CHAPTER 6

THE DEVELOPMENT PLAN

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6.1 Strategic Integration of Three Aspects

In pursuing the proposed development plan, this Study puts in mind a strategic integration of three aspects: People, Facilities and Institution. The three aspects are of course important at their individual level but the integration of the three is imperative since the three interact each other.

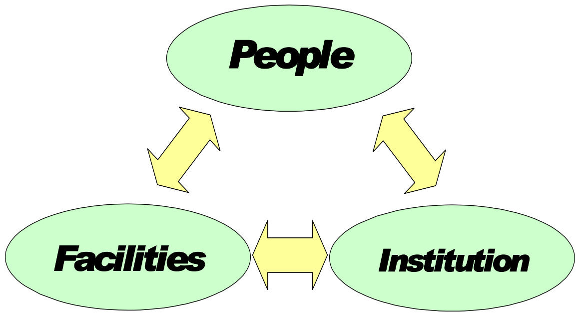


Figure 6.1.1 Strategic Integration of Three Aspects

Needless to say, the ones who use the irrigation system are the farmers and the Government. These two main actors are, so to say, the drivers to operate the tool that is irrigation system. The system should be well designed in order that the people can operate and maintain it as easily as they can. The easiness should be pursued in terms of not only user friendliness of facilities but also institutionalization of the system. In another word, integrating the three aspects from the viewpoint of easiness will contribute to realizing the sustainable O & M of the irrigation system.

An example of user friendliness is the introduction of un-gated type on-farm inlet applied already in SMIP. Gate installed in smaller canals like tertiary does not usually function because it is troublesome for farmers to adjust the opening according to the required amount of water. Therefore, the gate is rather left either fully opened or fully closed. As for the un-gated inlet, sophisticated intervention for it is hardly required, except for rotational irrigation during lean period, so that the people can more concentrate on their tasks; government on distributing equal water to concerned water users associations (WUA) and the farmers on their on-farm agriculture activities.

Another example taking into account the easiness of institutionalization is the size of the secondary canals. One secondary canal command area is usually correspondent to one WUA, where hydraulic decentralization/clustering can easily be established. Physical size and location of secondary canals, therefore, very interact with the people's norm in terms of how they can be well organized, how they organize a collective task to operate and maintain the irrigation system, etc. Bigger secondary canal, say incorporating hundreds of people, would make the WUA's collective task difficult. Much inequality in size among secondary canals results in big difference of number of membership among WUAs, thereby making overall coordination among WUAs very difficult.

Institution does not necessarily mean only organizing farmers but also overall irrigation system management, cost recovery mechanism, and also the beneficiaries' due for the initial investment. How to manage the irrigation system, to what extent the government should manage, and to what rest the farmers manage should be thoroughly discussed and agreed between the two and then institutionalized. Since irrigation project is a public work and the direct benefit accrues, at least for a while, only on the direct beneficiaries, full cost recovery mechanism should be pursued. From the viewpoint of public equality, the beneficiaries are also supposed to bear certain share of the project initial investment [1]. These institutionalization requires not only set up of policy and regulation on the paper but also public consultation and consensus with the beneficiaries on the ground. This Study, through the plan to be made herein, tries to give a reference which helps the Government to institutionalize those issues.

6.2 Overall Development Strategy and Framework

Having seen the present situation of the local population yet suffering from food shortage, the project should aim at raising the living standard primarily by means of agriculture development. The land and water, the primarily resources for the development, are in the project area, which will serve the betterment of the local population. Therefore, this Study sets as its development goal "to improve living standard in the Study area based primarily upon irrigated agriculture development". The development framework starting with the development goal and going down to the project component is presented in Table 6.2.1.

To realize the development goal, six development approaches are presented; 1) develop irrigation and drainage system, 2) promote irrigated agriculture, 3) develop basic rural infrastructure such as road, 4) mitigate flood and inundation, 5) mitigate environmental negative impact if any, and 6) improve irrigation policy. The first and second approaches are the main scope for this Study, though others should not be underrated. The 6th approach, 'improve irrigation policy' is not a direct approach toward the development goal, but presented as a by-product through this Study for the sake of future irrigation development in Nepal.

Under each program approach, there are projects and again under which a number of sub-projects are identified. For example, under program approach of 'develop irrigation and drainage system', there are three projects identified; namely, surface water (Sunsari river) development, groundwater development and drainage development. Each of the three projects is further divided into sub-project components; for instance, the project of 'surface water development is composed of six sub-projects as 1) Sunsari river development, 2) irrigation facilities development, 3) water management, 4) operation and maintenance, 5) institutional development, and 6) cost recovery.

