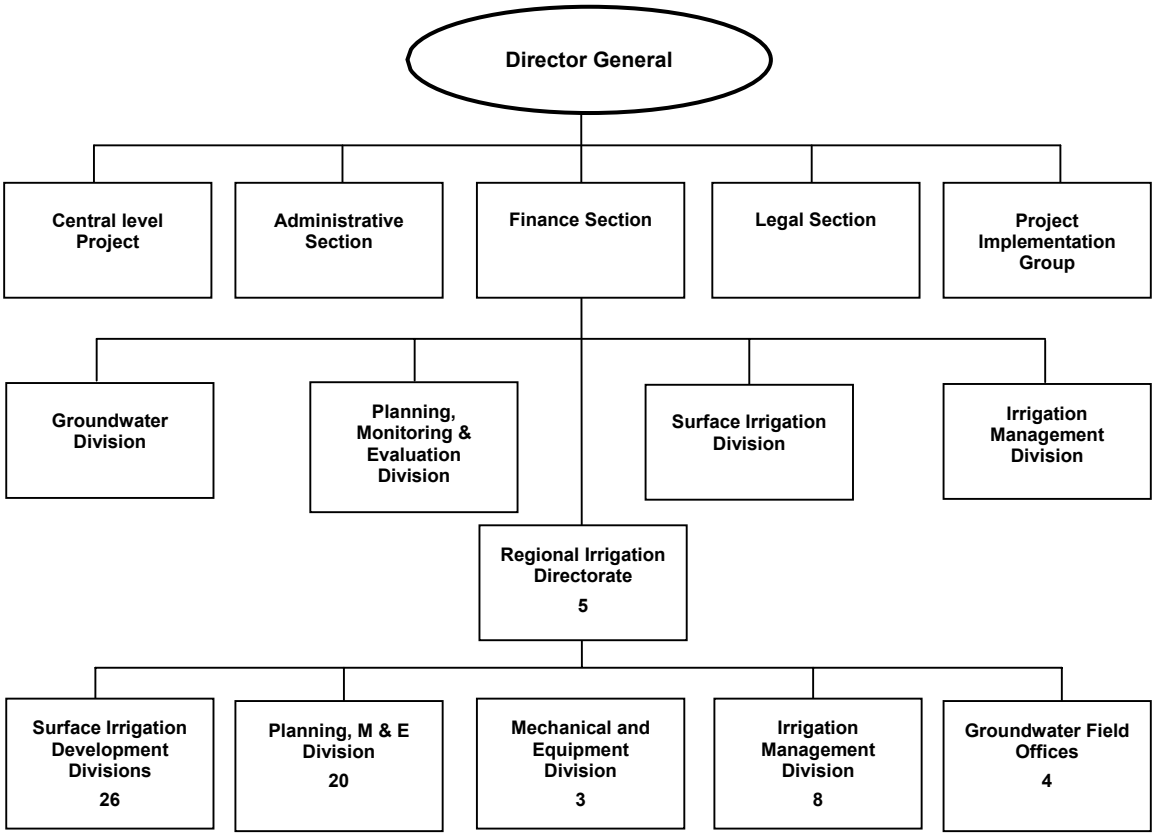
3.1 Authority in Irrigation Development

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.

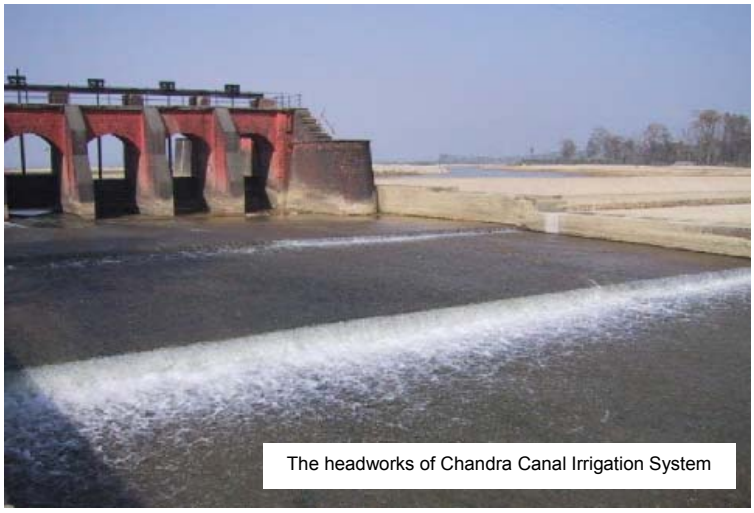
Then, five Regional Irrigation Development Directorates were established during the Fourth National Development Plan period (1975-80), and District Irrigation Offices in all the seventy-five districts were also opened around 1987 to 1988. As of October 2002, a restructuring plan is being carried out, 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 3.1.1 The New Organizational Structure of DOI



3.2 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.

3.3 Irrigation related Act, Regulation, and Policy in Nepal

3.3.1 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.

3.3.2 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.

3.3.3 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 3.3.1 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)

3.4 Relevant Projects and Programs

3.4.1 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.

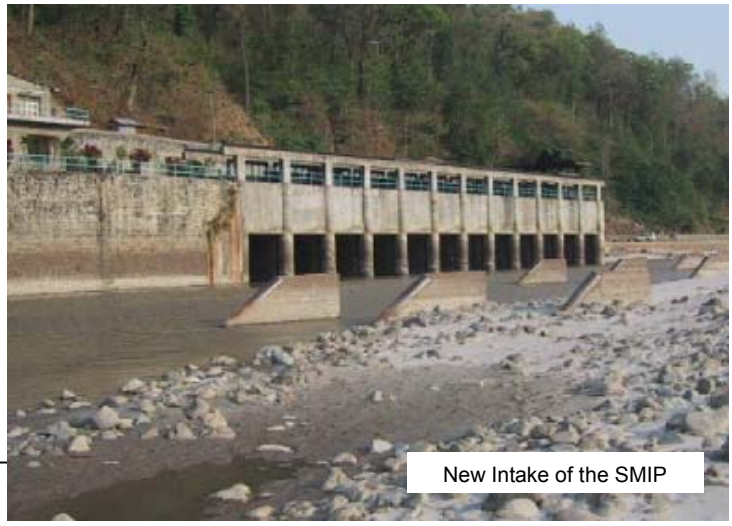
In pursuing the development with the assistance from the World Bank, the SMIP area was divided into 3 stages, apart from the construction of a new intake at Koshi river, and the Stage 3 was further divided into 3 phases. The development is still on-going and as of October 2002 the Phase 1 of Stage 3 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 3.4.1 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.

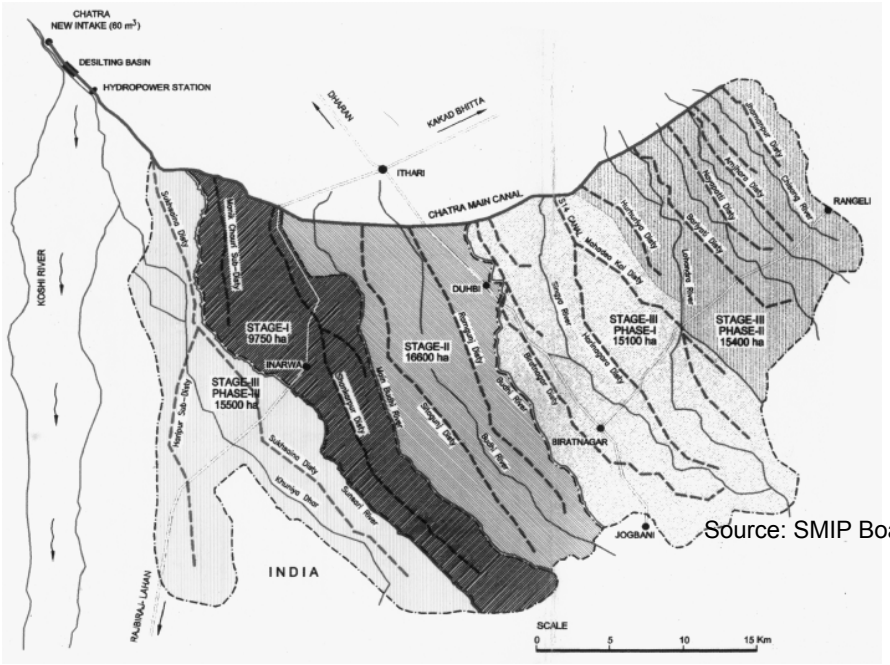


Figure 3.4.1 Stage-wise Development of Sunsari Morang Irrigation Project

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.

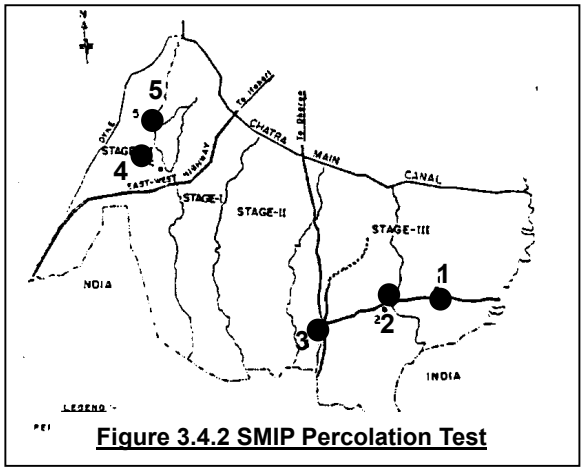


Figure 3.4.2 SMIP Percolation Test

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.

3.4.2 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
Local - HMGN:	0.264 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.

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.

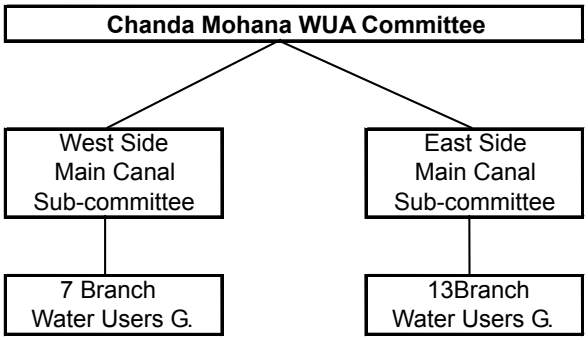


Figure 3.4.3 WUA in Chanda Mohana IP

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.

3.4.3 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).

3.4.4 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

3.4.5 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.

3.4.6 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.

3.5 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 4

THE STUDY AREA

CHAPTER 4 THE STUDY AREA

4.1 Demography

4.1.1 Administrative Jurisdiction

Local administrative jurisdiction in Nepal is categorized hierarchically from District Development Committee (DDC), Municipality and Village Development Committee (VDC), and then Ward (each VDC is divided by 9 Wards). Ward is the smallest administrative recognition. A Ward consists of a few settlements (several groups of households called "tole" in local language). Border of Ward sometimes separates a settlement to different Wards since the Ward is demarcated in a grid pattern. DDC, VDC and Ward are led by elected committee as well as their chairmen. Sunsari District consists of three Municipalities and 49 VDCs, out of which 13 VDCs falls in the Study area.

4.1.2 Population

Total population of the Study area according to year 2001 Census is 97,700 consisting of 50,400 and 47,300 of male and female respectively. The proportion of male and female is thus calculated at 1.00 : 0.94. Total number of households is 16,200 and the average family member per household is calculated at 6.0 per household. The population is living in an area of 16,800 ha, which is the Study area, giving a population density of 581 persons/km^2.

The annual growth rate from 1991 to 2001 is 2.5%, slower growth to the total district of 3.0%. Although the population growth of Sunsari district is relatively rapid due to migration from hill area, as one of the factors, it seems that the migration movement has not reached influentially to the Study area located southern most part of the district. Indian migration to Nepal has not taken place for the recent years.

In the vicinity of the Study area, there are two significant cities, which are Inarwa, the nearest Municipality to the Study area and Biratnagar, the second biggest city in Nepal. Total populations of Inarwa and Biratnagar in 2001 are 23,200 and 161,000 respectively. These cities are the major link of the economy with the Study area. Table 4.1.1 shows the area and population of the Study area by VDC.

Table 4.1.1 Demography of the Study Area by VDC

VDC/Municipality	Area (ha)		2001 Results of Census					Population	Annual Growth Rate
	Gross	Taxable	No. of HH	Male	Female	Total	Ave. HH	Density (p/km2)	1991-2001 (%)
Sahebganj	1,346.3	1,242.6	643	1,763	1,663	3,426	5.3	254	-2.9
Kaptanganj	1,469.0	1,362.4	1,327	4,253	3,893	8,146	6.1	555	3.0
Dewanganj	373.9	333.9	1,111	3,376	3,122	6,498	5.8	1,738	4.0
Ghuski	1,450.5	1,299.3	1,476	4,845	4,735	9,580	6.5	660	1.9
Rajganj Sinuwari	1,969.1	1,852.7	1,439	4,329	3,922	8,251	5.7	419	2.0
Madhya Harsahi	627.5	589.0	827	2,583	2,318	4,901	5.9	781	2.1
Basantapur	983.0	793.8	753	2,413	2,289	4,702	6.2	478	-1.7
Harinagara	1,089.9	988.8	1,148	3,641	3,397	7,038	6.1	646	1.9
Ramnagar Bhutaha	1,317.0	877.0	1,698	5,684	5,403	11,087	6.5	842	3.3
Jalpapur	599.9	543.2	1,084	2,927	2,754	5,681	5.2	947	2.9
Narsinmha	3,548.9	767.2	2,769	8,943	8,422	17,365	6.3	489	5.2
Gautampur	817.6	768.3	698	1,955	1,828	3,783	5.4	463	1.7
Babiya	1,226.2	1,112.2	1,218	3,716	3,503	7,219	5.9	589	2.7
Total	16,818.8	12,530.4	16,191	50,428	47,249	**97,677**	6.0	581	2.5
Inarwa Municipality	1,392.9	1,274.8	4,497	11,844	11,356	23,200	5.2	1,666	2.3
Biratnagar	5,990.4		33,678	87,664	79,010	161,036	4.8	2,688	2.2
Sunsari District	125,700.0		120,295	315,530	310,103	625,633	5.2	498	3.0

Source: District Development Profile of Nepal (Informal Sector Research & Study Center)
Inarwa Census Office, Result of 2001 Census

4.2 People's Livelihood

Most of the people in the Study area are engaged in agriculture. Those who earn from agriculture is categorized to land owner, tenant and farm laborer. Women are mostly engaged in agricultural labor. Livestock rearing is also a considerable income source. Fishery in rivers and fishponds is a common occupation, especially for those who are landless and who have only meager lands of several khatas (one khata equivalent to 0.03 ha), .

Other common industries are small retailer, cart driver, masonry, carpenter, blacksmith, sewing, and trading etc. Nearby sugar cane factory has employment capacity of 500 people and there are 101 industrial plants and factories along Binatragar – Dharan road[1]. Also, getting momentum is temporary migration work to India or Arabic countries as well as major cities inside Nepal. According to interviews to the farmers in the Study area, some 10% of the villagers in a VDC go to India or Arabic countries to work. Migrant work in India normally takes place 5 to 6 months from March[2].

4.2.1 Land Use and Agriculture

1) Land Use

The present land use in the Sunsari district is classified into agricultural land, forest and other land, which includes urban area, road and river etc. Out of the total land area (127,077 ha), agricultural land constitutes 64.5 % equivalent to 81,944 ha, while pasture, forest and other land occupy 5.0 % (6,471 ha), 18.3 % (23,204 ha) and 12.2 % (15,458 ha) respectively based on the 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 lands are estimated at 39,000 ha (72.2%) and 15,000 ha (27.8%) respectively.

Total cultivable area in the Study area is measured at 10,544 ha on a map. Out of the total agricultural land in the Study area, currently irrigated land occupies only 17 %[3] as shown in Table 4.2.1, according to the Rural Socio-economic Survey conducted by the Study Team in July 2002 (Hereafter referred as "Rural Socio-economic Survey"). In the southern part of the Study 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 does not mean that there is no water source for irrigation except rainfall. STW irrigation has widely been applied 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 part of the Study area.

The Study area was originally included in the command area of SMIP covered by both

[1] Inventory Survey by the Study Team in 2002

[2] According to the field interviews, people who go to work abroad are not necessary the poorest but rather aiming at some surplus income to improve their living standard.

[3] The area irrigated includes the command area of Chanda Mohana Irrigation Project, which is located in Sahebganj, the most southern part of the Study area.

Suksena and Shankarpur Canals. However, these canals can only provide irrigation water to limited farmlands along the canals upstream due to incomplete watercourse network as well as insufficient water supply from Chatra Main Canal (CMC).

Table 4.2.1 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 upland area whose elevation ranges from 66 m to 68 m. The area is estimated at 397 ha and it is impossible for this area to receive water by gravity from Sunsari irrigation system. There is also serious problem about inundation in the southern part, causing damage to the monsoon crops, particularly paddy. The affected area estimated at 880 ha expands over Kaptanganj and Ghuski. Flood often occurs at the area along the Sunsari River during monsoon season, but the extent of the damage is not serious. Whereas, once inundation occurs in the said area of Kaptanganj and Ghuski, it takes 30 to 50 days until the water in the farmland disappears.

2) Cropping Pattern and 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.

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 4.2.2. Paddy and wheat are dominant in the Study area, as the cropping intensities of paddy and wheat are 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 in the Study area, 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 from sharp fluctuations in price as compared with vegetables. The overall cropping intensity of the Study area is estimated at 164 %.

Table 4.2.2 Cropping Intensity and Area Planted

Season	Crops	Cropping Intensity (%)	Area Planted (ha)
Spring/Monsoon	Paddy	68.1%	7,180
	Jute	19.3%	2,035
	Vegetable	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-economibc 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 cultivate 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 because of necessity for self-consumption. Also, 85% of the sample households answered that they would cultivate paddy even if irrigation water was insufficient.

3) Production and Yield

Table 4.2.3 shows production and yield of each crop in the Study area. Total production of cereals is estimated at 28,850 MT (paddy; 16,514 MT, wheat; 12,336 MT). This does not meet the cereal requirement for the population in the Study area estimated at still 7,000 MT deficits at present. Marginal farmers who own only several katha of farmland cannot survive on their farmland (also referred in 4.2.2-3) Food Security). A farmer interviewee of RRA survey told that he harvests paddy to support his family only for five months from his 7-katha of farmland. Production of cereals is not stable due to lack of irrigation water as well as calamity, so that the food security in the Study Area has been threatened.

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

Table 4.2.3 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

Paddy Planting: Dominant Monsoon Crop

Wheat: Dominant Winter Crop

4) Farm Inputs

4.1) Seed

Usage of improved seeds has been prevailing among cereal growers in the Study area. Recently, improved varieties of paddy and wheat have been used in almost 100 % of the planted areas and some local varieties of paddy, such as Basmati, are just used for local festival. Most commercial vegetable growers usually prefer F_1 variety. As for oilseeds and pulses, conversion to improved varieties is behind the status of cereal seeds.

Farmers tend to apply much more amount of seeds than the recommendable ones. For example, 74 kg of paddy seed 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 pulses except mungbean, it is rare for the farmers to purchase the seeds from commercial suppliers. Repeated self-produce has resulted in a fall of yield and/or damage by pest & disease due to decrease of genetic ability. On the other hand, it is common to procure seeds of cash crops such as potato, vegetables, jute and sugarcane. Generally farmers prefer purchasing seeds at Indian market to Agricultural Inputs Cooperation (AIC) or local suppliers.

4.2) Fertilizers and Chemicals

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 can 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 for chemical fertilizers. However, the amount of the 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 fertilizers nor chemicals for pulse and oilseed production. On the other hand, there is a tendency to apply excessive amount of fertilizer among commercial vegetable growers. They do not usually have appropriate knowledge on spraying chemicals, either. 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.

4.3) Labor and Draft Animal Use

Mechanization for farming is not progressed in the Study area. About land preparation, most farmers depend on draft cattle. Planting, weeding and harvesting including threshing are usually carried out manually. Pump and thresher are utilized on rental basis for the majority of farmers. Labor force and draft power requirement for farming at present condition are shown in Table 4.2.4.

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

Table 4.2.4 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)"

4.2.2 Farm Economy

1) Land Holding

According to the Sample Census of Agriculture in 1991/92, majority of the farm households in Sunsari district owns less than 0.5 ha counting 31% of the total sample households and 86% of the households have no more than 3 ha. Owners who hold more than 10 ha occupy only 1%. Average size of land holding per owner in Sunsari district is estimated at 1.5 ha. Plots of land are fragmented as the average pieces of plots per owner in Sunsari district is counted at 2.5 pieces.

Turning to the Study area, the result of 2001 population census reveals that the number of household having no farmland reaches to 38% of the total households in the Study area (Table 4.2.5). Also a baseline survey, which covered all the households of Kaptanganj VDC carried out in 2001 by LGP, supports the reliability of the census, giving the data about 40% of the households are landless engaged either in sharecropping or farm labor or other jobs and average land holding size of landowners in Kaptanganj is estimated at 1.4 ha (Refer to Table 4.2.6). Considering the total area (taxable area), total households and adopting share of 38% for landless, average land holding size per landowner in the Study area is estimated at 1.24ha, (or 0.77ha per household including landless).

Table 4.2.5 Number of Household having Agricultural Land, Livestock and Poultry in 2001

VDC/Mun	Total HH.	Agri.Land only	Livestock only	Poultry only	Land and Livestock	Land and Poultry	Livestock and poultry	Land, livestock, poultry	None of all	Without Agri. Land	
										No.	share
Babiya	1,218	84	138	3	443	1	31	145	373	545	45%
Basantapur	753	74	56	4	406	10	17	87	99	176	23%
Dewanganj	1,111	151	85	9	406	11	41	117	291	426	38%
Ghuski	1,476	201	94	25	198	34	75	377	472	666	45%
Gautampur	698	79	84	2	317	1	15	53	147	248	36%
Harinagara	1,148	84	225	13	436	4	38	88	260	536	47%
Jalpapur	1,084	121	29	3	55	8	82	309	477	591	55%
Kaptanganj	1,327	160	148	35	570	22	53	79	260	496	37%
Madhya Harsahi	827	71	99	1	513	3	6	66	68	174	21%
Narsinmha	2,769	259	289	19	1263	15	103	264	557	968	35%
Rajganj Sinuwari	1,439	89	156	7	788	5	59	130	205	427	30%
Ramnagar Bhutaha	1,698	275	101	13	317	33	80	478	401	595	35%
Sahebganj	643	52	70	3	309	7	10	38	154	237	37%
Total	16,191	1,700	1,574	137	6,021	154	610	2,231	3,764	6,085	38%

Source: Population Census 2001

The land holding size ranges from less than 0.5 ha to 18 to 20ha in the Study area, but the majority of the owners are small-scale farmers. The baseline survey in Kaptanganj VDC

shows that 63% of the households are either landless (42%) or own less than 0.5 ha (21%) and 86% of households fall in the category of less than 2 ha. Households who own more than 5 ha only occupy 3% of the total households in Kaptanganj VDC. According to a series of field interviews with farmers, the situation in other VDC would be more or less the same.

2) Land Tenure

Land tenure is prevailing in the Study area. According to the sample Census of Agriculture in 1991/92, 29% of the households in Sunsari district are engaged in renting lands. Also the baseline survey in Kaptanagnj VDC shows that 14% landless households are tenants, probably implying majority of the landless are engaged in just farm laborers. Average renting area per tenant in Kaptanganj VDC is counted at 0.9 ha per household. The scale of farming becomes larger than the landowners who only cultivate their small piece of lands.

Beside the landless households, farmers who have own lands are also renting land for their farming. According to the baseline survey in Kaptanganj VDC, landowners who also rent land are 18% of the total households. Landowners, specially having small piece of land, tend to go for renting land. 73% of the owners who also rent lands have less than 1 ha of their own land in Kaptanganj VDC. By renting land, the average farming land per household becomes 1.6 ha against the average land holding area of 1.4 ha. Table 4.2.6 shows the land holding structure in Kaptanganj VDC.

Table 4.2.6 Land Holdings and Tenure in Kaptanganj VDC (2001)

Land Holding	Household			Average Farm Land (in ha)							Own + Rent		Food
				Own Land				Tenant	Total	Average			
	family member	No.	%	Self Cultivation	Lease	Total	Average	(Share)	Farming Land	Farming Land	No.	%	Availability (*)
Without Land													
Farm laborer and others	5.1	463	35.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
Sharecropping	6.2	74	5.7	0.00	0.00	0.00	0.00	69.38	69.38	0.94	0	0.0	1.3
With land													
under 0.5 ha	6.2	278	21.5	53.84	1.80	55.63	0.20	77.10	132.73	0.48	91	32.7	1.1
0.5 ha - 1.0 ha	6.1	149	11.5	94.37	2.45	96.83	0.65	48.20	145.03	0.97	60	40.3	2.1
1.0 ha - 2.0 ha	6.3	154	11.9	198.78	10.07	208.85	1.36	34.69	243.54	1.58	41	26.6	2.8
2.0 ha - 3.0 ha	6.6	69	5.3	161.73	1.97	163.70	2.37	12.57	176.27	2.55	14	20.3	3.5
3.0 ha - 4.0ha	7.6	44	3.4	135.58	7.60	143.18	3.25	17.47	160.65	3.65	11	25.0	3.7
4.0 ha - 5.0 ha	6.3	23	1.8	99.02	2.83	101.85	4.43	5.00	106.85	4.65	6	26.1	3.7
5.0 ha - 10.0 ha	8.1	34	2.6	185.94	31.66	217.60	6.40	4.00	221.60	6.52	3	8.8	3.9
10.0 ha and over	9.3	4	0.3	40.00	9.67	49.67	12.42	0.00	49.67	12.42	0	0.0	4.0
Total(Average) with land	6.4	755	58.4	969.26	68.05	1,037.31	1.37	199.02	1,236.33	1.64	226	29.9	2.2
Grand Total(Average)	5.9	1,292	100.0	969.26	68.05	1,037.31	0.80	268.41	1,305.71	1.01	226	17.5	1.4

Food Availability =
(*) see 3) Food Security

1= - 3months
2= 3-6months
3= 6-9months
4= 9-12months

Source: LGP (DPCP) Baseline Survey 2001

Major tenant system in the Study area is share cropping. Landowner and the tenant share the output by 50: 50. According to the field survey, landowners in the Study area normally share the input as well with 50: 50 except for labor, of which the tenant takes care. There are also some landowners who do not share the inputs but loan them to the tenant. They take interest for the loaned inputs from the tenant, as well.

In Sunsari district, there are other types of tenancy such as fixed rate in cash or in kind. According to the sample census of agriculture in 1991/92, of the total tenants, 63% were in the form of sharecropping and 23% for fixed rate in kind, 7% for fixed rate in cash and 7% for other arrangements.

SMIP stage III study finalized in 1995 also reported that about 36% of the total area of 46,000 ha covering Suksena canal command area and Morang side is cultivated by tenant farmers,

70% of whom are sharecropper dividing the produce by 50: 50 with landlord. In SMIP stage III area, it is reported that generally owners pay for expenditure for seed and manure. The tenants are, however, found initially bearing such expenditure and getting 11% of total output in owner's share as compensation. In this case, tenant receives 61% and the owner gets 39% of the share in total output.

SMIP stage III study also reports on the tenancy with fixed rate, describing that about 26% of around 900 sample households are sharing the crop produced in fixed quantity. The quantity of seasonal crop (generally paddy) paid to the owner is found as 681 kg/ha on average. The 26 % is very correlated with the figure given in the sample census of agriculture carried out in 1991/92; 23% in kind and 7% in cash.

It is also reported that tenants paying cash to the owner are very rare as counted only 4% of the sample households in SMIP stage III area. The amount of fixed rate in cash, according to the study, was 1,200Rs to 1,500Rs per ha per year depending on the soil conditions of the farm. However, during the field interviews in the Study area, the Study team has only met a tenant in Rajganj Sinuwari (midstream reaches of the Study area), who goes with fixed rate in kind (Rate is 1,190kg/ha/year).

In general, as crop yield becomes stable, owners and tenants are more likely to contract the rent with fixed rate, while the sharecropping is found in the area with unstable crop yield. Sharecropping system functions in such area as sharing of risks between owners and tenants. It could be confirmed, from such view, that the Study area is indeed located in the area of unstable crop production.

3) Food Security

According to a household survey carried out in 1998 by LGP (hereafter referred as "LGP Household Survey"), 53% of households answered that they live with inadequate food for more than nine months. The word "Inadequate" in this survey is defined that household who cannot support their food from their own farmland. So the meaning of inadequate rather indicates self-sufficiency at household level. As Table 4.2.7 below shows, the areas much constrained with food supply are not always located in the downstream reaches of the Study area, where it is envisaged the water shortage for agriculture should be much more than the upstream reaches.

Like Babiya and Jalpapur VDCs, though they are located fairy upstream within the Study area, the data indicates the considerable shortfall of food supply to the households. As the Study area is located far downstream from Chatra main canal, it is indicated that water shortage for agriculture is prevailing all over the Study area. Also social structure relative to land holdings may be a concern on the food shortage.

Table 4.2.7 Number and Share of Households having Inadequate Food in 1998

VDC/Municipality	No. of Families having inadequate food					% of Families having inadequate food			
	Up to 3 months	Up to 6 months	Up to 9 months	More than 9 months	Total	Up to 3 months	Up to 6 months	Up to 9 months	More than 9 months
Sahebganj	25	68	16	38	147	17	46	11	26
Kaptanganj	21	43	4	81	149	14	29	3	54
Dewanganj	13	45	17	194	269	5	17	6	72
Ghuski	12	86	67	216	381	3	23	18	57
Rajganj Sinuwari	11	84	9	169	273	4	31	3	62
Madhya Harsahi	25	77	62	16	180	14	43	34	9
Basantapur	9	30	20	85	144	6	21	14	59
Harinagara	28	77	28	82	215	13	36	13	38
Ramnagar Bhutaha	43	84	37	245	409	11	21	9	60
Jalpapur	5	40	3	187	235	2	17	1	80
Narsimha	113	169	35	156	473	24	36	7	33
Gautampur	22	31	9	47	109	20	28	8	43
Babiya	1	17	13	170	201	0	8	6	85
Study Area Total	328	851	320	1,686	3,185	10	27	10	53

Source: Local Governance Program Sampl Household Data Tabulation 1998

Aforementioned Table 4.2.6 shows the food availability of a household according to farming size. On the right hand edge of the table indicates the food availability throughout a year. If the rate is 4, it means food are available for more than 9 months from their own land. The data indicates that households who has less than 2 ha of farmland can secure food for not more than half of a year from their own land and 63% of the total households (less than 0.5 ha of land holdings) cannot supply food even for 3 months from their own land. This data in Kaptanganj is relatively correspondent to the "LGP household survey".

4) Income and Expenditure

Table 4.2.8 summarizes a feature of income and expenditure status of the farm household according to their farm size, based on the result of "Rural Socio-economic Survey". In "Rural Socio-economic Survey", the sample households were selected from the ones having own land and distributed as equal number as possible according to the farm size. Therefore, the sample households include much higher share of large-scale farm households against the actual share of large-scale of farm households in the total households in the Study area. Also the landless households are not included in the sample.

On condition that, the results of "Rural Socio-economic Survey" would indicate more apt for the structural difference of household economy by farm size, as compared to "LGP Household Survey" shown in Table 4.2.10. But the amount of other income obtained by "Rural Socio-economic Survey" is considerably higher than the result of "LGP Household Survey". It could be said that "LGP Household Survey" would have included poorer samples in their survey than "Rural Socio-economic Survey", since their target was directly poverty alleviation.

It is estimated that average household net incomes including self-consumption of agricultural produce for the households with 0.03 to 0.4ha, 0.45 to 0.9ha, 0.9ha to 1.8ha, 1.8 to 3.0ha and 3.0 to 14.0ha are 56,700Rs (9,500Rs/capita), 48,000Rs (8,100Rs/capita), 66,300Rs (10,300Rs/capita), 78,800Rs (11,300Rs/capita) and 149,800Rs (21,400Rs/capita), of which the shares of income from agriculture are 22%, 42%, 49%, 51% and 62% respectively.

As indicated that the households who own less farmland are getting more income from other income sources including farm labor. As well as relying on other income source, the households with less farmland cultivate their lands more intensively than the large-scale farm

households, as the farm size gets bigger, the cropping intensity shows decreasing tendency. Accordingly the agricultural productivity measured in gross value of output is higher in the small-scale farm households.

Some part of agriculture and livestock produce is self-consumed in practice and therefore, the income in cash basis is less than the value they harvest. Amounts of cash income estimated are 48,200Rs, 30,000Rs, 43,200Rs, 53,600Rs and 116,900Rs respectively for the households of 0.03 to 0.4ha, 0.45 to 0.9ha, 0.9 to 1.8ha, 1.8 to 3.0ha and 3.0 to 14.0ha. Compared to the cash expenditure, the sample households on average could have some savings in the last year[4].

Table 4.2.8 Income and Expenditure by Farm Size in the Study Area

Farm size		0.03 – 0.4ha	0.45 – 0.9ha	0.9 – 1.8ha	1.8 – 3.0ha	3.0 – 14.0ha
Sample		28	53	51	41	29
Ave. size	Family	6.0	5.9	6.4	7.0	7.0
	Farm (ha)	0.213	0.753	1.587	2.541	5.331
Cropping intensity	(%)	196	166	163	175	153
Agriculture						
Gross income (value)	(Rs/yr)	21,943	42,394	71,640	100,281	214,614
Input expenditure	(Rs/yr)	9,404	22,039	39,111	60,090	121,116
	(% to Gross)	(43)	(52)	(55)	(60)	(56)
Net income (value)	(Rs/yr)	12,539	20,355	32,529	40,191	93,498
Self-consumption	(Rs/yr)	6,686	15,729	20,511	23,154	30,191
	(% to Net)	(53)	(77)	(63)	(58)	(32)
Net income (Cash)	(Rs/yr)	5,853	4,626	12,018	17,037	63,307
Livestock						
Gross income (value)	(Rs/yr)	5,505	6,920	6,995	7,259	9,501
Input expenditure	(Rs/yr)	650	1,015	1,480	1,620	2,786
	(% to Gross)	(12)	(15)	(21)	(22)	(29)
Net income (value)	(Rs/yr)	4,855	5,905	5,515	5,639	6,715
Self-consumption	(Rs/yr)	1,847	2,165	2,659	2,015	2,623
	(% to Net)	(38)	(37)	(48)	(36)	(39)
Net income (Cash)	(Rs/yr)	3,008	3,740	2,856	3,624	4,092
Other income (Cash)	(Rs/yr)	39,314	21,698	28,287	32,958	49,542
Total net income (value)	(Rs/yr)	56,708	47,958	66,331	78,788	149,755
	(per capita)	(9,451)	(8,128)	(10,364)	(11,255)	(21,394)
	(% of agr.)	(22)	(42)	(49)	(51)	(62)
Total cash income	(Rs/yr)	48,175	30,064	43,161	53,619	116,941
	(per capita)	(8,029)	(5,096)	(6,744)	(7,660)	(16,706)
	(% of agr.)	(12)	(15)	(28)	(32)	(54)
Total cash expenditure	(Rs/yr)	32,673	28,762	33,139	48,893	75,820
Balance	(Rs/yr)	15,502	1,302	10,022	4,726	41,121
Gross agri. income/ha	*(Rs/ha)*	*103,019*	*56,300*	*45,142*	*39,465*	*40,258*

Source: Rural Socio-economic Survey by the Study Team in 2002

Expenditure by item is shown in Table 4.2.9. Food expenditure including self-consumption occupies the highest share in the total expenditure and the share is higher for the smaller-scale farm households. The shares of food expenditure for 0.03 to 0.4ha, 0.45 to 0.9ha, 0.9 to 1.8ha, 1.8 to 3.0ha and 3.0 to 14.0ha are 58%, 55%, 50%, 42%, and 39% respectively. Expenditure for clothes occupies the second highest share for most of the class with 12 to 13%. Larger-scale farm households have tendency to get higher amount of credit or it could be said that they could have better access to credit than the small-scale farm households. Education expenditure is spent much more in the larger-scale farm households.

[4] According to the field interviews, residual of the income for better off households is mainly used for repairing their houses or purchasing lands. Lands purchased are mainly of the purpose for sharecropping. As for the small-scale farm households, they tend to reinvest their residual in farm inputs to improve agricultural productivity.

Table 4.2.9 Household Expenditure by Farm Size

Farm size	0.03 – 0.4ha		0.45 – 0.9ha		0.9 – 1.8ha		1.8 – 3.0ha		3.0 – 14.0ha	
Sample	28		53		51		41		29	
Ave. Family size	6.0		5.9		6.4		7.0		7.0	
Education	1,875	(4)	2,074	(4)	2,695	(5)	6,370	(9)	6,359	(6)
Food (self consumption)	*13,693*	*(30)*	*19,235*	*(40)*	*21,100*	*(39)*	*25,676*	*(34)*	*26,724*	*(26)*
Food (purchase)	12,940	(28)	6,974	(15)	5,967	(11)	6,232	(8)	13,367	(13)
Medication	4,143	(9)	4,032	(8)	4,121	(8)	7,073	(9)	7,569	(7)
Tax	70	(0)	149	(0)	337	(1)	527	(1)	904	(1)
Energy	141	(0)	59	(0)	153	(0)	205	(0)	579	(1)
Repayment of Credit	2,484	(5)	3,785	(8)	6,671	(12)	8,706	(12)	16,652	(16)
Religious Event	3,018	(7)	3,830	(8)	4,788	(9)	4,617	(6)	7,017	(7)
Clothes	6,143	(13)	6,255	(13)	6,785	(13)	9,402	(13)	12,655	(12)
Water Fee	2	(0)	95	(0)	37	(0)	29	(0)	110	(0)
Others	1,857	(4)	1,509	(3)	1,585	(3)	5,732	(8)	10,607	(10)
Total Expenditure	46,366	(100)	47,997	(100)	54,239	(100)	74,569	(100)	102,543	(100)
Total Expenditure in Cash	32,673		28,762		33,139		48,893		75,819	

Source: Rural Socio-economic Survey by the Study Team in 2002

According to the "LGP household survey", average income per household is estimated at 15,800 Rs per year, of which 5,000 Rs is born from agriculture. Considering the results of the "Rural Socio-economic Survey", the samples of "LGP Household Survey" would have been focused on small-scale farmers or poorer households. The amount of other income is also found to be much little in "LGP Household Survey" than the result of "Rural Socio-economic Survey". Table 4.2.10 shows the household income by VDC.

Table 4.2.10 Annual Average Income per Household in the Study Area in 1998

VDC/Municipality	Annual Income (Total Sample)				Average Annual Income per Household (Rs)				
	Agricultural Crops	Livestocks	Others like employment	Total	Households	Agricultural Crops	Livestocks	Others like employment	Total
Sahebganj	368,575	46,164	341,325	756,064	156	2,363	296	2,188	4,847
Kaptanganj	1,414,665	200,875	1,105,800	2,721,340	152	9,307	1,322	7,275	17,904
Dewanganj	419,700	442,566	3,249,095	4,111,361	309	1,358	1,432	10,515	13,305
Ghuski	366,400	632,850	4,528,800	5,528,050	386	949	1,640	11,733	14,321
Rajganj Sinuwari	1,975,550	781,900	859,700	3,617,150	208	9,498	3,759	4,133	17,390
Madhya Harsahi	789,950	306,020	1,148,231	2,244,201	167	4,730	1,832	6,876	13,438
Basantapur	364,723	61,450	673,861	1,100,034	139	2,624	442	4,848	7,914
Downstream	5,699,563	2,471,825	11,906,812	20,078,200	1,517	3,757	1,629	7,849	13,235
Harinagara	758,700	170,410	4,937,001	5,866,111	292	2,598	584	16,908	20,089
Ramnagar Bhutaha	915,495	59,425	2,178,550	3,153,470	227	4,033	262	9,597	13,892
Jalpapur	430,400	770,854	1,156,102	2,357,356	269	1,600	2,866	4,298	8,763
Narsimha	4,182,700	503,500	4,183,702	8,869,902	400	10,457	1,259	10,459	22,175
Gautampur	1,243,400	315,145	645,500	2,204,045	129	9,639	2,443	5,004	17,086
Babiya	1,606,020	80,400	3,310,603	4,997,023	164	9,793	490	20,187	30,470
Upstream	9,136,715	1,899,734	16,411,458	27,447,907	1,481	6,169	1,283	11,081	18,533
Study Area Total	14,836,278	4,371,559	28,318,270	47,526,107	2,998	4,949	1,458	9,446	15,853
Share (%)	31	9	60	100		31	9	60	100

Source: Local Governance Program Sampl Household Data Tabulation 1998

Other fact we have to pay due attention is that the average income per household of VDCs located downstream is lower than that of VDCs located upstream. As the Table 4.2.5 and Figure 4.2.1 show, the average income per household of VDCs in the downstream reaches and upstream reaches are 18,500Rs and 13,200Rs respectively, indicating economic disparity rooted in their geographical conditions.

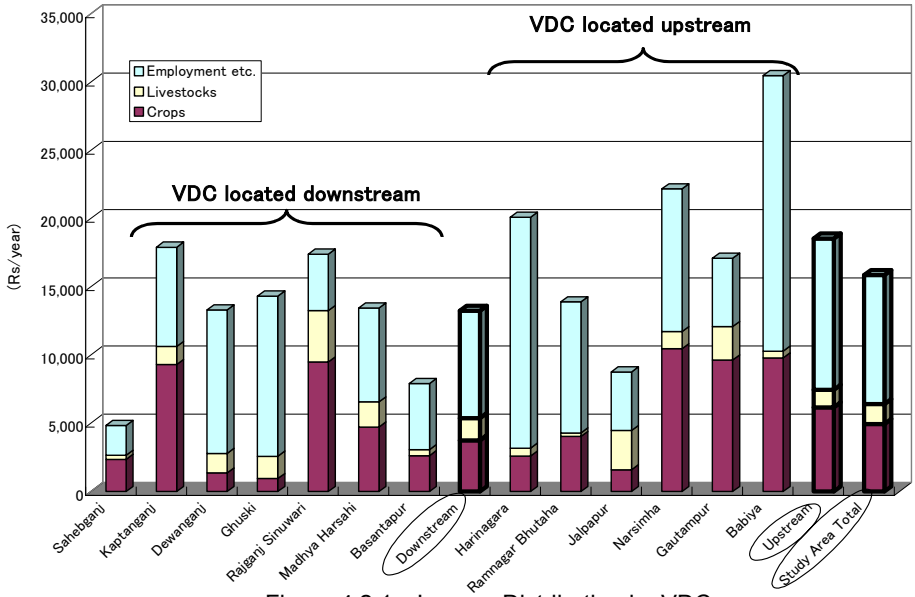


Figure 4.2.1 Income Distribution by VDC

4.2.3 Financial Sources

Agriculture Development Bank of Nepal (ADBN) is a popular financial source of the Study area. The Study area is covered by three branch and sub-branches of ADBN, which are Inarwa, Harinagara, and Laukahl. Repayment rate is 53% for Inarwa Branch and 61% for Harinagara branch. In Harinagara branch there was only one farmer whose collateral was auctioned last year. The repayment performance in the Study area is counted at 69%, fairly better, compared to overall ADBN performance (see Table 4.2.11).

Table 4.2.11 Credit Flow and Repayment of ADBN in 2001

VDC	Total no. of outstanding loans	Total Household	%	Amount of out standing loans (in'000)	Rs/HH	No. of over due loans	%	Amount of overdue loans(in'000)	%
Babiya	258	1,224	21	11,442.0	44,349	66	26	1,479.0	13
Jalpapur	89	1,093	8	3,030.0	34,045	18	20	348.0	11
Narshimha	581	2,770	21	15,195.0	26,153	304	52	8,217.0	54
Dewanganj	109	1,101	10	983.6	9,024	NA		45.6	5
Gautampur	186	700	27	368.0	1,978	NA		123.2	33
Ghuski	282	1,482	19	358.0	1,270	NA		144.0	40
Harinagara	266	1,142	23	725.0	2,726	NA		403.2	56
Kaptanganj	157	1,328	12	543.5	3,462	NA		145.8	27
Madhya harsai	107	824	13	167.1	1,562	NA		36.5	22
Rajganj Sinwari	249	1,435	17	3,849.2	15,459	NA		505.1	13
Ramnagar Butaha	224	1,703	13	2,355.5	10,516	NA		576.7	24
Sahebganj	110	641	17	798.3	7,257	NA		563.0	71
Basantpur	105	744	14	485.7	4,626	NA		27.1	6
Total	2,723	16,187	17	40,300.9	14,800			12,614.2	31

Source: ADBN, Inarwa, Harinagara, Laukahl

Credit facilities provided by the ADBN are for cereals, agro-industry, equipment, livestock, small cottage, bio-gas, horticulture, fishery etc. Each loan has different conditions in interest and repayment duration. Interest rate is 15% for short-term loan and 16% for other loan. Those who pay the interest monthly, they get 10% discount of the interest. Collateral is to be mainly lands and houses. There is a kind of loan without collateral for those who have skill, trained by Department of Cottage Industry. They can borrow up to 5,000 Rs without

collateral.

Basically the loan is an individual loan but ADBN has made special programs of group loan like Small Farmer Development Program (SFDP), Women Development Program, Micro Enterprise Development Program (UNDP supported lending program). SFDP supports group activity by lending to the group and the group is targeted to become a cooperative. When the group becomes a cooperative, ADBN will withdraw the support. (SFDP covers landless by group loan without requesting collateral.). They also look after the lending part of MEDEP and women Development program of HMG/N.

There are other sources of finance like Rural Development Bank and private local lenders (marchant). Also landowners sometimes lend money for purchasing inputs to their tenants. Interest of local lender can reach to as high as annual 50% to 60% vulnerable to the borrower. According to the baseline survey in Kaptanganj VDC, there are several sources of finance as shown in Table 4.2.12. 56% of the total households have got loan from several financial sources, of which 75% are borrowing money from local lenders. ADBN occupies only 20% of those who got loan. It is indicated that small scale farmers have difficulty to access public loan due to lack of collateral.

Table 4.2.12 Source of Finance in Kaptanganj VDC (2001)

Loan Borrowed	No.	%	
Rural Bank	25	3.4	1.9
Women Development Bank	0	0.0	0.0
Other Bank	8	1.1	0.6
Merchant	549	75.3	42.2
Other	5	0.7	0.4
ADBN	142	19.5	10.9
Total	729	100.0	56.0
Total Household	1,301	-	100.0

Source: Household Survey Data by LGP in 1998

Local Trust Fund (LTF) has been established as a part of LGP component. However, not everybody can access to the LTF, since the LGP has been implemented only in five VDCs in Sunsari district, out of which only Narshimha VDC is included in the Study area. Total credit capital flow of LTF since the commencement of year 1997 is 6.77 million Rs, giving an average of 753 Rs per member of the program. Now Village Development Program (VDP) under LGP is going to implement in Kaptanaganj VDC, so that the participants to LTF would increase.