Time Framework should also be defined, composed as it is of short, medium and long terms, when preparing any development plan. A focal or urgent project is placed within short-term development with high priority. In this sense, Sunsari river development aiming at irrigated agriculture promotion is of course placed in the short development term. This Study adopts the following time frame and development schedule is given in the Table 6.2.2.

- Project Preparation/construction: Year 0 to Year 4
  Appraisal: Year 0

1 In Japan, there is an act called Land Improvement Act specifying that; 1) The Central Government may cause Local Government, which covers the whole or a part of the boundaries of the Land Improvement Development where state project is executed, to bear a part of the expenses for said project, and 2) The Local Government may collect the whole or a part of the due, to that extent which the farmers are benefited, from the farmers who are to enjoy the profits through said project. Based on the Act, the beneficiaries bear certain amount of the initial investment depending upon the agreement which is made before the project commencement.

Detail design/tendering: Year 1
Construction: Year 2 – 4 (3 years construction)

- Project Operation: Year 5 – 24 (1st – 20th Year af. the operation)
  Short Term: Year 5 – 9 (1st to 5th Year after the operation)
  Medium Term: Year 10 – 14 (6th to 10th Year after the operation)
  Long Term: Year 15 – 24 (11th to 20th Year after the operation)

Table 6.2.1 Development Framework of the Study Area

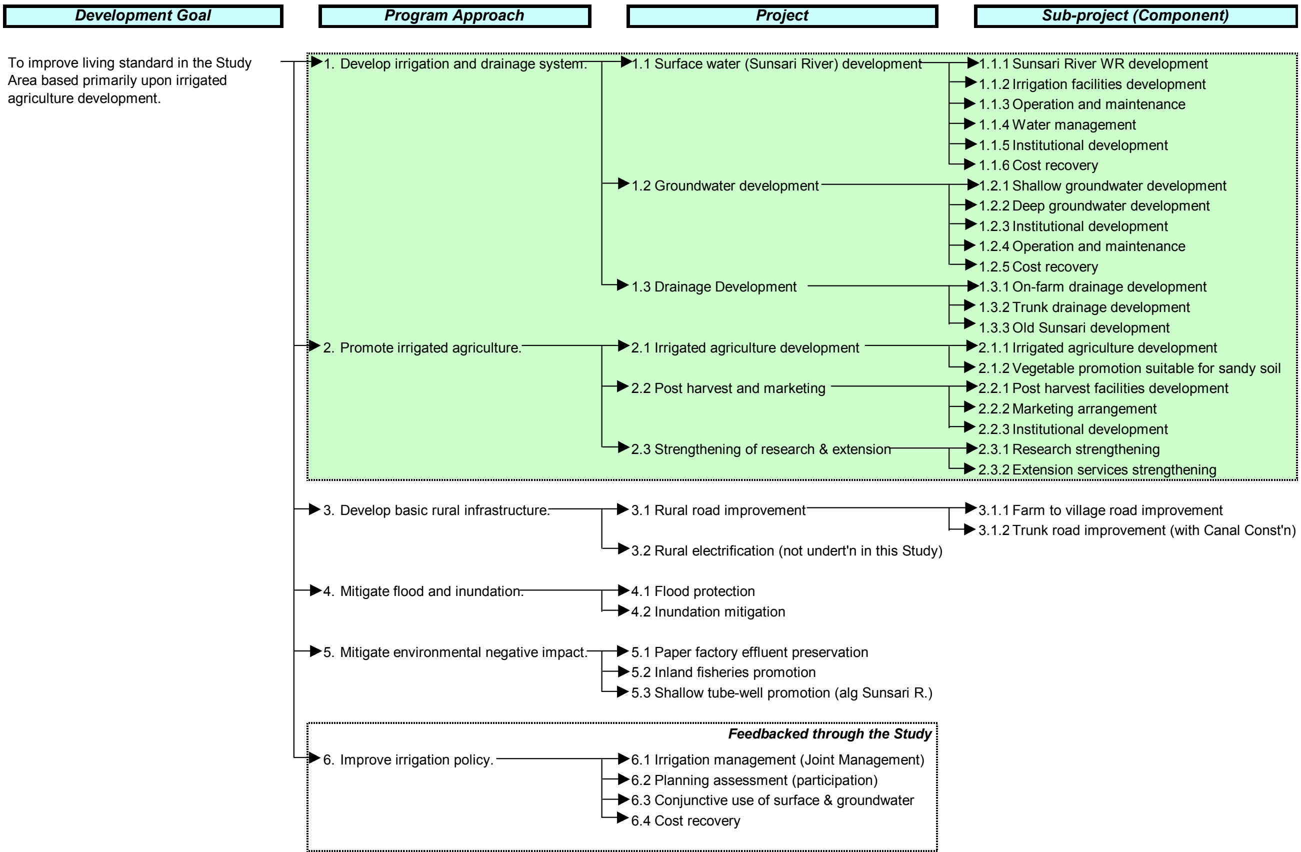


Table 6.2.2 Overall Development Timeframe

Program	Major Const'n Stage					Short Term					Mid Term					Long Term									
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Year after SRIP Complet'n					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Develop irrigation and drainage system.	appraisal																								
1.1 Surface Water Development																									
1.1.1 Surface Water Development Stage I						(1st year: DD & Tendering/ 2nd to 4th years: Construction; Headworks, Head Race, Main Canal)																			
1.1.2 Surface Water Development Stage II									(1st year: DD & Tendering/ 2nd to 4th years: Construction; Secondary and Tertiary Canal, Watercourse, On-farm)																
1.2 Groundwater Development																									
1.3 Drainage Development													(Old Sunsari River Development)												
2. Promote Irrigated Agriculture.																									
2.1 Irrigated Agriculture Development																									
2.2 Post harvest and marketing																									
2.3 Strengthening research and extension																									
3. Develop basic rural infrastructure.																									
3.1 Rural road improvement (w/ canal network)																									
4. Mitigate flood and inundation.																									
4.1 Flood protection						(Portion only related to canal network)																			
4.2 Inundation Mitigation													(Old Sunsari River Development)												
5. Mitigate environmental negative impact.																									
5.1 Paper factory effluent preservation																									
5.2 Inland fisheries promotion																									
6. Improve irrigation policy																									

6.3 Beneficiaries Involvement in Planning