4.3 People's Norm and Social Network

4.3.1 Feature of Network among Populations

Social network in the rural society is quite wide in the Study area regardless of the diversity of caste, religion and their origin. In this section, the range of social network will be discussed from several aspects.

1) Network in Kinship

Kinship is the smallest and tightest unit of the society. "Tole"(=settlement) consists of one to several kinship groups in the Study area. Usually, marriage is arranged by parents or

relatives, which is not necessarily neighbors, but with the one from outside of the village even from other district or beyond the international border, for avoiding consanguineous marriage. It means their kinship is physically wide as extending to different country. According to the interview to farmers, the proportion of marriage with people from India is 40 to 50% especially in the VDCs along the international border. In any family event, such as marriage or religious event, people with kinship get together to the house of head of the family.

2) Network in Agriculture Activity

2.1) Information on New Technology and Inputs

According to the field survey, farmers do never rely on public agriculture extension service and mostly exchanging information among them. The most common medium of information is, "see and talk among farmers". It might be common among farmers in general, but there is a tendency that farmers believe the effect of new technology or introduction of new varieties, when they confirm them by seeing the result with his eyes.

Giving the example, in Ward No.7 and No.8 of Jalpapur VDC, commercial vegetable growing is getting common. According to farmers, they have started vegetable cultivation since one innovative farmer with 15katha (0.45ha) succeeded commercial vegetables. There are some farmers who practice commercial vegetable growing and even they are leasing land or sharecropping. The information of fertilizer as well as insecticides is also collected through conversation among neighbors.

As it could be seen, the most reliable information source for farmers is "farmers". They are mostly neighbors in a same Ward or VDC. As for procuring inputs, they go to Indian market to buy fertilizer or seeds since the price is cheaper than in Nepal, but for selling product, they mostly sell to trader directly, or in local market, Inarwa, or sometimes in big cities such as Dharan or Biratnagar, depending on the quantity of production. It is not common for farmers to sell product collectively with other farmers.

2.2) Employment of Labor

Generally, the farmers who have more than 1.5 to 2.0 bigha (1.07 to 1.34ha) employ farm labors for their cultivation. It is common that the landowner does not have concrete contract with certain labors and depend on the content of the work and the necessity. The owner looks for workers who are physically strong within neighboring villages and employ them temporary. As for farm laborers, they always look for employment within their network, which is wide beyond VDC. According to the result of the field interviews, people know each other, at least which family they come from, despite the fact that the population in one VDC in the Study area reaches between 3,400 and 17,000. This could be possible because of the geographical condition as well as strong kinship across distance.

In the case of transplanting in average size of land, for example, the wife of landowner works together with laborers and she also works for others' land in spare time when she finishes transplanting in her family's land. It seems that their relationship is just like labor exchange.

3) Communal Event

There is no linear and formal information distribution system within Ward, Ward to Ward, Ward to VDC, and VDC to VDC. Because of the lack of information distribution system, what have been done at Ward or VDC levels are not properly informed to village people and could be cause of misunderstanding or increase suspicion of people who are not involved in that event.

In front of a house, which locates along the main road or with big tree, it is quite common to find group of people gathering. They are not necessarily a family, but neighbors regardless of caste or religion, ages, etc. and this will be the informal but important place for information exchange. The topic varies from gossip of neighbors to political issues.

4.3.2 Gender

In the case of the Study area, culture as a whole is male-dominated culture, in terms of decision-making process, access to control toward economic activities, education, and so forth due to patriarchy social system. Since "activities done by outside of the house" mostly are regarded as male job, even if female cooperate with them and, it will not appear on surface.

1) Agriculture Related Activities

According to the result of the "Rural Socio-economic Survey", the share of transplanting work done by male was shown as around 70%. However, observing in the field, it is hardly to find male doing this work, in turn, most of the ones who are transplanting are female labors. Meaning of "70%" could be analyzed that the male who supervises female labors regards him as the one who works for transplanting. Presence of women tends to be concealed in public, but they are actually the greater contributors to agriculture activities.

The wives or daughters of large-scale farmers are involved in farm work indirectly, such as preparing food for farm labors, in turn, women of small-scale farmers work as labor together with their husbands. Wage of farm labor also differs by sex: 35-80Rs/day with two meals for male, and 20-35Rs/day with two meals for female. People express that there is no specific reason for it, but just probably by cultural reason.

Plowing is totally done by male. It is culturally taboo for women to do it, probably considering physical difficulties. Apart from plowing, all of the works related to agriculture production are done by both male and female including vegetable caring, which of the weight done by male is 30% heavier than women. In turn, in terms of any decision such as what to grow, and/or where to sell and how to use the profit, is mostly made by male.

2) Communal Activities

It is observed that female seems to get more opportunities to participate in communal activities under facilitation of external agencies. Remarkable activities which should be mentioned in the Study area are, 1) District Health volunteer work, and 2) Grameen Development Bank.

Volunteers for District Health Center are selected by *Aama Samuha*(mothers group) according

to some criteria, such as active, leadership, comparatively educated and married. The process is, 1) an officer visits ward and ask *Aama Samuha* to select some potential women considering literacy, eagerness, etc., and 2) finally, district health officer makes interview to her.

Women interviewed say that they like meetings since meeting with friends are interesting, and like to learn new things, and the participation rate of the meeting is quite high, as they explained that there are always minimum15 participants in their meeting from each Ward.

It seems that Grameen Development Bank also utilizes this active district health volunteer group for starting micro-credit program. As the Grameen Bank in Bangladesh, the procedure to take loan will be through group basis consisting of five (5) members. The repayment is done under responsibility of the members under solidarity without any mortgage, as to say mortgage of solidarity, which means without repayment from the one who took loan, next member cannot get loan and have to pay fine as a group.

According to women who are participating in this micro-credit program, there was a problem that their husband took the money from his wife and therefore she could not repay the money in time. However, after the bank officers started to visit their houses to talk to their husband, their attitude has changed, and this kind of problem has disappeared for these days.

4.3.3 Feature of the "Community"

As summarizing the observation of the situation in the Study area, prominent features, which might have negative impact to establish organization, have been come up. In other word, this might be one of the internal reasons why the improvement of their living standard are stagnant comparing to the condition given to them. We define "community" as the size of one VDC, as a unit to approach from external side. It could be expressed that the feature of "community" in the Study area is in one word, *"independent but dependent"*. This could be explained from the major three social features of the Study area as shown in Figure 4.3.1. The three (3) circles show the dominant features of the "community", which are (1) Strong kinship, (2) Transitional social strata, and (3) Lack of critical situation for survival.

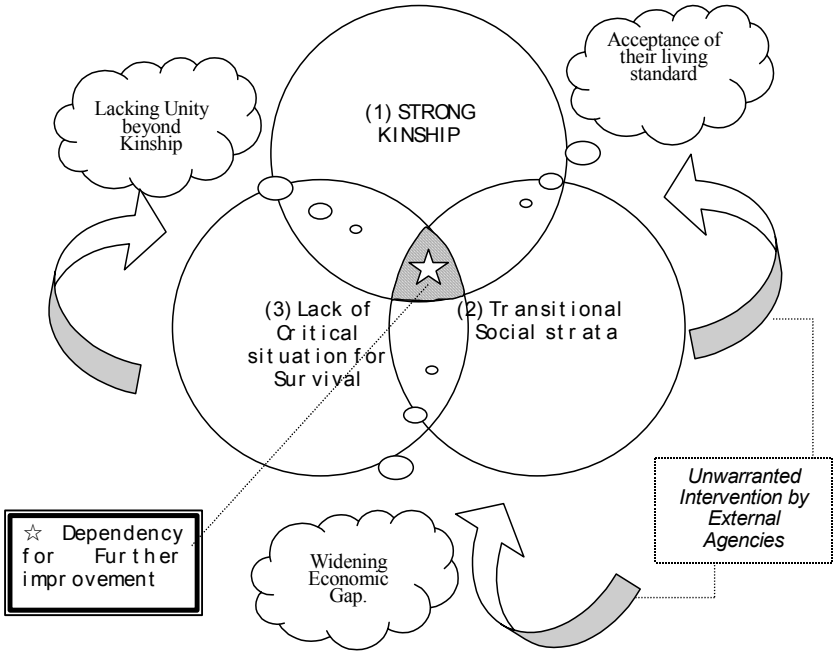


Figure 4.3.1 Feature of the "Community"

The feature (1) *Strong Kinship* shows literally strong bonds of kinship. As it could be observed, the behavioral pattern of farmers is quite individualistic, however it is the one as unit of kinship. The kinship generally consists of same

sub-caste/religions/tribes, which could be seen as they get married only to person from homogeneous group, even with the one who is living outside of the country as well as in a distant place. It could be said that farmers are individualistic based on this unit of kinship.

On the other hand, about the feature (2) *transitional social strata,* it shows the change in social strata. The social strata nowadays tend to be composed of living standard or landholding size, not of caste system within the certain society, here could be said as the society of farmers. However, still the caste system remains in mind in wide extent of the society including the lowest to highest, and it might be barrier for farmers to overcome beyond their certain world. Yet, there is a fact that the tendency of landholding size cannot be categorized by caste-wise anymore, while the income level is in proportion to landholding size. It means that the opportunity has been opened to improve their living standard regardless of labor of division determined by tradition. It could be analyzed that the social extension is getting wide and people could be more benefit-driven. In short, the social strata have two aspects, which are capitalistic aspect and traditional aspect.

As for (3) *No critical situation for survival*, the living standard of the Study area is relatively high comparing to other Nepalese standard. In other word, it is possible for them to survive anyway by their given natural resources such as rain and land. In case of agriculture, for example, people have physical capacity to use water pump with STW when there is necessity, and there is ground water availability as well.

1) Internal Characteristics

Next, looking at the overlapped area with those features, *firstly*, where (1) *strong kinship* and (2) transitional social strata are overlapped, namely, where they have relief to be bonded with kinship, which belongs to certain position of social strata, people tend to accept their lives and their spirit to pursue further development will be stagnant. *Secondly*, the overlapping sphere of (2) *transitional social strata* and (3) *no critical situation for survival* expresses the economic gap widen by following to capitalistic aspect of social strata. It means the person in higher class have more access to opportunity to amplify their property, in turn, the living standard of the person in relatively lower class will be stagnant since they can survive anyway, although there is difficulty and if they wish to improve, they need to make more efforts. Above all, even if they improve their lives up to certain level, there are traditional social strata which might not be easy to overcome, although the bias is getting less.

Furthermore, as it could be seen in the overlapped sphere of (3) *no critical situation* and (1) *strong kinship*, absence of critical situation for survival and relief of belonging to homogeneous group as kinship may be one of the causes for un-necessity of uniting themselves beyond some extent. The tendency of indifference to unrelated social group could be observed from this point. For example, in case of existing canal operation, it is easy to find extra outlet, which was not designed. The canal users do not care about it since they are not in problem as serious as affecting to their survival, and at the same time, farmers do not care what others do since they are indifferent to unrelated social group.

2) The Feature seen from integration of all three features

The point which is covered by these three (3) features could be expressed as "***dependency for***

further improvement" toward someone outside of their "community". It could be explained that where there are lack of unity, people accept their lives as they are, and the economic gap is getting large, people tend to rely on outsiders to further improve their lives. In other word, farmers do not have interest to improve their lives beyond certain extent, since they take it for granted that they cannot make largely improvement.

What should be pointed out in here is not the fact that this feature means that the farmers cannot live without depending on someone external. They have capacity to manage by themselves anyhow up to certain extent, as it could be seen at the present agriculture operation. However, for further improvement, they are indifferent and leave them in charge of external support.

4.4 Present Irrigation Practice

Shankarpur and Suksena irrigation canals, which run through the Study area, were constructed with assistance from the Government of India about 26 years ago. However, the discharges from Shankarpur and Suksena into the Study area are only 1.0 m^3/s (as of rotation; the discharge becomes 0.5 m^3/s in case of continuous flow) and 1.2m^3/s respectively. The area, which can be irrigated by these discharges with unit water requirement of 3.4l/s/ha, will be 200ha by Shankarpur and 500ha by Suksena canals (when the rotation is introduced to Suksena canal in the future, the command area will be 250ha).

The above discharges are the data recorded from May to December 2001. It was, however, confirmed that the farmlands which were well irrigated from Shankarpur and Suksena canals within the would-be gravity-fed irrigable area by Sunsari river were 55 ha (Babiya, Jalpaur, Gautampur VDCs) and 25ha (Narsimha VDC) only as of August 2001 respectively. Figure 4.4 below shows the area currently irrigated by Shankarpur and Suksena canals.

The irrigation facilities are usable only for 80 ha out of about 10,000 ha of the irrigable area. Therefore, most of the farmers in the Study area are relying on rainfall or otherwise pumping shallow groundwater for irrigation. Pump irrigation by shallow tubewell is prevalent especially in the southern parts of the Study area. However, the groundwater is not usually used for paddy irrigation except during acute water shortage but used for winter season's crops because paddy usually cannot bear the pumping cost (diesel).

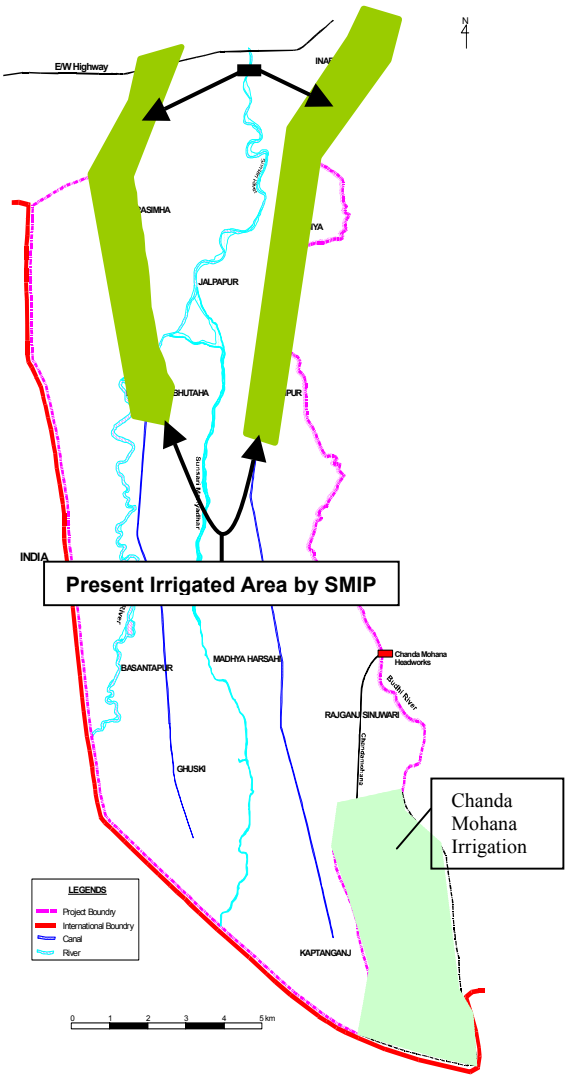


Figure 4.4.1 Area Currently Irrigated by SMIP

Water for agriculture is absolutely lacking as compared to the requirement. Due to the sandy soils, unit water requirement of paddy crop is very high. Hence improvement of irrigation facilities is necessary. Also inadequate operation and management of the Shankarpur and Suksena irrigation systems has caused damages in the canals, such as sedimentation on canal bed, sliding of side canal slops, countercurrent of canal bed inclination, O/M road subsiding, and leakage of canal water. These situations are aggravating current insufficient supply of irrigation water through the above two canals into the Study area.

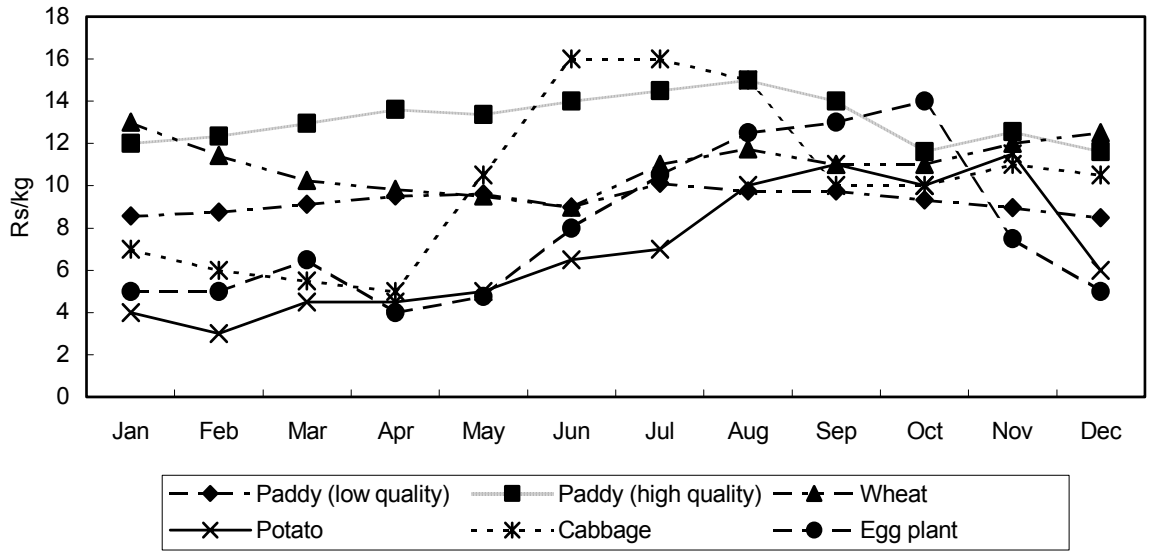
4.5 Infrastructure, Marketing and Agro-industry

4.5.1 Marketing

The agricultural products in the Study area is mostly self-consumed and some surplus and the produce of relatively large-scale farmers are sold at local markets such as Ramnagar Buthaha, Dewanganj, Harinagara and Ghuski in the Study area. Municipalities like Inarwa, Junka, Itahari and Biratnagar are also the major markets of the agricultural products in the Study area. Another significant markets are located in Indian side and farmers near the border are transporting their products by bicycle or on foot.

Farm products are brought to the local market by individual farmers or through local assemblers. They use bicycle, cattle cart and tractor. Renting tractor costs 1,000 to 1,200Rs/trip to Inarwa from the downstream reaches of the Study area. There are also middlemen coming in for purchasing the products. Cheaper price of products, apart from the quality, attracts middlemen and/or merchants coming from not only neighboring districts like Jhapa but also Kathmandu. In winter season, 4 MT of early cauliflower are shipped to Kathmandu by bus or truck. Collective marketing activity is not observed active.

Figure 4.5.1 shows retail price fluctuations of some products in the local markets. Price of perishables 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 (1988/99)

Figure 4.5.1 Retail Price Fluctuations

4.5.2 Marketing Infrastructure

There is a major trunk road running north-south along almost center of the Study area, north part of which is already paved. Road along the Suksena and Shankarpur canals are also in good condition and there are, apart from E-W highway, three roads in east-west direction between Biratnagar and the Study area, that are connected at Inarwa, Harinagara and Dewanganji VDCs. Through the trunk road, public bus is available. There are three trips between Dewanganji VDC and Inarwa and two trips between Biratnagar and Dewanganji VDC. The cost is 25Rs per trip for each bus route.

Road condition in the north side, east side and of course along the trunk road running at the center of the Study area is fairly good and there are no major difficulties to transport agriculture produce on this road network. However, the western parts of the Study area like Basantapur, Ghuski are in poor road condition. These areas are dominated by sandy soil, making it difficult to keep the road condition tough enough to transport agricultural produce.

In this year of 2002, a vegetable collection center was constructed by the Marketing Directorate of the Department of Agriculture in Kaptanganj, southern location of the Study area. This collection center was constructed to attract traders to come into the area to purchase agricultural products, so that the farmers in the area can save the transport cost and sell the products more collectively. So far, the management board of the center has not been identified and the aim of the center has not been realized yet. The section of the trunk road between Ramnagar Bhutaha and the collection center, which is around 9 km long, has not paved yet. If the road up to the collection center were paved, it would be an encouraging factor for traders to come to the center.

There is also a cold storage in Inarwa Municipality, which started operating in 2001 and the whole facility will be completed in year 2002. The storage is owned by private sector and has mainly targeted to preserve potatoes produced southern part of Sunsari district, which

includes Kaptanganj and Dewanganj VDCs. The capacity of the cold storage is 2,000 t/year, which can cover 100ha to 200ha of potato crop area. The cost for storage is 3 Rs/kg. The price of potato becomes three times in off-season from the rock-bottom price. Therefore, 3 Rs/kg of storage cost will be acceptable for potato growers.

4.5.3 Agro-Industry

Significant existing agro-processing relative to the Study area is four jute-processing factories seven rice mills, three flour mills and four vegetable oil refining factories along Biratnagar – Dharan road[5]. There are two sugar mills around the Study area. Jute processing has been a traditional agro-industry in the region. However, jute products are getting out of date, substituted by chemical products.

As for sugar processing, there is a large-scale sugar factory right eastern side of the Study area. The factory was established by a private sector in 1997 and has processing capacity of 250,000 t/year, which is the biggest magnitude in the whole eastern region. However, their actual operation is so low as the operation ratio of the first year was 50% and the ratio has been decreasing as they estimate the operation ratio in this year would be only 25%.

The evaluation of the factory management section is that the farmers are not interested in growing sugarcane, as it is not comparatively profitable. On the other hand it is pointed out that the purchasing price of sugarcane by the factory may not be high enough (132 Rs/100kg at mill gate price or 122 Rs/100kg at farm gate price) and the extension services by the factory is not intensive as they just facilitate farmers to get loan from ADBN, not being a form of contract basis cropping, indicating to be less care for farmers by the factory.

For milling rice and wheat, which are major crops in the Study area, some farmers in the villages own small-scale milling machine and they possibly cover the demand of milling in the Study area. Rice and wheat for sale are transported to the above mills. The milling machine is operated by a diesel engine which is also used for shallow tube-well pumping. Rice and wheat milling cost in the Study area is about 35 Rs/100kg.

4.6 Relation with India

South and West borders of the Study area are demarcated by the national boundary with India. Many people in the Study area originated in India and their major language is common with Indian dialectic. The villages near the Indian border in fact have strong connection with Indian side. They go to buy or sell vegetables to the towns (Phulka, Jogbani, Basmatia, Ramnagaputa) in India and buy fertilizers, as well. People are almost freely crossing the national border.

There is a custom office in Kaptanganj VDC, south edge of the Study area. There used to be another custom offices in Ghuski and Basantapur VDCs, which are located in the southwest and west edges of the Study area respectively, but these offices have been abandoned. The custom is regulating the traders who use truck or tractors. However, they cannot stop the residents around the border crossing it by bicycle or on foot with their vegetables for sale.

[5] Inventory Survey by the Study Team in 2002

Exports are dominated from Indian side to Nepalese side. Export from Nepalese side is insignificant. According to the record of the custom office in Kaptanganj VDC, value of export and import in October-November 2001 was 21,000 Rs and 435,000 Rs respectively, the import to Nepal being about 20 times than the export. As per fertilizer, there is a subsidy in India which lowers the price such as UREA of 9 Rs/kg and DAP of 16.5 Rs/kg against 10 Rs/kg and 21 Rs/kg respectively in Nepal. Farmers around the border preferably buy the fertilizer in India, but there is a quotation that the quality is often less.


Farmer carrying Pea to sell in India

Individual farmers are transporting their vegetables by bicycle. By bicycle, they can transport about 70 to 80 kg of vegetables such as green peas and cauliflowers at one time. The price in Indian market is expectedly 2 Rs to 3 Rs/kg higher than the price in Nepalese side, giving them around 140 to 240 Rs per bicycle load, which is equivalent to 2 to 3 days of farm labor wage.

Due to recent security problem (Maoist insurgency in Nepal), the border guarding has been so strict that the official trading at the point of Kaptanganj custom has been suspended since January 2002. All the trucks to export goods to Nepal found in Indian side have been stopped by the Indian police. Farmers transporting fertilizers from India by bicycle has now become risky, as may be stopped by the police. They are often, therefore, transporting fertilizers at night. Although India is traditionally within the economic block for the Nepalese living near the border, the national border could be an iron curtain shutting all the transactions.

4.7 Line Agencies Local Branch Offices

Relevant line agencies to this Study are; Eastern Regional Irrigation Directorate (ERID), Eastern Regional Agriculture Directorate (ERAD), both of which are located at Biratnagar, and Sunsari District Irrigation Office (DIO) and Sunsari District Agriculture Development Office (DADO). Also, located in Tarahara is a regional agricultural research station under National Agriculture Research Center (NARC). Sunsari DIO will be a divisional office by merging with Morang DIO from Nepal fiscal year 2002/03, which will look after irrigation activities over the both Sunsari and Morang districts.

4.7.1 Eastern Regional Irrigation Directorate and Sunsari District Irrigation Office

Eastern Region Irrigation Directorate (ERID), one of five Regional Irrigation Directorates (RID), looks after 16 districts in the Eastern Region. The objectives of RIDs are to: 1) monitor DIOs activities, 2) supervise irrigation projects and coordination, 3) approve irrigation schemes or to recommend DOI for approval, 4) manage irrigation related personnel within the region, 5) monitoring and evaluation, and 6) policy implementation, etc. The staffs presently working at ERID are comprised of following personnel as of February 2002.

Table 4.7.1 Staff at ERID as of February 2002

Director	1
Senior Divisional Engineer (SDE)	2
SDE Monitoring	1
SDE Agriculture	1
SDE Geologist	1
Engineers	5
Agronomist	1
Sociologist	1
Section Officer	1
Account Officers	1
Overseer	5
Asst	4
Asst	2
Drivers	4
Peon/Guards	7

Source: Eastern Regional Irrigation Directorate

Sunsari DIO, established in 1988, is mandated to alleviate poverty in the district by providing reliable irrigation water and increasing agriculture productivity. The assigned tasks are: 1) implementation of yearly approved programs, 2) identification of various irrigation schemes, 3) implementation of river training works, 4) coordination between farmers and ADB assisted SISP program, 5) training of WUAs of ongoing schemes as well as of completed schemes, 6) registration and renewal of WUA, etc. The staff as of February 2002 is shown in the following table:

Table 4.7.2 Staff at Sunsari DIO as of February 2002

Office In-charge SDE (Irrigation)	1
Engineers (Irrigation)	3
Agri Engineer	1
Hydrologist	1
Overseer	10
Asst	2
Asst	3
Drivers/Peon	8

Source: District Irrigation Office

4.7.2 Concerned Agricultural Offices

ERAD controls 16 DADOs in the eastern region. Out of sixteen DADOs, Sunsari DADO is the responsible agency for agricultural development in the Study area. Sunsari DADO was established in 1966 as an 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, 6 sections (administration, planning, agronomy, horticulture, fishery and plant protection section) and 15 extension centers (4 Agricultural Service Centers and 11 Sub Centers) have been 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 the Agriculture Perspective Plan in cooperation with other department.

Extension service is provided through Agricultural Service Center (ASC) and Sub Centers (SC) at the front line. One ASC and 3 SCs are arranged in the Study area (see in Table 4.7.3). These extension centers provide extension services covering not only crop husbandry but also livestock raising and fishery.

Table 4.7.3 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 (1988/99)

Extension worker called Junior Technician (JT) and Junior Technical Assistant (JTA) play a role to disseminate improved technology and to give advice to problems related to farm management. Group approach as a method of extension service is introduced for the purpose of raising up farmers participation. There are 24 farmers groups certificated by the Sunsari DADO in the Study area.

4.8 Donors and NGO Activities

To date, several significant development programs have been on going by the assistance of donors in the Study area. Those are Local Governance Program (LGP) funded by UNDP, Decentralized Planning for Child Program (DPCP) by UNICEF, Sunsari-Morang Program by PLAN International, an international NGO, and Nepal Participatory Learning and Advisory Project (NPLAP) funded by DFID of UK government.

4.8.1 Local Governance Program (LGP)

LGP is aimed at strengthening the capacity of DDC local governance and implementing Village Development Program (VDP) in a manner of participation. Sunsari district is one of the 30 districts implementing LGP since 1997. VDP in Sunsari district was initially implemented in 5 VDCs, and the VDC number which is to have the VDP will increase 16 in 2002. Narshimha, one of the VDCs in the Study area, is one of the five VDCs.

VDP is to form Community Organization (CO) with 30 to 50 members as the basis of the development activities. A locally hired social mobilizer has assisted to formulate 72 COs with total members of 2,036 households covering 94% of the total households in Narshimha VDC. The difficulties he has faced were; people's unreadiness of introducing new concept of community based organization, distrust of the people, less involvement of women, etc. The social mobilizer evaluates that currently about 60% of the COs in Narshimha VDC are

considered to be active.

The VDP in Narshimha VDC marked the utilization of Local Trust Fund totaling to 991,000 Rs or 880 Rs/member, as of February 2002, for investing in agriculture, business, livestock and industry with 70%, 21%, 9% and 0.1% respectively. In addition to it, there has been a series of trainings and the participants were 44 members for livestock raising, 44 for health and sanitation (smokeless stove and toilet installation), and 21 for cottage and small industries such as bamboo crafts, pumping set maintenance.

4.8.2 Decentralized Planning for Child Program (DPCP)

DPCP (the name will change to Decentralized Action for Child And Women (DACAW) from 2002) has been operated as a partnership program with LGP in 20 districts, especially supporting the side of female social empowerment. Based on the COs formed by VDP, group monitoring of childcare, sanitation, training etc. have been conducted. In Narshimha VDC, the program assisted to build two childcare centers, in which one mother of the village rotationally takes care of their children so that other mothers can go to work.

4.8.3 Sunsari-Morang Program

Sunsari-Morang Program established in 1993 by PLAN International, an international NGO, for health, education, income generation etc. are fostering some 9,500 vulnerable families in 40 VDCs of Sunsari and Morang districts, out of which six VDCs that are Harinagara, Madhe Harashi, Dewanganji, Rajganji Sinwari, Gautanpur and Jalpapur are the recipients located in the Study area. One of their projects, which they evaluate successful, is a kitchen gardening project. PLAN provides, without any rental fee, foster families with two khatas (0.0 6ha) each of land for 3 years together with subsidy for agricultural inputs. The subsidy is 100% in the first year, 75% in the second year, 50% in the third year and zero in the fourth and the following years.

4.8.4 Local NGOs

The number of local NGOs so far registered at Sunsari District Administration Office has reached 903. However the NGOs, which had renewed their registration in 2001, is counted at 171 only. There are 11 NGOs considered to be somehow active in the Study area and 21 NGOs in Inarwa Municipality. People who graduated college but cannot get suitable occupation are likely to engage in NGO activities. The NGO is now somehow considered to be an occupation of the educated youth in villages.

For the capacity building of the local NGOs, a DFID funded program, called Nepal Participatory Learning and Advisory Project (NPLAP), has been implemented in eight districts including Sunsari. By next April 2002, the program will select one NGO as a program partner. They will work with the NGO for another one year for its capacity building, and then the program will terminate.

4.9 Development Constraints and Potentials

4.9.1 Development Constraints

1) Lack of Irrigation Water

It is confirmed that the lack of irrigation water is the main cause of the low productivity of cereals in the Study area. According to the interviews to farmers who live far from the main canal of Suksena, they grow paddy dependent on rainwater and the harvest can be nil unless they were favored with adequate rain. At worse, the rainfall in the Study area is erratic even during monsoon season. Farmers have an option of using groundwater, which is abundant in the Study area, and most of the farmers actually irrigate the winter crops by shallow tube wells, but irrigating paddy by the well is too expensive for farmers to practice, since it requires three to five times of wheat.

There is a gap of access to irrigation water provided by SMIP. Access to irrigation water is limited to the farm located along the upper part of Shankarpur and Suksena canals in the northern part of the Study area due to insufficient water supply from CMC and non-existence of watercourses. Irregular supply of irrigation water causes low productivity of the crops even in the area that is irrigated from SMIP.

2) Soil Unsuitable for Paddy Production

According to the Land Resource Mapping Project (LRMP) conducted 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 only to around 10% of the Study area located in Ghuski, Rajganj Sinuwari, Madhay Harsahi and Gautampur VDCs.

Sandy soils prevalent in the Study area have little capacity to hold moisture and nutrients. Such physical soil condition is also a limiting factor for paddy production that requires much irrigation water. Yet the present land utilization in monsoon season is still represented by paddy crop. Farmers who prefer to eat rice tend to plant paddy no matter if it will be harvested or not. This fact shows there is a gap between rational land use in theory and farmers' intention of farming.

3) Poor Access to Quality Farm Inputs

The second concern following irrigation water among farmers is how to access quality farm inputs, particularly fertilizer. The country completely depends on imported fertilizer 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.

Lack of capital is also a problem for farmers to access farm inputs and difficulty to access practical credit scheme worsen the issue. Farmers have an opportunity to borrow money from local moneylenders, but their annual interest is as high as over 60 %, pressing farm economy. Existing credit scheme provided by ADBN is also inconvenient for farmers due to

complicated paper works and compulsory of mortgage.

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 practically defunct, even though a group approach has been applied with intent to deliver the services efficiently. Many farmers also point out the quality problem of the extension services.

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 transport agricultural products out of the Study area. However, feeder roads that connect between farmlands and the trunk road have not fully been provided. During monsoon season, distribution network is often interrupted due to heavy flood. Road condition is poorer particularly in the western side (Basantapur and Ghuski) comparing to other sites, leading to less attention from the development assistances, as well.

The Study area is well known for a vegetable production area, although there are few numbers of commercial vegetable growers in the Study 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 even at low price at a peak period of harvesting.

6) Flood and Inundation

On the contrary of the shortfall of irrigation water, a rush of flood sometimes occurs in every monsoon season causing inundation in some part of the Study area. Based on the interviews to the local farmers from April to May 2001 and after a big flood that occurred in July 2002, there are eight areas of inundation in the Study area. These areas are concentrated in a nearly level valley floor, southern part of the Study area, although a few flood areas show up in the north and northeast. These areas are limited in the active flood plains in the Study area, meaning that most of the cases the inundation takes place due to flood coming from nearby rivers such as Sunsari and Budhi and also replenished by rainfall.

7) Environmental Issues

There are two paper mills discharging effluent into the Sunsari River just downstream the E-W high way bridge. The water of the Sunsari River was found contaminated by the effluent at the points of the outlets of the factories and, to some extent, the downstream reaches from the sites of the outlets. The inhabitants around the factories have been

complaining about the effluent and they have been reporting adverse impacts incurred by this such as decrease of fish in the river. This issue will have to be taken into consideration in exploiting the Sunsari River water for irrigation. Detail is discussed in Chapter 12.

4.9.2 Development Potentials

1) Effect of Irrigation Observed in SMIP

Present agriculture situation in the upper stream reaches of Suksena and Shankarpur canals or upper part of Chatra main canal may give a clue to catch a glimpse of the future agriculture in the Study area since the area is considered to have been in with an irrigation project condition. The cropping pattern in the upper stream reaches of SMIP (along Chatra canal) is very different from the one in the Study area. Cropping pattern in winter season in the Study area is seen as mainly wheat crop. Whereas, the cropping pattern in the upper stream reaches of SMIP in winter season is dominated by vegetables or pulses crop.

As some interviews to farmers revealed, majority of farmers in the Study area are growing wheat during winter season for their cereal consumption, due to low yield of paddy. They can only eat rice once a day (and wheat twice a day) or some times every three days, although they prefer to have rice. If the paddy yield in monsoon season increases by irrigation development, farmers in the Study area will be able to have options of growing profitable vegetable crop other than wheat as seen in SMIP area.

2) 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, though 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 commercial vegetable production. With effective extension services, the vegetable crop in the area can be expanded.

3) Geographically Advantageous Position for Marketing

The Study area is located at geographically advantageous position for agricultural marketing. There are several urban areas that have large numbers of consumers; Biratnagar (population; 161,036 in 2001), which is ranked as the second largest city in Nepal and some neighboring cities like Inaruwa (population; 23,200 in 2001), Ithahari (population; 41,210 in 2001) and Darhan (population; 95,332 in 2001) are the targets of the marketing. 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, as well. 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. In the future, there is also a possibility of being a major supplier of agricultural products to Indian markets near the border, which are Kulkaha, Basmatiya and Bathnaha in Bihar state of India, if the quality and price of the growers in Nepal become competitive with Indian growers.

4) Community Feature and Possibility to Change

As it has been mentioned, the feature of dependency for further improvement could be observed in the community, but there is also a symptom that it could be changed. It could be explained that, while the feature of "strong kinship" and "lack of critical situation for survival" have not changed, the social strata has been in transition period. As mentioned, the size of landholding is not related to caste and the opportunity to improve living standard has been open regardless of labor division determined by tradition. It means that they can improve their lives more, if they really wish. Once farmers can feel confidence that they can change their lives by themselves, the feature of dependency could be reduced. Moreover, it could be further improved if there is appropriate external support.

On gender issue, in terms of any decision-making such as what to grow and/or where to sell and how to use the profit is mostly managed by male. This tendency is remarkable in relatively large-scale landholder class. On the other hand, though women in lower class are less educated, they have lauder voice since they are earning money through farm labor, whose workload is quite same or sometime heavier than male. This kind of cultural change observed among women in relatively lower class implies that the change in culture is possible depending on the social circumstances.

CHAPTER 5

WATER RESOURCES ASSESSMENT

CHAPTER 5 WATER RESOURCES ASSESSMENT

The prospective water resources that this Study should focus on are; 1) Sunsari river, 2) groundwater either shallow or deep, 3) water release from SMIP if extra water available in the Chatra main canal, and 4) other rivers such as Budhi and its tributaries. The last one, Budhi river, has been already provided a diversion weir at a place Kathale Nadi and Budhi Khola merge into the main Budhi Nadi. The diversion weir commands about 1,800 ha of the area near the international border. Therefore, the downstream from the weir has no possibility that further water exploitation could be made.

Though Kathale Nadi demarcating upstream eastern boundary of the Study area looks an option to develop, the runoff is very little as suggested by the catchment area of only 20 km^2. Also, a diversion in the Kathale Nadi will reduce the water release to the already functioning weir of the Budhi river. Therefore, this chapter examines the potential of Sunsari river as the first development priority source and the groundwater as the supplemental water source together with the possibility of getting water from SMIP.

5.1 Surface Water Potential (Sunsari River)

5.1.1 Gauging Stations and Data Collection

In and near the Sunsari river basin, there are four gauging stations which observe daily rainfall; Dharan Bazar, Chatra, Tarahara and Biratnagar airport. Location and duration of observation are as follows, and the first three rainfall data are employed in assessing the surface water potential of Sunsari river, and the last one, Biratnagar airport, is for effective rainfall to be considered in estimating irrigation water requirement.

Table 5.1.1 Gauging Stations

Stations	Code	Longitude	Latitude	Elevation	Period	Remarks
Dharan Bazar	1311	26°49'	87°17'	444 m	1973-2001	Runoff assessment
Chatra	1316	26°49'	87°10'	183 m	1973-2001	
Tarahara	1320	26°42'	87°16'	200 m	1973-2001	
Biratnagar Airport	1319	26°29'	87°16'	72 m	1973-2001	For irrigation requirement

5.1.2 General Feature of Rainfall

Long-term patterns of annual rainfall at above stations from 1973 to 2001 are shown on the following figures; Figure 5.1.2 for Dharan Bazar and Chatra stations and Figure 5.1.3 for Tarahara and Biratnagar Airport. No significant difference among them is observed. The figures may tell us that the rainfall fluctuates almost in 7 to 8 years term. In addition, rainfall at Biratnagar airport is noticeably high in 1974 and low in 1994.

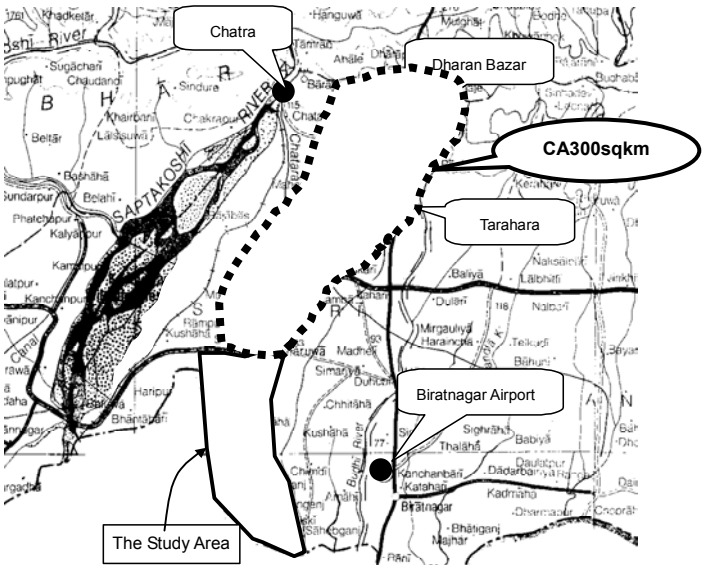


Figure 5.1.1 Location of the Gauging Stations

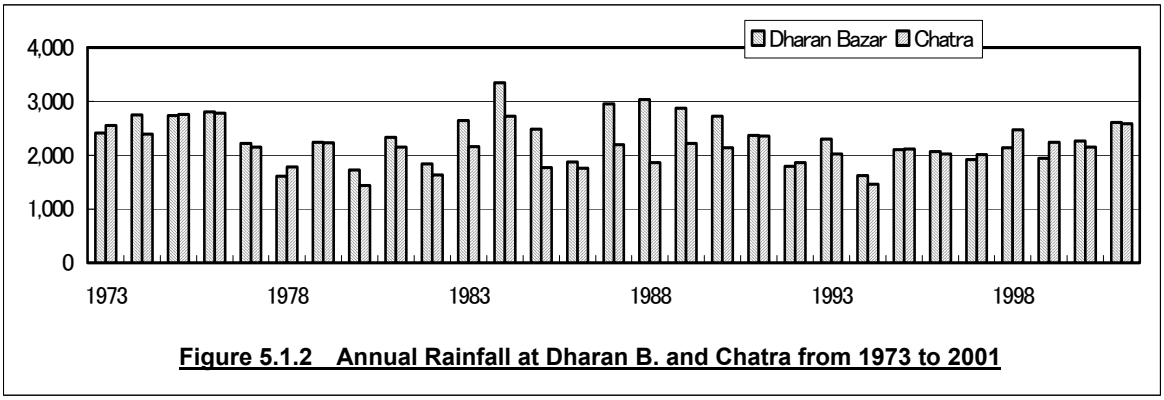


Figure 5.1.2 Annual Rainfall at Dharan B. and Chatra from 1973 to 2001

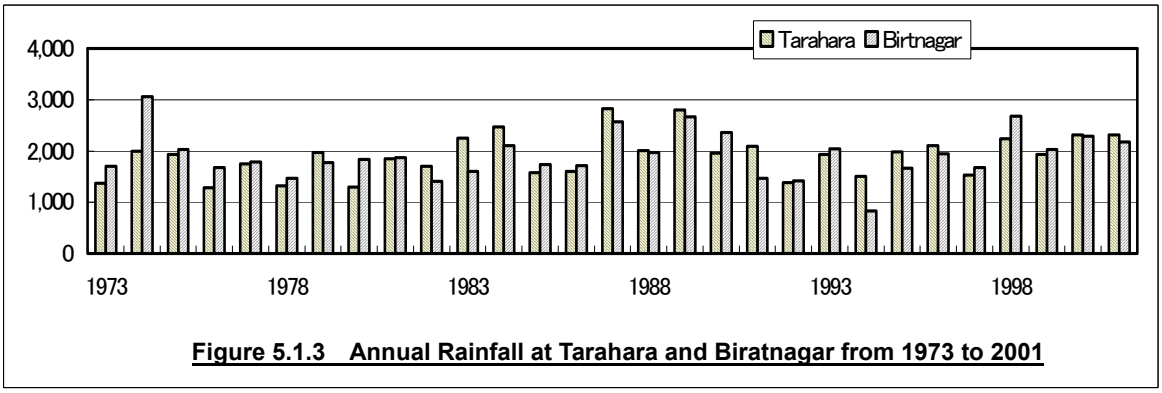


Figure 5.1.3 Annual Rainfall at Tarahara and Biratnagar from 1973 to 2001

Mean annual rainfall and monthly rainfall are summarized as follows. As to annual rainfall, it ranges from 1900 mm to 2400 mm and increases northward. Monthly distribution of rainfall is almost same among the stations with about 80 % rainfall occurring in monsoon season. However, correlative coefficient of daily rainfall among stations is about 0.6 only.

Table 5.1.2 Mean Annual and Monthly Rainfall

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Dharan Bazar	13	15	24	61	173	374	631	572	408	143	15	7	2441
Chatra	17	14	24	58	161	394	603	474	353	143	17	7	2265
Tarahara	14	13	18	62	163	323	525	380	300	102	14	11	1925
Biratnagar	10	13	15	52	165	323	526	375	313	108	10	7	1917

5.1.3 Areal Rainfall

Observed rainfall by a gauging station pertains to the point where the rainfall is recorded. To analyze hydrological conditions, it is necessary to convert the point rainfall to an areal rainfall. Thiessen polygon method is adopted in this Study to compute the areal rainfall in the Sunsari river basin. In computation, rainfall data at Dharan Bazar, Chatra and Tarahara were selected based on the division by Thiessen polygon. Each polygon area in the Sunsari basin that is the upper basin of the proposed headwork site is as follows:

Table 5.1.3 Polygon Area

Representative Station	Dharan Bazar	Chatra	Tarahara	Total
Polygon area (km^2)	91	46	163	300

There are some data missing in short period that is 10 or 15 days at most. Missing data were estimated with reference to the data at other nearby stations. The computed areal rainfall is shown below by annual rainfall distribution and by monthly distribution. The mean annual rainfall is 2072 mm which falls in between the rainfalls of Chatra and Tarahara.

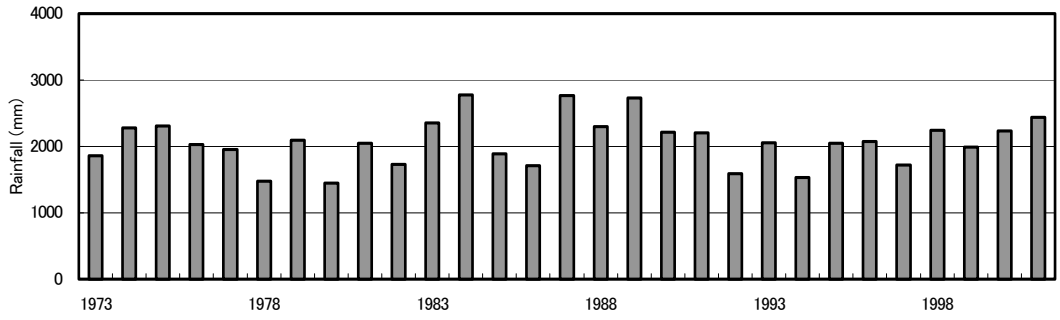


Figure 5.1.4 Areal Rainfall in Sunsari Basin computed by Thiessen Polygon Method

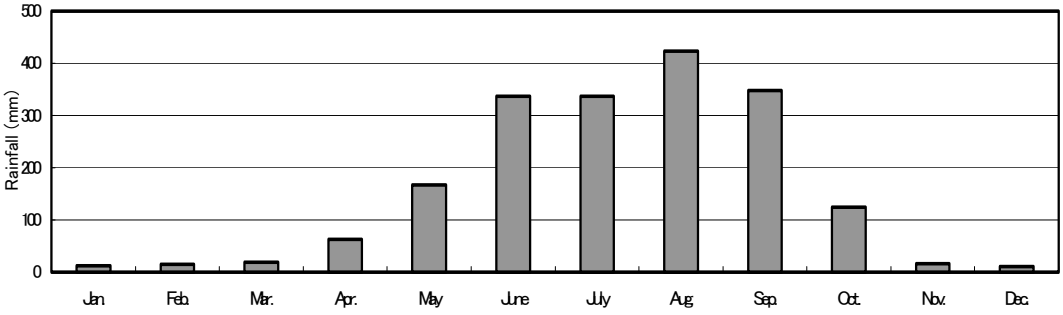


Figure 5.1.5 Monthly Areal Rainfall Distribution in Sunsari Basin

5.1.4 River System

Sunsari river has a catchment area of 300 km^2 at the prospective headwork site which is 600 m downstream from the E-W highway crossing point. Sunsari river originates in a mountainous area called Siwalik Range that is located in northern part of Sunsari district. The river flows from the north to south in meandering. The upper stream of Sunsari river after confluence of Belaha Khola and Thalaha Khola is called Sunsari Nadi.