Irrigation development planning in Nepal as elsewhere was sometimes criticized for not being participatory in real sense. Governmental agencies for irrigation were once blamed for their highly bureaucratic processes and techno-centric approaches of irrigation development and management. In this context, the Government of Nepal had adopted new irrigation policy over the last one decade which is considered to be more participatory than what was earlier.

Currently, the existing policy frameworks mainly the irrigation policy and irrigation regulation, in principle, are straight forward in this regard. Irrigation policy envisages beneficiary's participation in all stages of irrigation development and management from the very beginning of planning. Irrigation policy insists irrigation projects to be demand driven. There are various mandatory provisions of capital cost and O&M cost sharing by the beneficiary farmers in different type of irrigation development and management.

However, the social constructions of written policies are diverse in Nepal and are leading to the contemporary political discourses. Farmers are criticizing irrigation authority for their conventional approaches of supply driven and non-transparent mode of work. Irrigation authority, on the other hand, complains that farmers very much expect government expenses in the entire capital cost and in O&M cost as well and reluctant to contribute from their side. In this context, clear delineation of rights and responsibilities in between beneficiary farmers and the irrigation authority seems to be timely needed.

In the background above, the Sunsari River Irrigation Project (SRIP) this Study proposes has attempted to move a little bit beyond from the conventional approaches of project planning and development. A series of focus group discussions and consultation workshops have been arranged in the Study area. Consultation was not done only with the potential beneficiaries of the proposed project but also with the group of people who are supposed to be affected by the project in negative way.

6.3.1 Consultation Workshop

Along with those endeavor, one district level workshop was conducted on 1st of August 2002 with the local officials of various government organizations (GOs) and NGOs related to agriculture development aiming to familiarize them in the matter of on-going study. Later on, four batches of farmers level consultation workshops during August 2002 had been conducted, and then one consultation meeting with fishermen who may be affected by SRIP in negative way.


A Consultation Workshop

For the farmers' level consultation workshops, the four different meetings were arranged at around the upstream, upper-midstream, lower-midstream and downstream reaches of the proposed command area. Participants of three VDCs each were drawn in the first three workshops and the last one called participants from the rest four VDCs (most downstream VDCs).

Mainly, out-going representatives of local VDCs such as chairman, vice-chairman and ward chairman, the local representative of all the recognized national parties and the farmer representatives had participated in those workshops (see Table 6.3.1). Figure 6.3.1 shows the distribution of their land holding which could be regarded as their social status. Most of the participants, say about 90%, have more than 1 bigha (0.67ha), and the average landholding is about 2.6 ha which is about twice bigger than the average 1.24 ha of the whole Study area. This implies most of them belong to rather upper social stratum. Although consultation process should deal with the entire social stratum from rich to poor and the poorest, these workshops as the entrance of the planning dealt with the people, say local representatives.

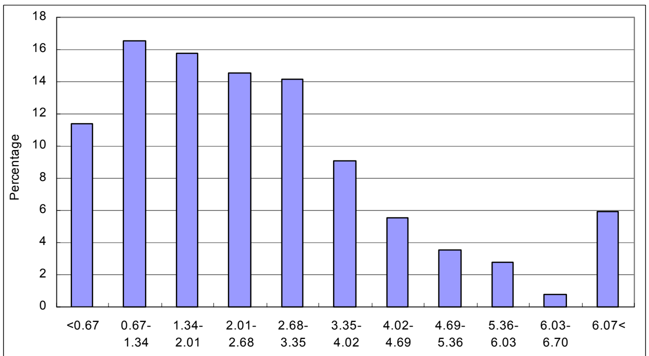


Figure 6.3.1 Landholding Distribution of WS Participants

Table 6.3.1 Distribution of participant by their socio-economic categories.

Meeting place	Participants from:	No. of VDC chair/vice ch	No. of non-local*	No. of ward rep.	No. of party rep.	No. of farmer rep.	Total
Babiya	Upstream	5	3	28	6	14	56
Ramnagar	upper-midstream	5	16	17	13	19	70
Harinagara	lower- midstream	5	5	19	15	27	71
Kaptangunj	Downstream	2	16	15	10	42	85
Total		17	40	79	44	102	282

Note: * this denotes teachers, VDC secretary, health post personnel and others who are categorized as non-local.

After observing district level familiarizing workshop and farmer level consultation workshop a consultation workshop with fishermen was held on 14th August, 2002 at Bhutaha ward no.8. Total 42 local fishermen/farmers participated the meeting. The participant raised mostly negative response regarding the local environment and their livelihood if in case proposed project would be brought into being. The discussion with the fishermen is detailed in CHAPTER 11 SOCIAL AND ENVIRONMENTAL ISSUES.

6.3.2 Consultation Proceedings

The consultation firstly presented the initial (provisional) irrigation development plan and then solicited their opinions, advices, suggestions, and whatever it is concerned to the Project. The detail of these consultation workshops and meeting are discussed hereunder and incorporated in the development plan.

1) Technical and Institutional Proposal

As a matter of technical proposal, the Study Team talked about the place and structural aspect of the headwork and the proposed feature of canal layout including conveyance, distributaries, farm structure, gates, regulators and drainage. Before entering into the concrete technical proposal, the Study Team talked about the special feature of soil type of the area and the causes of the inability of SMIP to deliver water to this area. Accordingly, the Team proposed to utilize the structure already developed by SMIP wherever is possible.

The design so far envisioned was based on continuous water distribution during monsoon season and rotation during lean period, and also would be very much free of gated structure. Taking into consideration the future prospects of farmer's manageability of the canal below the main canal, it was told that the attempts was made to increase the number of secondary canals thereby reducing the size of command area of secondary canal limiting to 200-400 ha. Likewise, size of water course was proposed to reduce to as low as 20 ha in order to facilitate the farmers in contributing full capital cost up to the water course level.

Side by side with the technical proposal, the proposal for institutional development was presented. Institutional proposal mainly covered the aspect of water users association and their functions, cost sharing by the beneficiaries in construction and O&M phase, modality of canal operation and maintenance, etc.

2) Social, Environmental and Agro-economic Presentation

In terms of social, environment and agro-economic aspects, the Team rather used the opportunity of the meetings to collect information about the various aspects. For example, social group discussed broadly the farmers' overall concern about their livelihood, problems, development opportunities, etc. The group identified the priority of irrigation development as the first one except the last workshop whose participants came from the lowest reaches of the Study area.


A Consultation Workshop

Environmental group consulted participants about the possible positive and negative impacts of the proposed project if bring it into being. During the presentation, the environmental group enunciated the concern of effluent of the paper factories which were being drained to Sunsari River without any essential measure of treatment so far. They also opined the concern of fishermen who were using Sunsari River as one of their main sources of fishing.

Agro-economic group consulted farmers about the existing farming practices and proposal of cropping pattern change in the project area in case if the project was implemented. Mainly, the proposal was in line of changing cropping pattern from the paddy dominated existing pattern of the locality to the vegetable and other cash crop centered one for water scarce season.