As to the tributaries of Sunsari river, there are two major ones; Kakar (Sardu) and Kuruwa (Seuti) Kholas. These rivers also originate in the mountainous area. Kakar Khola flows along the right edge of alluvial fan in Dharan to the southeast and passes through the Terai plain. This tributary joins Sunsari river at about 35 km from the top of Dharan alluvial fan. Kuruwa Khola flows along the left edge of Dharan alluvial fan to the south. It joins Sunsari river at about 36 km from the top of Dharan alluvial fan.

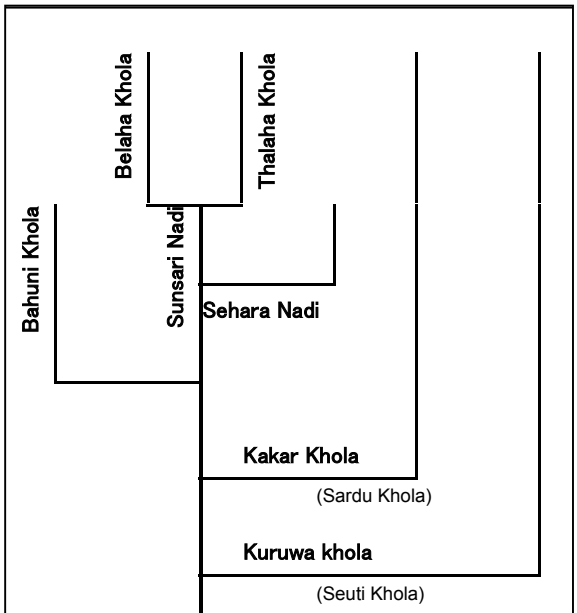


Figure 5.1.6 River System of Sunsari River

Surface water is not found in Kakar Khola and Kuruwa Khola except during and until soon after rainfall. Sunsari river, on the other hand, has perennial flow throughout year. Sunsari river is obviously recharged by seepage from Sapta Koshi river and also by irrigation water from SMIP. As Chatra main canal starts carrying certain amount of irrigation water, runoff in the Sunsari river correspondingly increases to some extent.

5.1.5 Runoff Analysis

There are several methods to estimate long-term runoff on daily base. This Study carries out a runoff analysis to estimate how much water is available in the Sunsari river for irrigation development. The analysis should deal with runoffs of not only in wet season but also in dry season, so that a model called Tank Model has been adopted. The model is composed of four tanks. The first tank from the top represents surface runoff and second tank represents subsurface runoff. Likewise, the third and fourth tanks represent the base flow by groundwater. Each tank has side runoff outlet and is vertically combined with other.

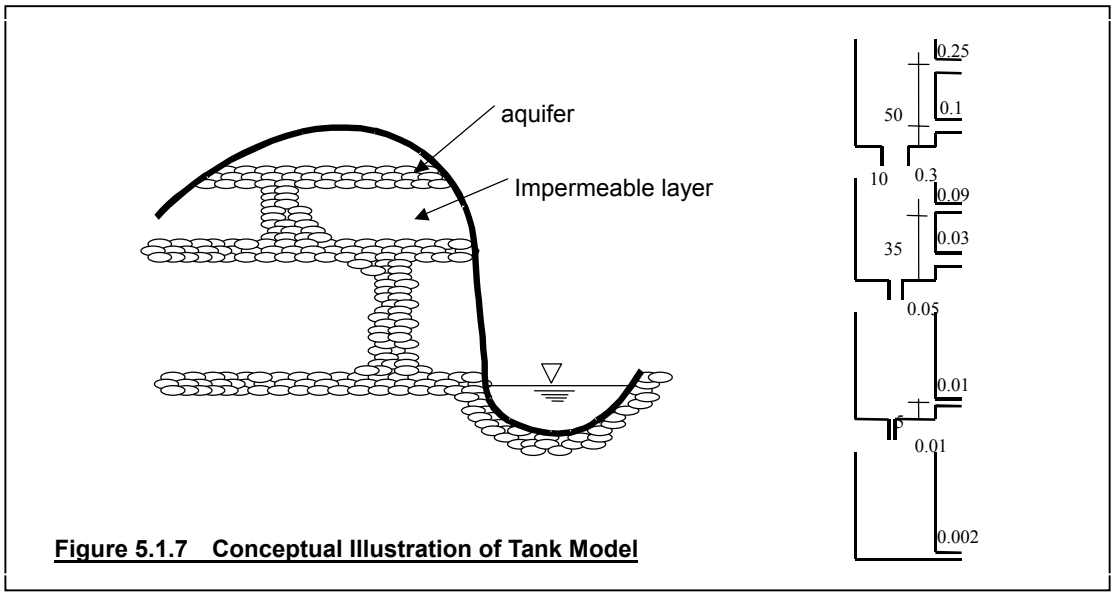
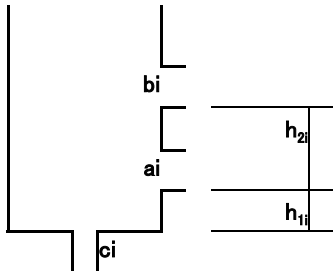


Figure 5.1.7 Conceptual Illustration of Tank Model

At the simulation, data of daily rainfall and observed daily runoff together with evaporation (mean monthly basis data accepted) are the necessary inputs. Daily runoff is calculated repeatedly as shown below. Calculation is started from the first tank and repeated to the fourth tank successively.

$$R = \Sigma Ri$$
$$Ri = \Sigma (Rai + Rbi)$$
$$Wi = W1i + P - E$$
$$Rai = (Wi - h1i) \times ai$$
$$Rbi = (Wi - h1i - h2i) \times bi$$
$$Rci = (Wi - h1i - h2i) \times ci$$
$$W2i = Wi - R + Rci$$



Where, R: total daily runoff (mm)
Ri: daily runoff from each tank (mm)
Wi: initial water height in each tank (mm)
W1i: former day's water height in each tank (mm)

W2i:	last water height in each tank (at the end of calculation on exact day, W1i is replaced by W2i)
P:	daily rainfall (mm)
E:	evaporation (mm)
Rai,Rbi,Rci:	coefficient of runoff outlet
h1i,hli:	height of runoff outlet (mm)

Verification of the Tank Model, based on the observed runoff from May 2001 to July 2002, was conducted by changing coefficient and height of runoff outlet. The verification of the Tank Model is shown as below, giving a correlative coefficient of 0.91 between the observed and simulated runoffs (see Figure 5.1.8). The correlation is acceptable so that the model has served for 29 years simulation from 1973 to 2001.

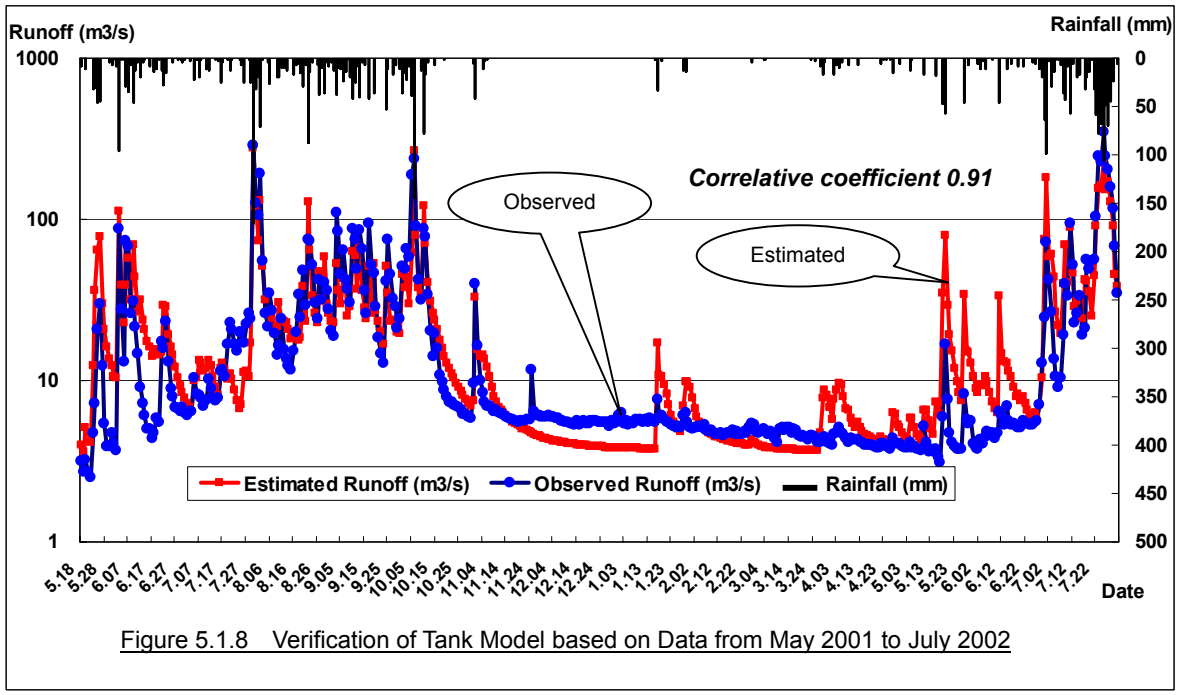


Figure 5.1.8 Verification of Tank Model based on Data from May 2001 to July 2002


Sunsari River viewed from E-W Highway

On the basis of the results for the 29 years simulation, the availability of water was examined correspondent to different reliabilities (probabilities). The reliabilities examined are at 50 %, 60 %, 70 %, 80 % and 90 %. The water availability was examined by 10 days each throughout year to clarify which period water deficit occurs in. The following table shows the available water by 10 days in accordance with the reliabilities of 50, 60, 70, 80 and 90%. Available water with 80 % reliability is graphically shown in Figure 5.1.9, giving 388 MCM, 321 MCM and 67 MCM for annum, monsoon season from May to October and dry season from November to April respectively.

Table 5.1.4 Probable Runoff for Sunsari River at E-W Highway Point, cum/s

Probability (%)		50	60	70	80	90	Average of Estimated Runoff
Jan.	F	4.876	4.397	4.176	4.048	3.805	4.953
	M	5.049	4.553	4.323	4.191	3.939	5.128
	L	4.620	4.166	3.956	3.835	3.605	4.693
Feb.	F	4.700	4.238	4.025	3.902	3.667	4.774
	M	4.763	4.295	4.079	3.954	3.717	4.838
	L	4.631	4.176	3.966	3.845	3.613	4.704
Mar.	F	4.449	4.012	3.810	3.694	3.472	4.519
	M	4.479	4.039	3.836	3.719	3.495	4.550
	L	4.929	4.445	4.221	4.093	3.846	5.007
Apr.	F	4.982	4.493	4.267	4.136	3.888	5.061
	M	5.278	4.760	4.520	4.382	4.119	5.362
	L	6.978	6.292	5.976	5.793	5.445	7.088
May	F	7.782	7.018	6.665	6.461	6.073	7.905
	M	10.466	9.438	8.963	8.689	8.166	10.631
	L	12.189	10.992	10.439	10.120	9.511	12.382
June	F	16.242	14.647	13.909	13.484	12.673	16.498
	M	25.565	23.055	21.894	21.225	19.949	25.969
	L	25.515	23.009	21.850	21.183	19.909	25.918
July	F	39.390	35.522	33.733	32.703	30.736	40.013
	M	36.207	32.652	31.007	30.060	28.253	36.779
	L	42.303	38.149	36.227	35.121	33.009	42.972
Aug.	F	31.935	28.799	27.348	26.513	24.919	32.439
	M	36.048	32.508	30.870	29.928	28.128	36.617
	L	29.465	26.572	25.233	24.463	22.992	29.931
Sep.	F	27.035	24.380	23.152	22.445	21.095	27.462
	M	32.291	29.120	27.653	26.809	25.196	32.801
	L	23.664	21.341	20.266	19.647	18.465	24.038
Oct.	F	17.912	16.153	15.339	14.871	13.977	18.195
	M	15.225	13.730	13.038	12.640	11.880	15.465
	L	8.859	7.989	7.587	7.355	6.913	8.999
Nov.	F	6.743	6.081	5.774	5.598	5.261	6.849
	M	5.936	5.353	5.083	4.928	4.632	6.030
	L	4.889	4.409	4.187	4.059	3.815	4.966
Dec.	F	5.156	4.649	4.415	4.280	4.023	5.237
	M	4.772	4.304	4.087	3.962	3.724	4.848
	L	4.920	4.437	4.213	4.084	3.839	4.997
Total (MCM)		466.7	420.9	399.7	387.5	364.2	474.1

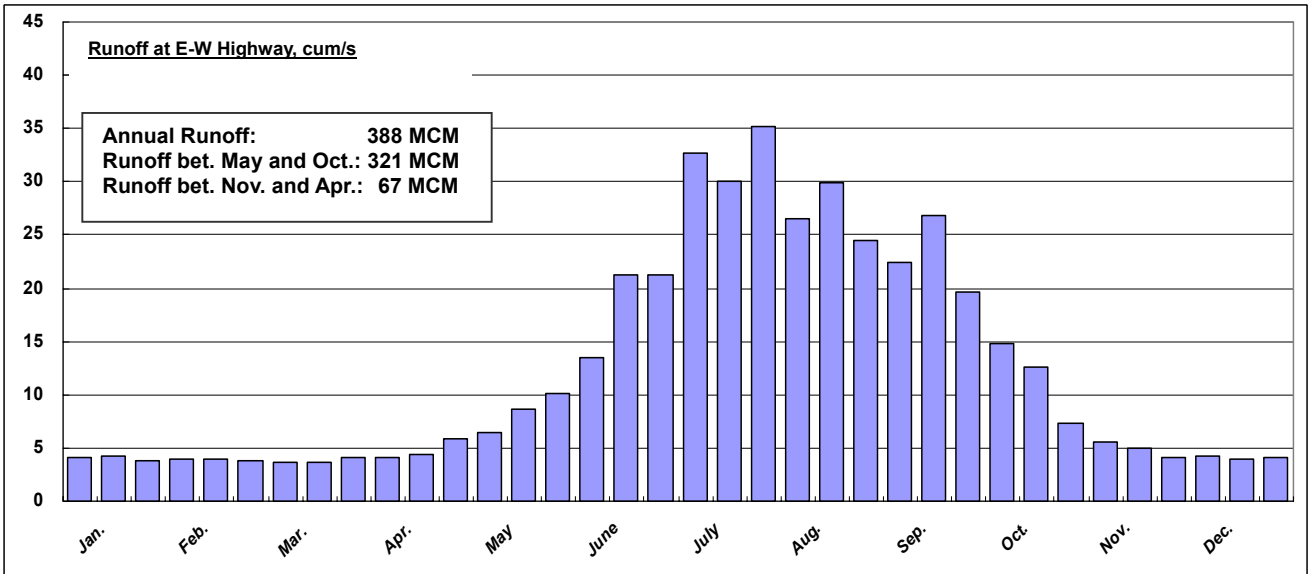


Figure 5.1.9 Runoff for Sunsari River at E-W Highway Point with P80%, cum/s

5.2 Groundwater Potential

5.2.1 Topography and Geology

The Study area is located at 26° 24′ N to 26° 30′ N in latitude and 87° 04′ E to 87° 12′ E in longitude, falling in a northern part of the Indo-Gangetic plain. The terrain starts from the foothills of the Siwalik range and slopes gently down to south with an inclination of five degrees on the average. The terrain of the Study area ranges between 64 to 80 m in elevation and is formed by alluvium of old and present rivers.

Tectonically/Geologically surroundings of the Study area can be divided into four zones: the Alluvial Formation, Siwalik Group, Takure Formation and Seti Formation. The Alluvial Formation un-conformably overlies Siwalik Group. Siwalik Group contacts in fault with Takure Formation. Also, Takure Formation contacts in fault with Seti Formation. Table 5.2.1 summarizes the stratigraphic classification and outline of the general geology around the Study area:

Table 5.2.1 The Stratigraphic Classification of the Study Area

Quaternary (Recent)	Alluvium	Boulder, Gravel, sand and Silt-Clay	The Study Area, Bhabar Zone (Alluvial Fan)
Mid-Miocene - Pleistocene	Siwalik Group (Churia)	Fine to medium grained arkosic pebbly sandstone, unconsolidated conglomerate. Fine grained, hard gray sandstone inter-bedded with purple colored shale	Siwalik Range (Mountain)
Permo - Corboniferous	Takure Formation	Sandstone, quartzitic sandstone, graphitic coals, chloritic phyllites	(Mountain)
Precambrian	Seti Formation	Gray to greenish gray phyllites, quartzites with minor conglomeratic	(Mountain)

The Terai plain was created by tectonic upheaval of Himalayas and development of fore deep of Indo-Gangetic basin a million years ago[1]. When Himalayas rose to this final shape, a fore deep was created in which Siwalik and older sediment layers sunk in the trough. Now Siwalik rock lies at a depth of 1.2 to 1.5 km below the Terai alluvium.

The alluviums in Nepalese Terai were deposited by sediment derived from nearby mountains. Lithology of top part of the alluvium beds is found to be similar to those rocks exposed in nearby mountains. Not all rivers which are at presents flowing through Terai have contributed to the deposition. Only major rivers like the Koshi, having antecedent nature, had deposited first in the basin. Later on when other rivers came into existence, they also started depositing on the top of older material.

The Study area is underlain by unconsolidated alluvial deposit. This formation is irregular alternating beds of silt, sand and gravel. These deposits grade laterally and vertically into each other. Local boulders are found with a scattered pattern outcrops at a construction site of road and bridge. The unconsolidated sedimentary deposits are mostly pervious and make an excellent aquifer.

[1] Sedimentary environment on the Study area is based largely on Sharma C.K., 1995 Shallow Aquifers of Nepal.

5.2.2 Hydrogeology

Groundwater table contour line in above sea level around the Study area is shown in Figure 5.2.1 together with the available observation wells including a deep tube well constructed by this Study. According to monitoring records of the existing tube-wells, groundwater is found widespread, and exists in the relatively shallow subsurface beneath most of the Study area. Groundwater flows approximately northwest to southeast along the landform of the Study area. The groundwater is composed of confined aquifer and unconfined aquifer. Confined aquifer exists deeper than about 50 meters below the ground surface, while unconfined aquifer is limited to a depth of about 50 m.

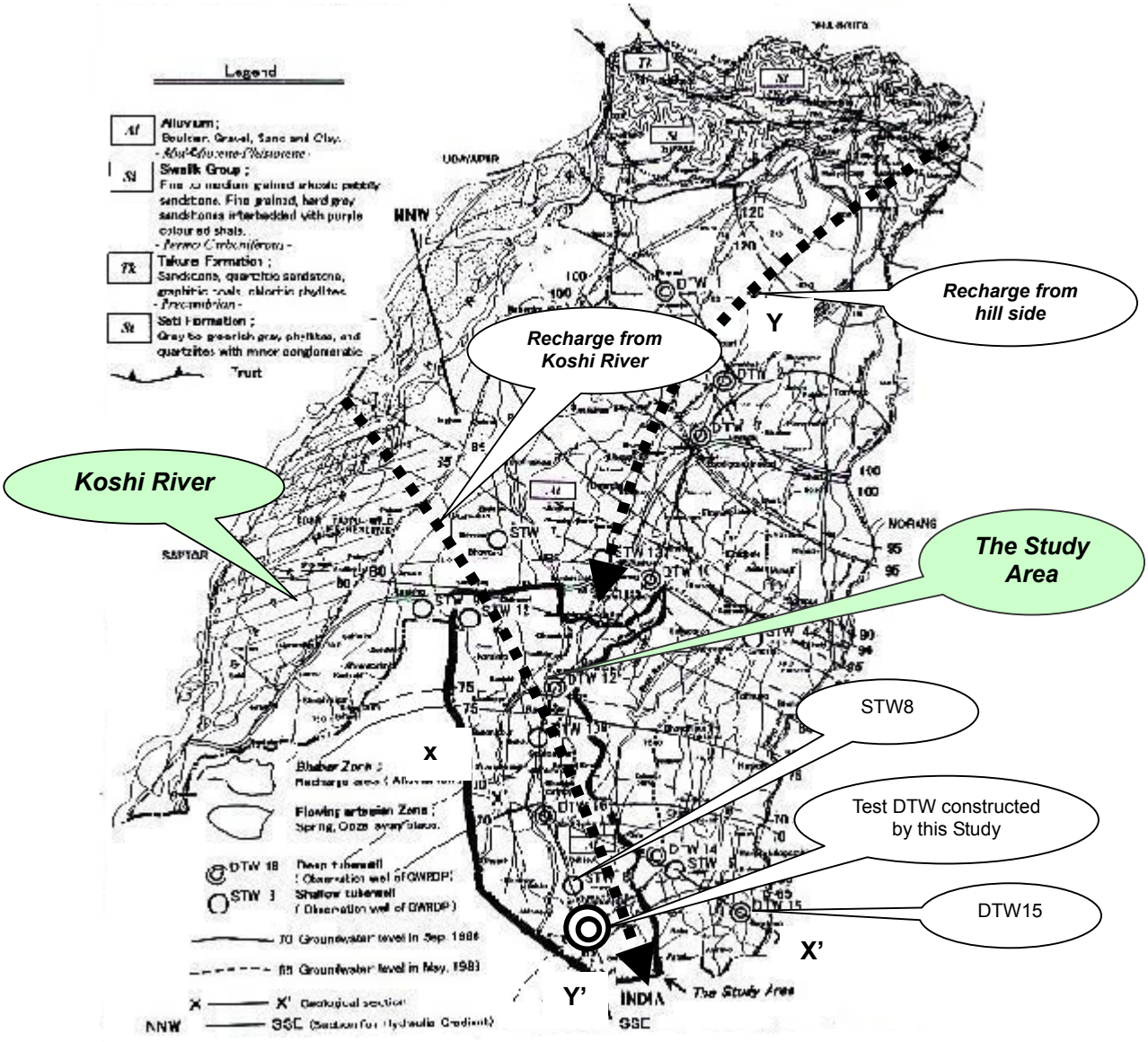


Figure 5.2.1 Hydro-geological Map of the Study Area

Unconfined aquifer is subject to fluctuations according to the seasons of the year and local irrigation practices. A monitoring of groundwater level in the Study area indicates that groundwater table in unconsolidated aquifer varies seasonally, very often in response to climatic variations. The monthly groundwater level of STW-8, located at Dewanganj which is one of the typical shallow tube-well areas in the Study area, varies from 1.5 m to 6.5 m

below the ground surface (see Figure 5.2.2).

This condition is almost same as on deep tube-wells, i.e. DTW-10 and DTW-15 that are located at just north and east from the Study area respectively (see Figure 5.2.3 for DTW-15). These tube-wells were installed with screen in both un-confined and confined aquifer. Groundwater level rises from May to August and decreases from September to April. That fluctuation range is about 3 – 5 m.

Rainfall, falling in the mountains and Terai plain, is the principal source of groundwater in the Study area. Rainfall supplies the unconfined aquifer with the water passing through Bhabar zone or directly. Confined aquifer is also recharged by rainfall but it does not come into directly. As aforementioned Figure 5.2.1 shows, groundwater flow at northern side of the Study area is indicated almost from NNE to SSW correspondent to the topographic condition which is hilly area to Terai plain.

The Koshi river is another major source of groundwater recharge to the Study area. As Figure 5.2.4 shows, the Koshi river connects to the Sunsari river, the Old Sunsari river and the Budhi river with unconfined aquifer. Contour of the groundwater table given in Figure 5.2.1 shows a groundwater flow from northwest to southeast as we move to southern part of the Study area, implying much recharge from the Koshi river. The Koshi river recharges both the unconfined and the confined aquifer.

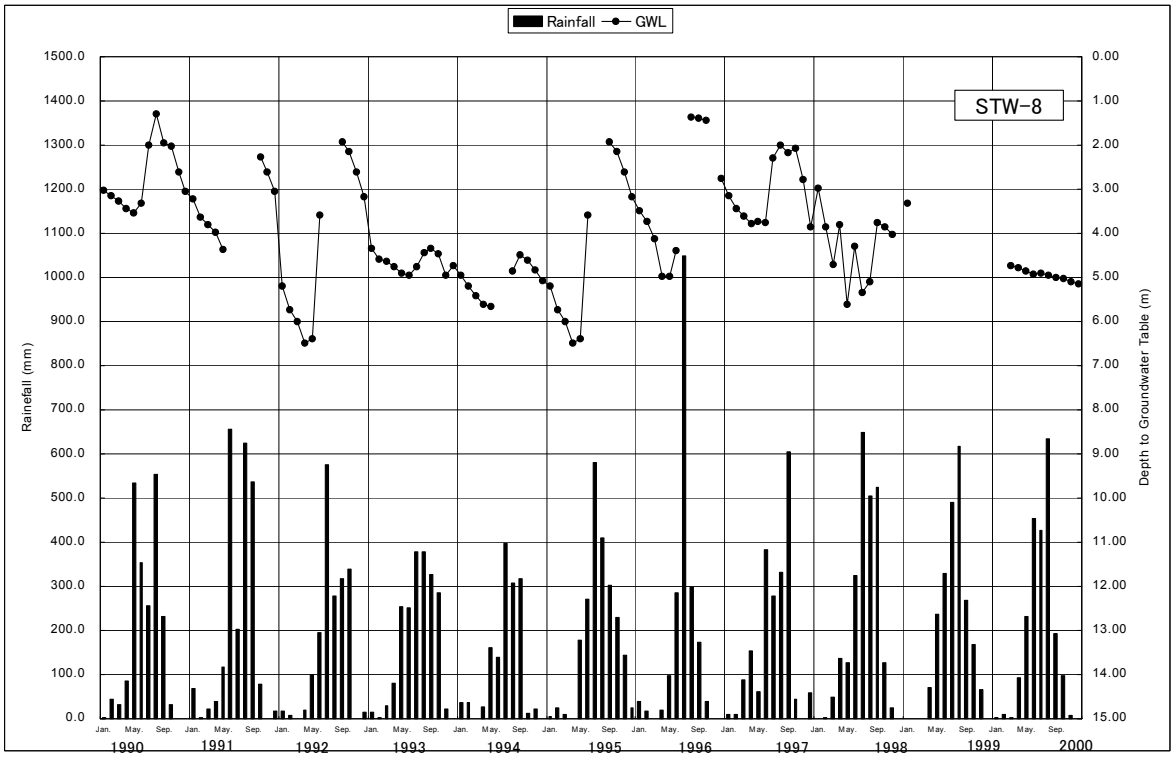


Figure 5.2.2 Depth to Groundwater Table of the Shallow Tube-well (STW-8)

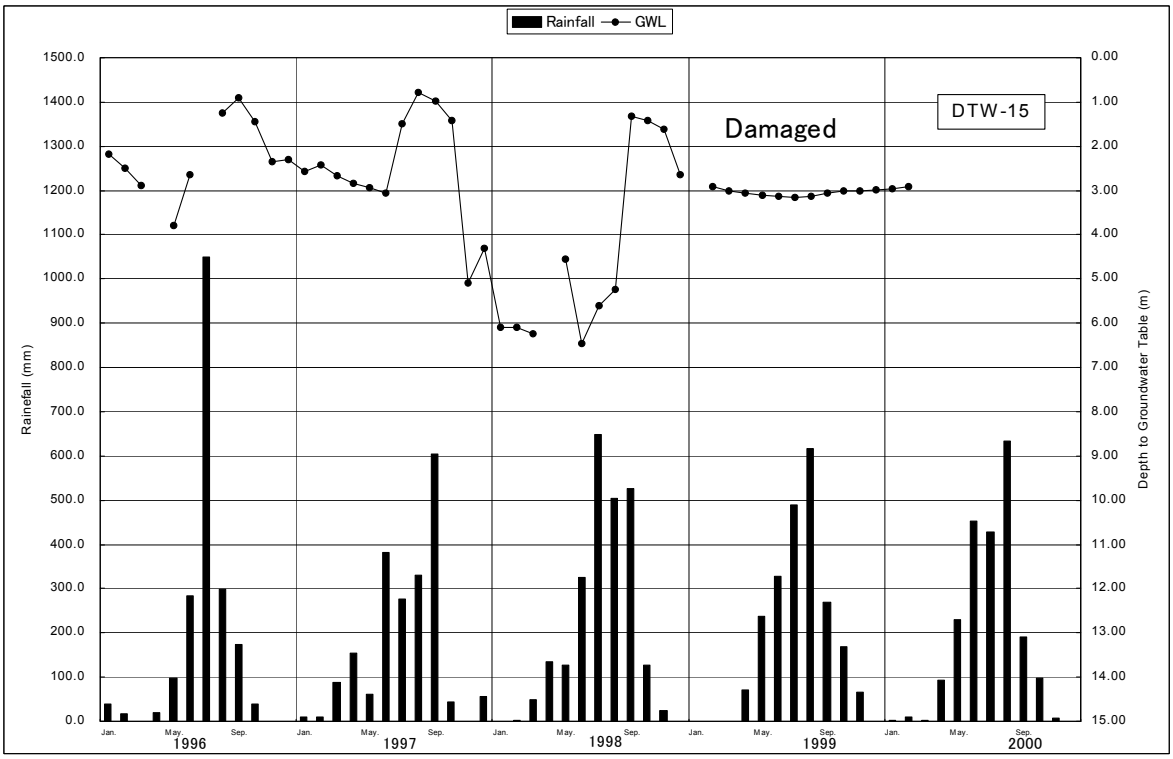


Figure 5.2.3 Depth to Groundwater Table of the Deep Tube-well (DTW-15)

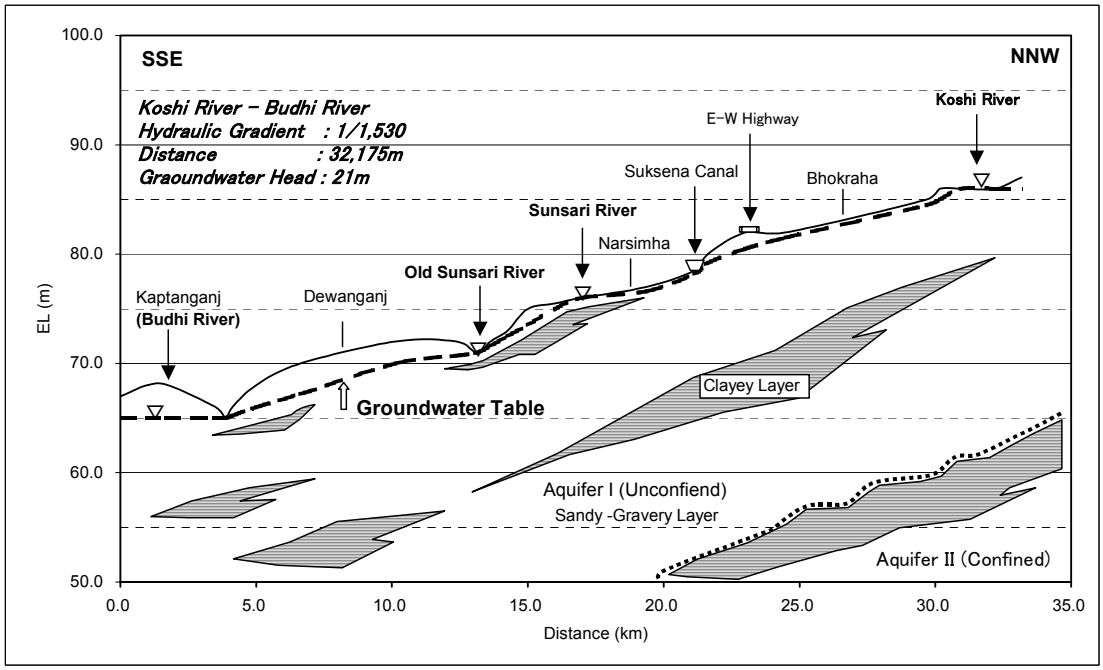


Figure 5.2.4 Groundwater Recharge System from Koshi River

5.2.3 Existing Observation Well

In Sunsari district, seventeen observation shallow tube-wells were drilled in 1989 and further sixteen observation deep tube-wells drilled in 1996 by Groundwater Resources Development Project (GWRDP). The Study Team selects 9 shallow tube-wells and 5 deep tube-wells from above wells which have relation to the Study area from the view point of hydro-geology. Table 5.2.2 summarizes the data:

Table 5.2.2 Pumping Test Result of the Existing Wells

Test Items	Sallow Tube-well			Deep Tube-Well		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Well Depth (m)	13.7	50.9	30.2	55.48	120	87.30
Screen Lange (m)	2.86	10.00	5.98	8.74	33.24	20.40
Aquifer type	Unconfined			Unconfined and Confined		
SWL (bgl m)	1.01	3.47	2.52	4.13	11.63	6.10
Draw-down (m)	1.01	4.54	2.59	1.62	12.17	4.81
Discharge (l/s)	2.00	24.00	18.19	30.00	39.00	35.16
Specific Capacity (l/s/m)	4.41	23.76	9.58	2.94	18.52	11.93
Transmissivity (m2/d)	900	4300	1920	-	-	-
Storage Coefficient	-	-	-	-	-	-

SWL: Static Water Level
bgl: below ground level

Above table shows that discharge ranges between 2 to as much as 24 l/s and 30 to about 40 l/s for shallow tubewell and deep tubewell respectively. Shallow aquifer shows very promising groundwater potential. Though the discharges of deep tubewell in the above table are not much attractive, this may have been due to poor well construction or otherwise insufficient capacity of the pump employed for the pumping test.

A Shallow Tubewell yielding about 20 l/s

5.2.4 Test Deep Tubewell

Accumulated data indicate incompetent as basic data on hydro-geological contents such as transmissivity, storage coefficient, drawdown and radius of influence particularly for planning irrigation and well design. These data are indispensable for groundwater condition. Therefore this Study has constructed a test deep tubewell with 10/6" diameter and an observation well with 4" diameter at distance of 50m. The depth of the wells is 120 m each. The drilling site is located at Kaptanganj VDC, just west of the Kaptanganj Police Station (for the location, see Figure 5.2.1).

Existing lithological data of the Study area found that there are three aquifer layers (for detail discussion, see Section 5.2.5) in the Study area. From the present data of drilling log and the electric log, it is also found that there is presence of all the aquifers and confining layers as mentioned in the Section 5.2.5. The summary of the aquifer and lithological status found in the Kaptanganj drilling site is presented in Table 5.2.3 below:

Table 5.2.3 Summary of Aquifer and Geological Status of Kaptanganj

Aquifer	Depth in m (bgl)	Thickness (m)	Geology
Aquifer I (unconfined)	upto 42m	Upper 32m, Lower 3m	Alternative layers of fine to medium sand and medium to coarse sand with some fine Gravels
1st Confining layer	42m	2m	Silty Clay
Aquifer II (confined)	44m	12m	Medium to coarse sand with some fine gravel
2nd Confining layer	56m	5m	Sandy Clay
Aquifer III (confined)	61m	>60m	Alternative layer of fine to medium sand and gravel with coarse sand
3rd Confining layer			Beyond this depth of study

1) Transmissivity (T)

According to the well design, the Aquifer II and Aquifer III were tapped for the tube well. Both of them, Aquifers II and III, are confined type. As per the pumping test result, the drawdown were found as 0.045m in observation well and 14.71m in test well under pumping discharge of 30 l/s respectively. The Transmissivity for this location is calculated by using Jocob Method, giving 4312 m^2/day.

2) Storage Coefficient (S)

Storage coefficient value for confining aquifer usually falls in a rage of 0.0005-0.005. From the analysis of the pumping test, the Storage Coefficient for the Kaptanganj area is found to be 0.003.

3) Radius of Influence (R)

The radius of influence is a function of time of pumping, the capacity of the well and the aquifer characteristics. The radius of influence for the Kaptanganj area was calculated by Jacob formula (distance-drawdown relationship). It is found to be 50 m.

5.2.5 Aquifers

Aquifer characteristics of the Study area are established on basis of the existing shallow and deep tube wells and the test deep well constructed by this Study. Three major aquifers are identical named as Aquifer I, Aquifer II and Aquifer III. The Aquifer I is unconfined type whereas Aquifer II and Aquifer III are confined type. All the Aquifers are sloping down toward south, nearly parallel to the topography. Figure 5.2.5 shows the hydro-geological cross sections from north to south (along Y-Y' section shown in aforementioned Figure 5.2.1).

1) Aquifer I Unconfined Type

The thickness of Aquifer I varies approximately from 40 to 50 m. The Aquifer I is classified into two layers by composition namely Upper layer and Lower layer. The thickness of the Upper layer varies from 25 to 35m. This layer is composed of mainly sand. Some lenses of clay layers with thickness of few meters to ten meters are found in this Upper layer. Almost all the shallow tube-wells that were drilled up to this depth and tapped lower part of this Upper layer aquifer. This Study carried out simple pumping test on 5 existing STWs by using the farmers' diesel engine, and found that the average discharge is about 20 l/s (see Table 5.2.4 below).

Table 5.2.4 Result of Pump Running Test of Sallow Tube Well

Location	Pump	Depth (m)	Establish	Operating Time (h/Y)	Discharge (l/s)
RAMNAGAR BHUTAHA VDC Nathunitol	Centrifugal 5.5hp, 4"	15	1999	500hr/Y(Dec. –Feb.) 0.67ha/6hr	21.9 22.2
HARINAGARA VDC Kumaltol	Centrifugal 5.5hp, 4"	27	1993	1500hr/Y 1200hr/(Dec.-Feb.)	20.1 18.8
MADHYA HARASAHI VDC Madhya Harasahi	Centrifugal 7hp, 4"	14	1999	25hr/Y/3.35ha for Wheat	23.7 23.3
DEWANGANJ VDC Yadavtol	Centrifugal 5.5hp, 3"	18	1998	1500hr/(Dec.-Feb.) for Wheat, Vegetable	13.7 13.6
KAPTANGANJ VDC Shankarpur	Centrifugal 5.5hp, 4"	15	1996	1200hr/(Dec.-Feb.) for Wheat, Vegetable	Pump Trouble -
Max.	**4" (100mm)**	-	-	-	23.7
Min.		-	-	-	18.8
Ave.		-	-	-	**21.6**
Max.	**3" (75mm)**	-	-	-	13.7
Min.		-	-	-	13.6
Ave.		-	-	-	**13.65**

The average discharge is found at 20l/s (21.6 l + 13.65 l. *(4"/3"))/2 = 19.9 i.e. avg. 20 .l/s of STW

The transmissivity of this upper layer is calculated from the Logan's approximation theory. In this area, the maximum transmissivity is found to be 2710 m^2/day whereas the minimum is 502 m^2/day, and the average is about 1200 m^2/day. The range of storage coefficient for the unconfined aquifer is considered at 0.05 to 0.3.

The Lower layer of the Aquifer I is composed of mainly sandy gravel and its thickness is about 15 to 25 m. Most of the deep tube-wells in and around this area tapped this Lower layer of unconfined aquifer as well. Then, the first confining layer composed of clay/sticky clay underlies the Aquifer I. Its thickness varies from 1 to 3 m.

2) Aquifer II Confined Type

This aquifer underlies the first confining layer at a depth of about 55 m below ground level. This aquifer is composed of mainly sandy gravel and pebble. The thickness of this aquifer varies from about 4 m to 25 m. In the hydro-geological cross section Y-Y', it is clearly seen that the Aquifer II is thicker toward the North of the Study area about 25 m and thinning out toward South-West Indo-Nepal border to about 4 m.

Almost all the deep tube-wells in this area tapped this Aquifer II and it is found that an average discharge is about 35 l/s. The maximum transmissivity is found 1983 m^2/day whereas the minimum is 1590 m^2/day (considering the DTW 15 and DTW16 in the Study area) and the average is about 1800 m^2/day. The storage coefficient for the confined aquifer is considered as a range from 0.0005 to 0.005.

The second confining layer underlies the Aquifer II at a depth of about 55 to 75 m below ground level. The composition of this confining layer varies from north to south direction. To the North, the composition of this layer is found to be sticky clay which changes to silty/sandy clay toward the south of this area. The thickness of this layer varies from about 10 m to the north to about 20m to the south Indo-Nepal border.

3) Aquifer III Confined Type

This aquifer underlies the second confining layer at a depth of 70 to 80 m below ground level. The composition of this aquifer is mainly sandy gravel, pebble and boulder. The thickness of this aquifer is about 20 m that continues throughout the area from north to south but it is thinning out toward south-east. This aquifer is tapped by those deep tube-wells which have more than 60 m depth.

Since the existing deep tube-wells of this area tapped multi-aquifers that is Aquifer I (unconfined), Aquifer II (confined) and Aquifer III (confined), the result of aquifer test have been found similar to Aquifer II. In this case, the transmissivity of Aquifer III is also found similar to Aquifer II.

Below this Aquifer III, the third confining layer underlies at a depth of about 90 to 100 m below ground level. The composition of this confining layer is same as second confining layer; that is, sticky clay to the north and changing to south as silty-sandy clay. The thickness of this confining layer remains unknown due to the lack of deeper lithological data.

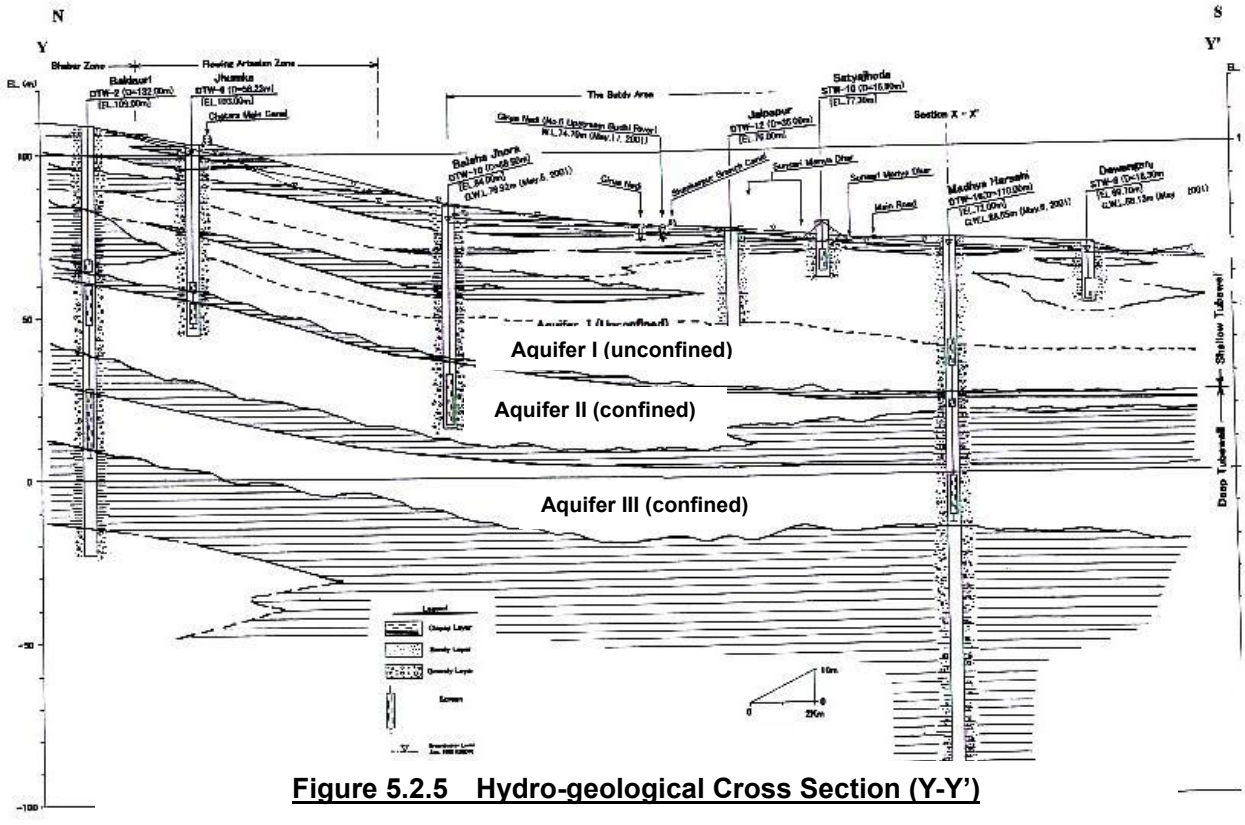


Figure 5.2.5 Hydro-geological Cross Section (Y-Y')

5.3 Water Release from SMIP

This sub-chapter examines if SMIP has any extra water that can be used for JICA Sunsari study area. The new intake of SMIP with 60 cum/s was completed in 1996 and undergone test operation during 1997 and 1998. The SMIP is still operated with the old design discharge of 45 cum/s being the maximum because about 30,000 ha on-farm has not yet been developed. The SMIP is, though it is not enough, giving some amount of water to the JICA Sunsari area.

5.3.1 Approach of the Examination

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 Sunsari River Irrigation Project (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.

1) Intake Capacity

As the first step, the Team examines 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 examines 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

2) 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 has to estimate the water requirement for 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 further

takes into account future development areas by using drainage water and existing rivers.

The cropping patterns to be referred in estimating the water requirement are the present pattern given by SMIP's seasonal crop coverage report of 1999/00 and also proposed patterns by 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 patterns are 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 planed area.

3) SRIP Demand Driven Mode

This mode examines the water release from SMIP on basis of SRIP demand driven for which the water release to SRIP 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 should be delineated within the SMIP whole command area (not all the SRIP area is in the SMIP). For operational point of view, the present cultivable command area (CCA) of SMIP which falls in SRIP command area is to 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.

5.3.2 Examination and Findings

1) Available Data (WL & Q)

Data for Koshi river's water level and discharge were collected from the Department of Hydrology and Meteorology (DHM). The data is at Station No.695, located 975m upstream from the Chatra new intake, and covers a period of January 1990 to June 2002. Data relative to Chatra were collected from SMIP office, 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 5.3.1, having some missing periods. The Koshi river's data, therefore, supplements the missing data at Chatra intake by using a linear correlation, and also serves 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)

Table 5.3.1 Available Data for Koshi River WL&Q, Chatra Intake WL and Chatra MC Q

Year	Item	J	F	M	A	M	J	J	A	S	O	N	D	Remarks
1996	Koshi WL, Q													Available 90 - 95
	Chatra WL													At the intake
	Chatra Q													At Hydro PS
1997	Koshi WL, Q													
	Chatra WL													
	Chatra Q													
1998	Koshi WL, Q													
	Chatra WL													
	Chatra Q													
1999	Koshi WL, Q													
	Chatra WL													
	Chatra Q													
2000	Koshi WL, Q													
	Chatra WL													
	Chatra Q													
2001	Koshi WL, Q													
	Chatra WL													
	Chatra Q													
2002	Koshi WL, Q													
	Chatra WL													
	Chatra Q													

2) Koshi River's WL and Chatra Intake's WL

Figure 5.3.1 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 5.3.2 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 lowest water level in the beginning of 1990s was about 109.4m, but now it is around 107.7m. The Koshi river's water level has lowered by bout 1.7m for the last 13 years (13cm/year).

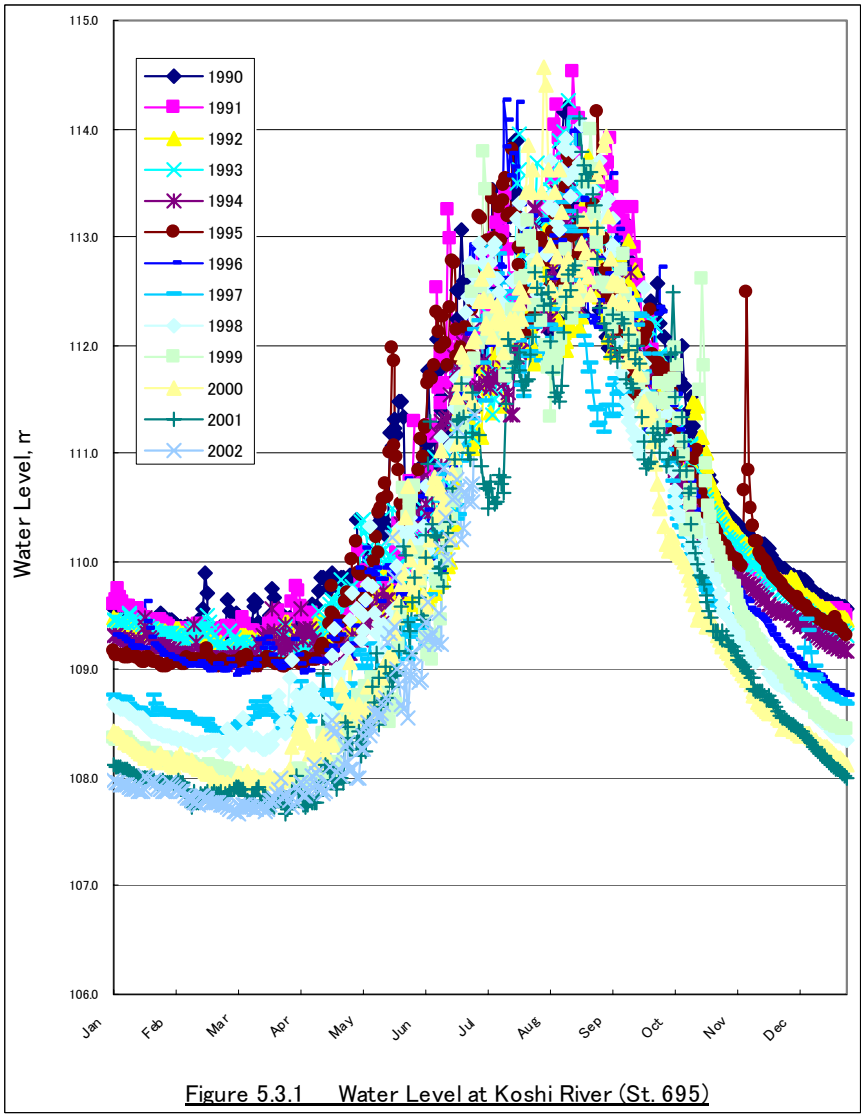


Figure 5.3.1 Water Level at Koshi River (St. 695)

Figure 5.3.3 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[2] 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 5.3.4 tells us the water level during lean season has a tendency of lowering at least for the last three years (2000 – 2002).

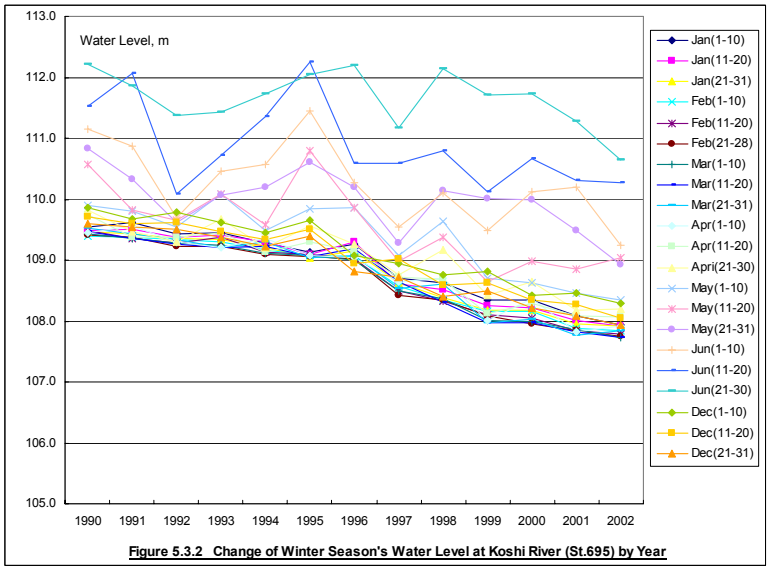


Figure 5.3.2 Change of Winter Season's Water Level at Koshi River (St.695) by Year

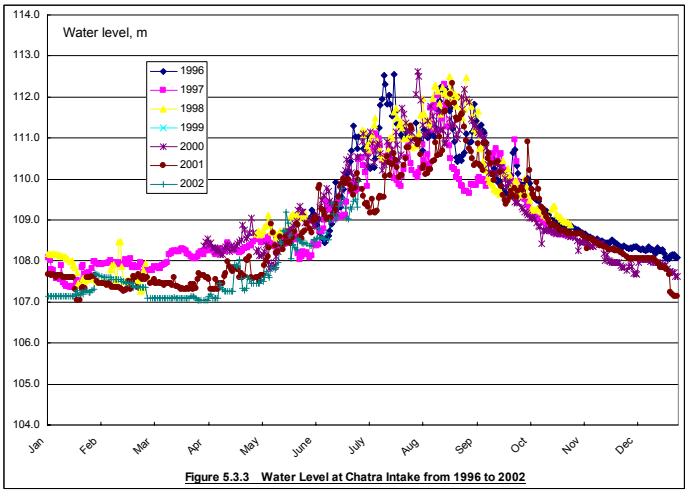


Figure 5.3.3 Water Level at Chatra Intake from 1996 to 2002

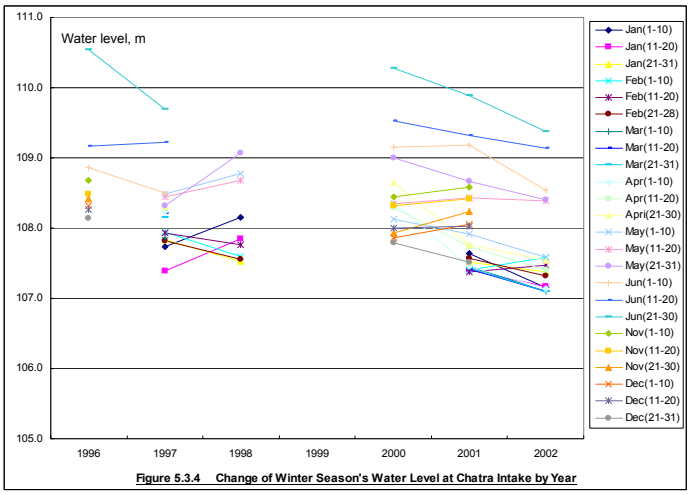


Figure 5.3.4 Change of Winter Season's Water Level at Chatra Intake by Year

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: $Vc = \sqrt{g \times hc}$

Velocity head: $hv = Vc \times Vc / 2g$

Where: g: gravity (9.8 m/s/s)

hc: overflowing depth (critical flow depth, m)

[2] 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.

Figure 5.3.5 shows the calculated capacity based on such data as; 1) 80% probability[3], 2) last 3 years average, 3) last 2 years average, and 4) latest year 2002 data. Also, Figure 5.3.6 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).

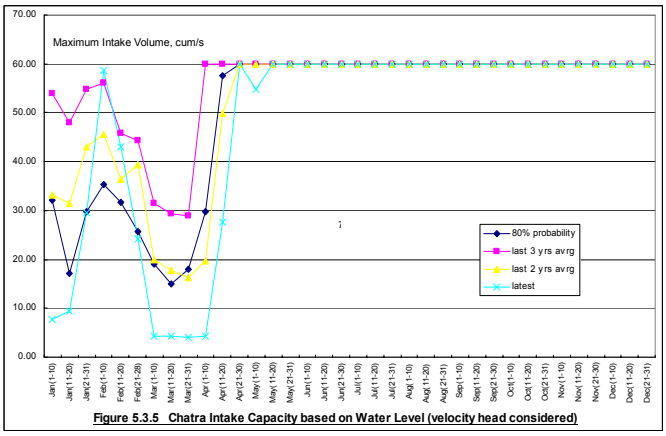


Figure 5.3.5 Chatra Intake Capacity based on Water Level (velocity head considered)

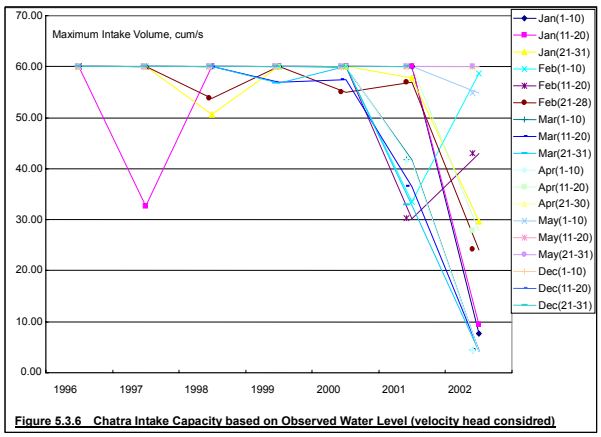


Figure 5.3.6 Chatra Intake Capacity based on Observed Water Level (velocity head considered)

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. Figure 5.3.7 and Table 5.3.2 show 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.

Table 5.3.2 Koshi River Water Level Forecast based on Trend between 1997 and 2002, and Probable Year that Chatra Intake stops withdrawing water with Different Qs

Term	Koshi River Water Level (St. 695) Forecast year									Probable Year with Different Q Limit									
										Velocity head not considered				Velocity head considered 0.171			Average		
	2002	2003	2004	2005	2006	2007	2008	2009	2010	Q=30 cum/s	Q=20 cum/s	Q=10 cum/s	Q=0 cum/s	Q=30 cum/s	Q=20 cum/s	Q=10 cum/s	Q=30 cum/s	Q=20 cum/s	Q=10 cum/s
Jan(1-10)	107.79	107.64	107.48	107.32	107.17					2002.4	2003.5	2004.7	2006.8	2003.9	2004.6	2005.4	2003.1	2004.0	2005.1
Jan(11-20)	107.75	107.61	107.47	107.33	107.18					2002.1	2003.2	2004.6	2007.0	2003.7	2004.5	2005.4	2002.9	2003.8	2005.0
Jan(21-31)	107.71	107.58	107.44	107.30	107.16					2001.7	2002.9	2004.4	2006.8	2003.4	2004.2	2005.2	2002.6	2003.6	2004.8
Feb(1-10)	107.65	107.51	107.36	107.22	107.07					2001.3	2002.5	2003.9	2006.2	2003.0	2003.7	2004.6	2002.1	2003.1	2004.2
Feb(11-20)	107.59	107.44	107.30	107.16	107.01					2000.9	2002.1	2003.4	2005.8	2002.5	2003.3	2004.2	2001.7	2002.7	2003.8
Feb(21-28)	107.57	107.43	107.29	107.14	107.00					2000.8	2002.0	2003.3	2005.7	2002.4	2003.2	2004.1	2001.6	2002.6	2003.7
Mar(1-10)	107.53	107.37	107.22	107.06	106.91					2000.7	2001.8	2003.0	2005.2	2002.2	2002.9	2003.7	2001.4	2002.3	2003.4
Mar(11-20)	107.48	107.31	107.13	106.96	106.79					2000.6	2001.6	2002.7	2004.7	2002.0	2002.6	2003.4	2001.3	2002.1	2003.0
Mar(21-31)	107.52	107.35	107.18	107.01	106.84					2000.8	2001.8	2003.0	2005.0	2002.2	2002.8	2003.6	2001.5	2002.3	2003.3
Apr(1-10)	107.66	107.49	107.32	107.15	106.98					2001.6	2002.6	2003.8	2005.8	2003.0	2003.6	2004.4	2002.3	2003.1	2004.1
Apr(11-20)	107.82	107.68	107.54	107.40	107.26	107.12				2002.5	2003.7	2005.1	2007.5	2004.2	2005.0	2005.9	2003.4	2004.3	2005.5
Apri(21-30)	108.01	107.85	107.70	107.54	107.38	107.22	107.06			2003.8	2004.8	2006.1	2008.2	2005.3	2005.9	2006.8	2004.5	2005.4	2006.4
May(1-10)	108.07	107.86	107.66	107.45	107.24	107.03				2003.9	2004.7	2005.6	2007.2	2005.0	2005.5	2006.2	2004.4	2005.1	2005.9
May(11-20)	108.88	108.85	108.82	108.79	108.77	108.74	108.71	108.69		2039.5	2045.6	2052.9	2065.3	2048.1	2052.1	2057.0	2043.8	2048.9	2054.9
May(21-31)	109.26	109.16	109.05	108.94	108.83	108.73	108.62	108.51		2015.9	2017.4	2019.3	2022.4	2018.0	2019.1	2020.3	2017.0	2018.2	2019.8
Jun(1-10)	109.72	109.70	109.68	109.67	109.65	109.63	109.62	109.60		2110.9	2120.6	2132.3	2152.1	2124.7	2131.0	2138.8	2117.8	2125.8	2135.5
Jun(11-20)	110.22	110.15	110.08	110.01	109.94	109.87	109.80	109.73		2036.4	2038.8	2041.6	2046.4	2039.7	2041.3	2043.2	2038.1	2040.0	2042.4
Jun(21-30)	110.93	110.78	110.63	110.48	110.33	110.18	110.04	109.89		2023.3	2024.4	2025.7	2028.0	2024.9	2025.6	2026.5	2024.1	2025.0	2026.1
Nov(1-10)	109.01	108.93	108.85	108.77	108.69	108.60	108.52	108.44		2016.8	2018.8	2021.2	2025.4	2019.7	2021.0	2022.6	2018.2	2019.9	2021.9
Nov(11-20)	108.63	108.52	108.41	108.30	108.19	108.08	107.97	107.86		2009.8	2011.3	2013.1	2016.2	2011.9	2012.9	2014.1	2010.9	2012.1	2013.6
Nov(21-30)	108.39	108.27	108.16	108.04	107.93	107.81	107.69	107.58		2007.3	2008.7	2010.4	2013.3	2009.3	2010.3	2011.4	2008.3	2009.5	2010.9
Dec(1-10)	108.16	108.03	107.90	107.77	107.64	107.51	107.38	107.25	107.13	2005.1	2006.4	2007.9	2010.5	2006.9	2007.7	2008.8	2006.0	2007.1	2008.3
Dec(11-20)	107.87	107.69	107.51	107.34	107.16					2002.9	2003.8	2004.9	2006.8	2004.2	2004.8	2005.6	2003.5	2004.3	2005.2
Dec(21-31)	107.79	107.64	107.50	107.35	107.20	107.05				2002.4	2003.5	2004.8	2007.1	2003.9	2004.7	2005.6	2003.1	2004.1	2005.2
Koshi WL	107.888	107.723	107.526	107.19	107.655	107.547	107.415	107.772	107.635	107.471									
Chatra W	107.512	107.391	107.246	107.000	107.341	107.261	107.164	107.427	107.326	107.205									

Regression of Koshi WL and Chatra Intake WL
Dry season (December - April)
Chatra Intake WL = 0.7352 x Koshi WL + 28.1852 (R = 0.707)
Monsoon seaon (May - Nobember)
Chatra Intake WL = 0.7429 x Koshi WL + 27.2686 (R = 0.984)

	Q, cum/s	Crest L, m	q, cum/1m	hc, m	Vc, m/s	head (hv), m	T. head, m
hc=0.467q^0.66668	10	48	0.208	0.164	1.269	0.082	0.246
hv=Vc*Vc/2G	20	48	0.417	0.261	1.599	0.131	0.391
	30	48	0.625	0.341	1.831	0.171	0.512
hc: critical flow depth	40	48	0.833	0.414	2.015	0.207	0.621
hv: velocity head	50	48	1.042	0.480	2.171	0.240	0.720
	60	48	1.250	0.542	2.307	0.271	0.813

[3] Since a continuous lowering trend is observed for the water level, this probability does not make sense and is given as a reference only.

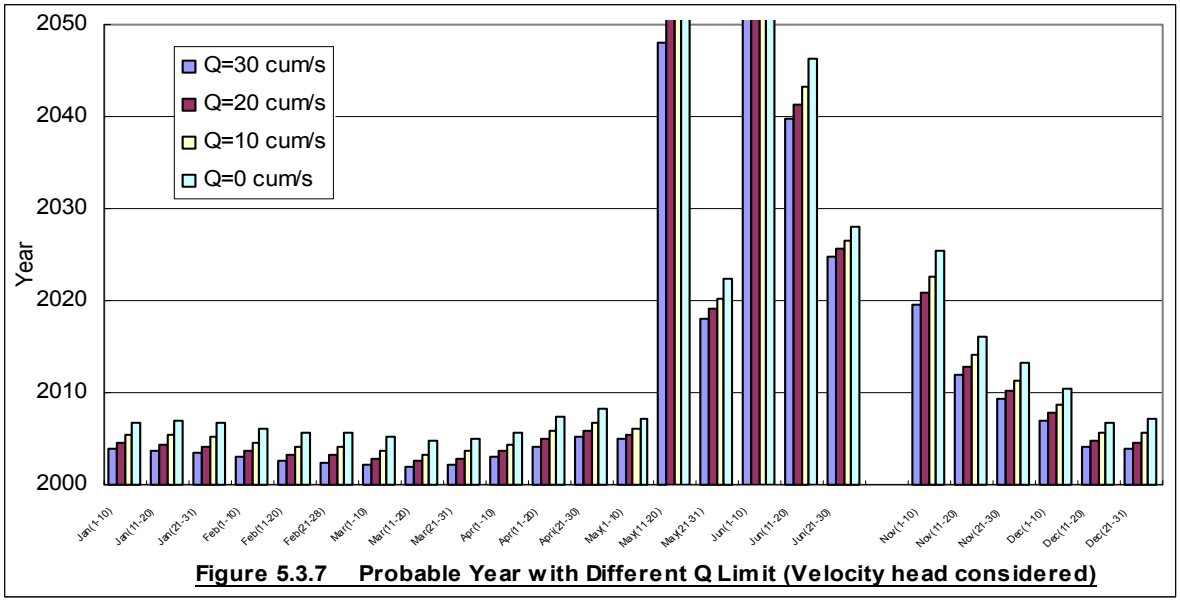


Figure 5.3.7 Probable Year with Different Q Limit (Velocity head considered)

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 Table 5.3.3. In examining the SMIP demand driven, the present probable command area and also future command area are considered. Given the Table 5.3.3, 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 9,050ha[4]. 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[5]. In estimating water requirement, the crop requirements mentioned in the Detailed FS III 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 5.3.4 and Figure 5.3.8 reveal the following:

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

[4] 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.

[5] 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.

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).

Table 5.3.3 Summary of SMIP and SRIP Command Area and SRIP's Judicial Area Proportion to SMIP

Stage Phase		Canal System	Intended Dev't Area	CAD compl'd	Future CAD Dev't	Area lost by urbaniz'n	Area lost by high ele'n	Area ex'd by HW prjt	CCA by SMIP	ISP & SISP	Present Dr'g Area	Future Dr'g Area	Future HW prjt	Operation Plan				Remarks
														CCA (monsoon)	CCA (monsoon)	CCA(OP) - CCA(SMIP)	Irrigated Area	
			ha (net)	ha (net)	ha (net)	ha (net)	ha (net)	(Ch. Mohana)	ha (net)	ha (net)	ha (net)	ha (net)	ha (net)	ha (net)	ha (net)	ha (net)	ha (net)	
Stage I	1	Sunder Gunder	650	650	0				650					385	385	-265	385	
Stage III, Ph3	2	Suksena	15,500	0	15,500				15,500					8,146	8,146	-7,354	7,700	
Stage I	3	CMC2/T1	9,750	9,750	0	300			9,450					203	9,684	234	203	CCA by OP > CAD
	4	CMC 1-9												388			388	
	5	Ramdhuni												371			368	
	6	Manikchauri												1,295			1,290	
	7	Singhiya												740			740	
	8	Shankarpur												6,687			6,630	
Stage II	9	Jhumka(SSJ)	16,600	16,600	0		50	1,000	15,550					946	16,605	1,055	946	CCA by OP > CAD
	10	Vishrampur(S8)												403			403	
	11	Sitagunj(S9)												7,985			7,860	
	12	Ramgunj(S10)												6,845			6,380	
	13	Duhabi(S12)								1,130 (560) (winter)	3,325 (955) (winter)	3,150 (1,250) (winter)	3,500 (2,100) (winter)	426			426	
Stage III, Ph 1	14	Biratnagar(S13)	15,100	11,200	2,240	1,660	450		12,990					5,184	17,678	4,688	5,030	CCA by OP > CAD
	15	Hattimuda(SS13A)												650			650	
	16	S14-T1												197			197	
	17	S14-T2												248			248	
	18	Harinagara(S14)												11,399			11,200	
Stage III, Ph2	19	Hurhuriya	15,400	0	15,400				15,400					960	11,427	-3,973	930	
	20	CMC 10/13-18												330			330	
	21	Bariyati												3,697			3,530	
	22	CMC 11/19-21												165			165	
	23	Nayapati												2,000			1,950	
	24	CMC 12/22&23												110			110	
	25	Amjora												960			930	
	26	Ranjani												960			930	
	27	Chisang												170			170	
	28	Jhamanpur												2,075			2,010	
Total			**73,000**	**38,200**	**33,140**	**1,960**	**500**	**1,000**	**69,540**					**63,925**	**63,925**	**-5,615**	**62,099**	
								deducted	monsoon	68,410	65,085	61,935	58,435					
								deducted	winter	68,980	68,025	66,775	64,675					

JICA Study Area 10,500 Total net, ha
9,050 within SMIP
1,450 outside SMIP (tail end of Shankarpur canal area)

SRIP area portion, % 13.0 base area= 69,540
13.1 **68,980** **Proposed on basis of SMIP command area**
13.3 68,025
13.6 66,775
14.0 64,675
14.2 63,925
14.6 62,099

JICA Study area presently covered by SMIP Plan of Operation
Suksena 3,713 ha
Shankarpur 3,170 ha
Total 6,883 ha

SRIP area portion, % 10.8 base area= 63,925
11.1 **62,099** **Proposed on basis of SMIP actual operation**

SMIP area excluding SRIP
59,900 ha (68,980 - 9,050)
55,625 ha (64,675 - 9,051)

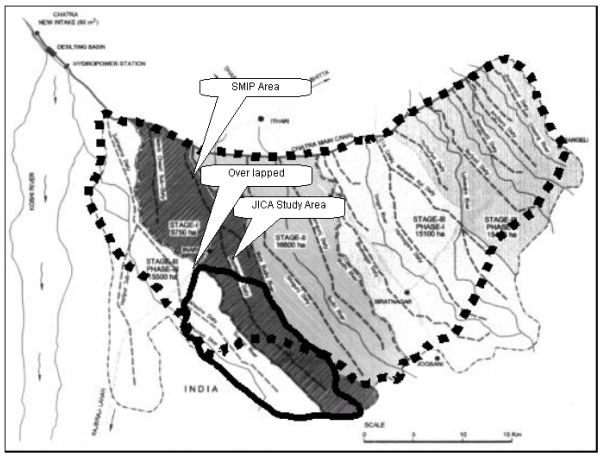


Table 5.3.4 Examination of Water Requirement with various Command Areas and Comparison with Actually Intaken Volume & Probable Q based on WL at Chatra Intake (high percolation area not considered)

Average Actual Q intaken and Probable Q maximum based on WL for 1996 - 2002

Year (96 - 02)	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
Actual Q intaken	21.3	18.5	17.4	19.4	18.1	18.2	18.4	17.0	9.2	8.6	9.6	10.7	9.7	8.9	14.1	20.6	24.8	31.9	32.9	30.6	37.1	34.9	36.6	32.3	32.9	35.7	40.2	31.3	25.5	21.5	10.0	6.5	5.7	5.4	10.1	20.3
Q based on WL	39.4	22.1	30.2	36.1	36.5	30.7	23.4	31.1	30.0	51.4	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	53.0

Water Requirement: Area: 68,980ha (CCA by SMIP inclusive of 9,050 ha SRIP CA and excusive of 50% ISP & SISP Areas)

Present CP	30.0	31.9	30.6	40.7	33.5	29.5	26.0	13.3	4.9	4.8	6.1	5.8	5.2	5.0	8.2	29.9	44.9	52.7	40.2	45.6	31.6	59.8	52.4	54.6	45.1	32.1	44.8	45.9	48.3	43.9	36.5	35.7	30.0	25.7	27.0	25.8
Proposed CP	30.3	32.2	30.9	41.1	33.8	29.8	26.3	13.4	4.9	0.0	0.0	0.0	3.4	4.3	12.0	29.0	43.6	51.1	39.0	44.3	30.7	58.1	50.9	53.0	46.5	33.1	46.1	47.3	49.8	45.2	37.6	36.8	30.9	26.5	27.8	26.6
Alternative A	31.1	32.3	30.2	38.4	31.5	25.9	24.4	14.5	14.7	27.1	32.8	39.3	38.4	30.6	39.3	37.7	51.2	56.7	33.3	34.7	22.0	42.2	37.1	36.9	34.9	25.0	35.2	41.3	49.4	51.0	43.8	43.9	39.4	28.4	28.7	28.2
Alternative B	30.3	31.9	30.4	39.1	30.4	25.6	22.0	11.9	9.7	12.4	15.7	15.0	13.4	12.9	21.4	32.2	46.2	51.2	33.4	36.8	26.9	52.8	49.4	49.4	42.2	29.9	41.8	42.6	46.9	45.4	40.8	40.0	34.2	27.1	27.7	27.1

Water Requirement: Area: 64,675 ha (CCA by SMIP inclusive of 9,050 ha SRIP CA and exclusive of ISP & SISP, Drainage Irrigated Area, Future Drainage Area and Future HW Project Area)

Present CP	28.1	29.9	28.7	38.2	31.4	27.7	24.4	12.5	4.6	4.5	5.7	5.4	4.8	4.6	7.7	28.0	42.1	49.4	37.7	42.8	29.6	56.1	49.1	51.2	42.3	30.1	42.0	43.1	45.3	41.1	34.2	33.4	28.1	24.1	25.3	24.2
Proposed CP	28.4	30.2	29.0	38.6	31.7	28.0	24.7	12.6	4.6	0.0	0.0	0.0	3.2	4.0	11.2	27.2	40.9	47.9	36.6	41.5	28.8	54.5	47.7	49.7	43.6	31.0	43.3	44.4	46.7	42.4	35.3	34.5	29.0	24.8	26.1	24.9
Alternative A	29.2	30.3	28.3	36.0	29.5	24.3	22.8	13.6	13.8	25.4	30.7	36.8	36.0	28.7	36.8	35.4	48.0	53.2	31.2	32.6	20.7	39.6	34.7	34.6	32.7	23.5	33.0	38.7	46.3	47.8	41.1	41.2	36.9	26.7	26.9	26.4
Alternative B	28.4	29.9	28.5	36.7	28.5	24.0	20.6	11.1	9.1	11.6	14.8	14.1	12.6	12.1	20.1	30.2	43.3	48.0	31.3	34.5	25.2	49.5	46.3	46.3	39.6	28.1	39.2	40.0	44.0	42.6	38.2	37.5	32.1	25.4	26.0	25.4

Water Requirement: Area: 59,900ha (68,980 - 9,050:SRIP CA within SMIP)

Present CP	26.0	27.7	26.6	35.4	29.1	25.6	22.6	11.5	4.2	4.1	5.3	5.0	4.5	4.3	7.1	25.9	39.0	45.7	34.9	39.6	27.4	52.0	45.5	47.4	39.2	27.9	38.9	39.9	42.0	38.1	31.7	31.0	26.1	22.3	23.4	22.4
Proposed CP	26.3	28.0	26.9	35.7	29.4	25.9	22.8	11.7	4.3	0.0	0.0	0.0	3.0	3.7	10.4	25.2	37.9	44.4	33.9	38.5	26.6	50.4	44.2	46.0	40.4	28.7	40.1	41.1	43.3	39.3	32.7	31.9	26.9	23.0	24.1	23.1
Alternative A	27.0	28.1	26.2	33.4	27.4	22.5	21.2	12.6	12.8	23.6	28.5	34.1	33.4	26.5	34.1	32.7	44.5	49.2	28.9	30.2	19.1	36.7	32.2	32.0	30.3	21.7	30.6	35.9	42.9	44.2	38.1	38.1	34.2	24.7	24.9	24.5
Alternative B	26.3	27.7	26.4	33.9	26.4	22.2	19.1	10.3	8.4	10.8	13.7	13.0	11.7	11.2	18.6	28.0	40.1	44.5	29.0	31.9	23.3	45.9	42.9	42.9	36.7	26.0	36.3	37.0	40.7	39.4	35.4	34.8	29.7	23.5	24.1	23.5

Water Requirement: Area: 55,625ha (64,675 - 9,050:SRIP CA within SMIP)

Present CP	24.2	25.7	24.7	32.8	27.0	23.8	21.0	10.7	3.9	3.9	4.9	4.7	4.2	4.0	6.6	24.1	36.2	42.5	32.4	36.8	25.5	48.2	42.2	44.0	36.4	25.9	36.1	37.0	39.0	35.4	29.4	28.8	24.2	20.7	21.7	20.8
Proposed CP	24.4	26.0	25.0	33.2	27.3	24.1	21.2	10.8	4.0	0.0	0.0	0.0	2.8	3.4	9.6	23.4	35.2	41.2	31.5	35.7	24.7	46.8	41.0	42.7	37.5	26.7	37.2	38.2	40.2	36.5	30.3	29.7	25.0	21.4	22.4	21.4
Alternative A	25.1	26.1	24.4	31.0	25.4	20.9	19.6	11.7	11.9	21.9	26.4	31.7	31.0	24.7	31.7	30.4	41.3	45.7	26.8	28.0	17.8	34.1	29.9	29.7	28.2	20.2	28.4	33.3	39.8	41.1	35.3	35.4	31.7	22.9	23.2	22.7
Alternative B	24.4	25.7	24.5	31.5	24.5	20.6	17.7	9.6	7.8	10.0	12.7	12.1	10.8	10.4	17.3	26.0	37.3	41.3	26.9	29.7	21.7	42.6	39.8	39.8	34.1	24.1	33.7	34.4	37.8	36.6	32.9	32.3	27.6	21.8	22.3	21.8

Balance bet. Intaken Volume and WR of 59,900ha

Present CP	-4.7	-9.2	-9.2	-15.9	-11.0	-7.4	-4.3	5.4	5.0	4.5	4.4	5.6	5.2	4.6	7.0	-5.4	-14.2	-13.8	-2.0	-9.0	9.7	-17.1	-8.9	-15.1	-6.2	7.9	1.3	-8.6	-16.5	-16.6	-21.6	-24.5	-20.4	-16.9	-13.3	-2.1
Proposed CP	-5.0	-9.5	-9.5	-16.3	-11.3	-7.7	-4.5	5.3	4.9	8.6	9.6	10.7	6.7	5.2	3.7	-4.6	-13.1	-12.5	-1.0	-7.9	10.5	-15.6	-7.6	-13.7	-7.5	7.0	0.1	-9.8	-17.8	-17.8	-22.6	-25.5	-21.2	-17.6	-14.0	-2.8
Alternative A	-5.7	-9.5	-8.9	-13.9	-9.3	-4.3	-2.8	4.3	-3.6	-14.9	-18.8	-23.5	-23.7	-17.6	-20.0	-12.2	-19.7	-17.3	4.0	0.4	17.9	-1.8	4.4	0.3	2.6	14.0	9.6	-4.6	-17.4	-22.8	-28.0	-31.7	-28.5	-19.3	-14.8	-4.2
Alternative B	-5.0	-9.1	-9.0	-14.5	-8.3	-4.0	-0.7	6.7	0.8	-2.1	-4.0	-2.4	-2.0	-2.2	-4.5	-7.4	-15.4	-12.6	3.9	-1.4	13.8	-11.0	-6.3	-10.6	-3.8	9.7	3.9	-5.7	-15.2	-18.0	-25.4	-28.3	-24.0	-18.1	-13.9	-3.2

Balance bet. Probable Q based on WL and WR of 59,900ha

Present CP	13.4	-5.6	3.6	0.7	7.4	5.0	0.8	19.6	25.8	47.3	54.7	55.0	55.5	55.7	52.9	34.1	21.0	14.3	25.1	20.4	32.6	8.0	14.5	12.6	20.8	32.1	21.1	20.1	18.0	21.9	28.3	29.0	33.9	37.7	36.6	30.6
Monthly basis avrg		**3.8**			**4.4**			**15.4**			**52.3**			54.7			23.1			26.0			11.7			24.7			20.0			30.4			**34.9**	
Proposed CP	13.1	-5.9	3.4	0.3	7.1	4.8	0.5	19.5	25.7	51.4	60.0	60.0	57.0	56.3	49.6	34.8	22.1	15.6	26.1	21.5	33.4	9.6	15.8	14.0	19.6	31.3	19.9	18.9	16.7	20.7	27.3	28.1	33.1	37.0	35.9	29.9
Monthly basis avrg		**3.5**			**4.1**			**15.3**			**57.1**			54.3			24.2			27.0			13.1			23.6			18.8			29.5			**34.2**	
Alternative A	12.4	-6.0	4.0	2.7	9.1	8.2	2.2	18.5	17.2	27.9	31.5	25.9	26.6	33.5	25.9	27.3	15.5	10.8	31.1	29.8	40.9	23.3	27.8	28.0	29.7	38.3	29.4	24.1	17.1	15.8	21.9	21.9	25.8	35.3	35.1	28.5
Alternative B	13.1	-5.6	3.9	2.1	10.1	8.5	4.3	20.9	21.6	40.7	46.3	47.0	48.3	48.8	41.4	32.0	19.9	15.5	31.0	28.1	36.7	14.1	17.1	17.1	23.3	34.0	23.7	23.0	19.3	20.6	24.6	25.2	30.3	36.5	35.9	29.5

Balance bet. Intaken Volume and WR of 55,625ha

Present CP	-2.8	-7.2	-7.3	-13.4	-8.9	-5.6	-2.6	6.2	5.3	4.8	4.7	6.0	5.5	4.9	7.5	-3.5	-11.5	-10.5	0.5	-6.2	11.6	-13.4	-5.7	-11.7	-3.5	9.9	4.1	-5.7	-13.5	-13.9	-19.4	-22.3	-18.5	-15.3	-11.6	-0.5
Proposed CP	-3.1	-7.5	-7.6	-13.7	-9.2	-5.9	-2.9	6.1	5.3	8.6	9.6	10.7	6.9	5.5	4.5	-2.8	-10.4	-9.3	1.4	-5.1	12.4	-12.0	-4.4	-10.4	-4.6	9.1	3.0	-6.9	-14.7	-15.0	-20.3	-23.2	-19.2	-16.0	-12.3	-1.2
Alternative A	-3.8	-7.5	-7.0	-11.6	-7.3	-2.7	-1.3	5.2	-2.7	-13.3	-16.8	-21.0	-21.3	-15.7	-17.6	-9.8	-16.5	-13.8	6.0	2.6	19.3	0.8	6.7	2.6	4.8	15.6	11.8	-2.0	-14.3	-19.6	-25.3	-29.0	-26.0	-17.6	-13.0	-2.4
Alternative B	-3.1	-7.2	-7.1	-12.1	-6.4	-2.4	0.6	7.4	1.4	-1.4	-3.1	-1.4	-1.2	-1.4	-3.1	-5.4	-12.5	-9.4	6.0	0.9	15.4	-7.7	-3.2	-7.5	-1.1	11.6	6.5	-3.1	-12.3	-15.1	-22.8	-25.8	-21.9	-16.4	-12.2	-1.6

Balance bet. Probable Q based on WL and WR of 55,625ha

Present CP	15.2	-3.6	5.5	3.2	9.5	6.9	2.4	20.4	26.1	47.6	55.1	55.3	55.8	56.0	53.4	35.9	23.8	17.5	27.6	23.2	34.5	11.8	17.8	16.0	23.6	34.1	23.9	23.0	21.0	24.6	30.6	31.2	35.8	39.3	38.3	32.2
Monthly basis avrg		**5.7**			**6.5**			**16.3**			**52.7**			55.1			25.7			28.5			15.2			27.2			22.9			32.5			**36.6**	
Proposed CP	15.0	-3.9	5.3	2.9	9.2	6.6	2.2	20.3	26.0	51.4	60.0	60.0	57.2	56.6	50.4	36.6	24.8	18.8	28.5	24.3	35.3	13.2	19.0	17.3	22.5	33.3	22.8	21.8	19.8	23.5	29.7	30.3	35.0	38.6	37.6	31.5
Monthly basis avrg		**5.5**			**6.3**			**16.2**			**57.1**			54.7			26.7			29.4			16.5			26.2			21.7			31.7			**35.9**	
Alternative A	14.3	-4.0	5.9	5.1	11.1	9.8	3.7	19.4	18.1	29.5	33.6	28.3	29.0	35.3	28.3	29.6	18.7	14.3	33.2	32.0	42.2	25.9	30.1	30.3	31.8	39.8	31.6	26.7	20.2	18.9	24.7	24.6	28.3	37.1	36.8	30.2
Alternative B	15.0	-3.6	5.7	4.5	12.0	10.1	5.7	21.6	22.2	41.4	47.3	47.9	49.2	49.6	42.7	34.0	22.7	18.7	33.1	30.3	38.3	17.4	20.2	20.2	25.9	35.9	26.3	25.6	22.2	23.4	27.1	27.7	32.4	38.2	37.7	31.1

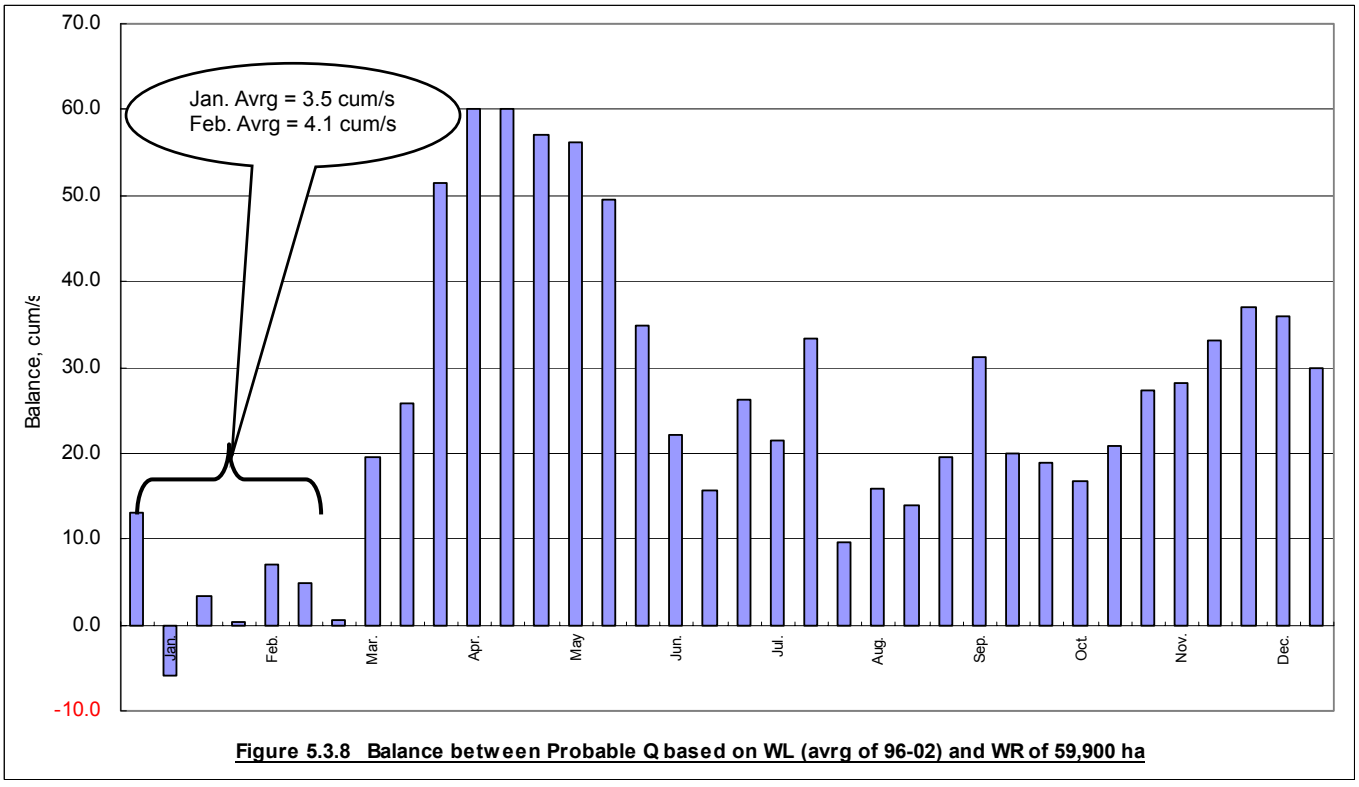


Figure 5.3.8 Balance between Probable Q based on WL (avrg of 96-02) and WR of 59,900 ha

5) SRIP Demand Driven Mode

As mentioned in the "SMIP supply 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 5.3.5 & Figure 5.3.9 (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 the 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 volume that the SRIP is entitled is 0.8 to about 2 cum/s during lean period (see Table 5.3.5 & Figure 5.3.10). As per early monsoon season like May and June, about 1.2 to 2.9 cum/s will be available for SRIP.

Table 5.3.5 Average Actual Q intaken and Probable Q maximum based on WL for 1996 - 2002

Year (96 - 02)	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
Q based on WL	39.4	22.1	30.2	36.1	36.5	30.7	23.4	31.1	30.0	51.4	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	53.0
Actual Q intaken	21.3	18.5	17.4	19.4	18.1	18.2	18.4	17.0	9.2	8.6	9.6	10.7	9.7	8.9	14.1	20.6	24.8	31.9	32.9	30.6	37.1	34.9	36.6	32.3	32.9	35.7	40.2	31.3	25.5	21.5	10.0	6.5	5.7	5.4	10.1	20.3
13.1% of Q(WL)	5.16	2.90	3.96	4.72	4.78	4.02	3.06	4.08	3.93	6.74	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	6.94
Monthly basis	4.01			4.51			3.69			7.49			7.86			7.86			7.86			7.86			7.86			7.86			7.86			7.55		
11.1% of A.Q	2.37	2.06	1.93	2.16	2.01	2.02	2.04	1.88	1.02	0.96	1.07	1.18	1.07	0.99	1.57	2.28	2.75	3.54	3.65	3.39	4.12	3.87	4.06	3.59	3.65	3.97	4.46	3.47	2.83	2.38	1.11	0.72	0.63	0.60	1.12	2.25
Monthly basis	2.12			2.06			1.65			1.07			1.21			2.86			3.72			3.84			4.03			2.89			0.82			1.32		

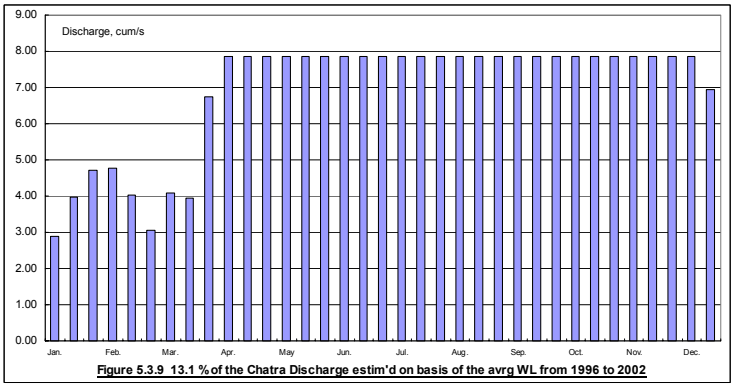


Figure 5.3.9 13.1 % of the Chatra Discharge estim'd on basis of the avrg WL from 1996 to 2002

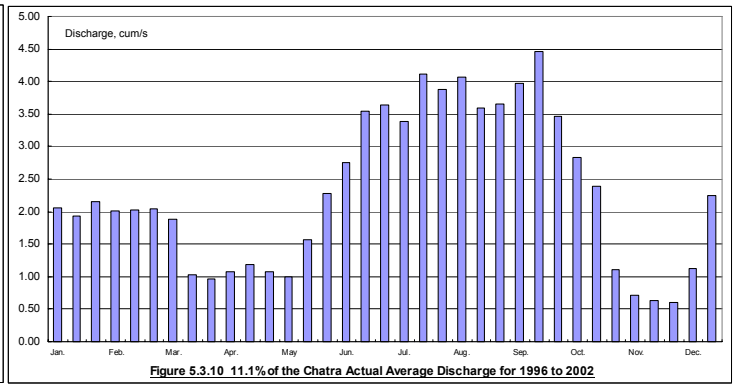


Figure 5.3.10 11.1% of the Chatra Actual Average Discharge for 1996 to 2002

5.3.3 Possibility of Water Release from SMIP

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 to SRIP at least 3.5 cum/s under SMIP proposed cropping patter and at least 3.8 cum/s under the present cropping patter.

- 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 takes a position 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[6] of the Vortex tubes.

Note: This Study undertakes, according to a request by DOI, a case study for which SMIP could provide some water during lean period based on the past operating years' average. The water assumed is 3.8 cum/s at minimum correspondent to the case of SMIP supply driven mode with 59,900 ha under the present cropping pattern.

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.

6 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.