3) Issues Raised

The presentation of each aspect; technical, institutional, social, environment and agro-economy, was followed by floor discussion (clarification and comment collection) with the farmer participants. The technical and institutional proposal was presented in plenary whereas the latter three administered in three different parallel session workshops. The following are the topics-wise main issues raised or the opinion expressed by the farmers during the workshops.

- include river control component along the bank of Sunsari river to mitigate inundation problem,
- include intensive drainage network in the detail design,
- reduce the command area of water course even smaller than 20 hectare,
- consider for not disturbing natural drainage of the local river rather think for its conjunctive use,
- do not ask farmers participation only for cost sharing but involve in every stage of project planning and execution,
- expressed it is hard for them to contribute 100% capital cost for the construction of water course but they do not like to loose the project only due to this cause, so that they likeed to request government agencies and donor to give them more concession in this regard,
- liked to begin the ISF rate same to the rate of SMIP and later on if in case found insufficient to cover O&M they would raise it upon the consensus of and consultation with fellow farmers,
- expressed their willingness to adopt changing cropping pattern in case if project come into being,
- expressed grievances about the exit of effluents even today and very much liked to request the government to take essential action to stop further worsening the situation,
- expressed mixed response about the practicability of the proposal of fish culture development in Mariyadhar due mainly to land tenure problem.
- expressed mixed reaction about the potential of using Mariyadhar (Old Sunsari river) as a corridor for flashflood,
- were in line of releasing higher flow in Sunsari river even during lean season though Sunsari river was not that much big source of fishing, and
- accepted WUA structure and the management regime as proposed.

6.3.3 Issues to be Considered

When analyzing the responses and concerns raised by the participants the Team came to the meaningful explanation in the context of broader socio-cultural and politico-economic landscape prevalent as follows:

1) Bargaining Motivation

In the interaction and interfaces with the farmers, what is clearly understood was that they had motivation of bargaining. They perceive that the government will fulfill their demand if they continue their resistance and bargaining. It is interesting that on one hand they do not like to loose any project like SRIP potential to come into their area and on the other they have tendency to try to minimize cost sharing as much as they can bargain.

Widespread rumor about corruption in public sector agencies inspires farmers for more bargaining in dealing with government agencies. Even presenting the fact that the cost for groundwater irrigation augmented up to Rs 1800 per bigha per for wheat, they were saying that it was preferable for them since it is under their control. They said, in case of surface irrigation, that it should have been free because they have already been paying land revenue.

2) Reflection of First Hand Experiences

Technical issues raised by the farmers are the reflection of the reality they experienced. Though sometimes it only reflects vested interest of an individual or a particular group, the issues raised in mass are worth taking into consideration. For example, farmers concerns about the need of intensive drainage can be taken as an example. Reportedly, farmers had removed number of drainage in the first stage area of SMIP in the initial year of the construction which brought many problems later on. Therefore, now farmers are proactive in demanding to have more number of drainage in the proposed project, which is the reflection of their experiences of the past.

3) Reflection of Social Hierarchies

The farmers' level consultation workshops very meaningfully illustrated the hierarchies of social reality and the political forum for different interest group. In the consultation process, local elites having socio-economically and politically sound background sometimes tried to influence the consultation processes. It became tough consequently, to make the people of disadvantaged group speaking out in the meeting. The Team could easily understand the social hierarchies by their posture, sitting places and behavior they illustrated in launch place.

A Consultation Workshop

Even the issue coming from the floor was interesting for scrutiny. The people of disadvantage group raised the practical concern of getting water to their small parcel of plots. They talked on how they were suffering from the lack of proper field channel. Whereas the elite raised the concern of WUA's share in project implementation. Thus, the voice coming from the floor may especially represent the voice of elites. Therefore, there is a need of significant effort of real sense of participation from all the concerned people together with the government side.

4) Scope of Project governing the willingness to pay

Willingness to pay is also determined by the differentiated scope and potential of the project to the people of different geographical region, socio-cultural and politico-economic strata and else. Particularly what is observed that the framers who were experiencing the benefit of water with stressed supply were much more interested in the proposed project and heartily willing to pay more capital cost and O&M cost than those who were getting abundant water and those who have less hope to get water even after the construction of the proposed project.

The participants of midstream were well found to be motivated to pay more than the participant of downstream and upstream of the proposed project. The farmers of upstream reaches such as Babiya, Narsimha and Jalpapur VDCs were currently getting water from SMIP without any significant contribution in capital and O&M cost. They were, therefore, less willing to pay to the Project. On the other hand, the farmer of downstream reaches, the southernmost part of this project such as Dewanganj, Ghuski, Kaptangunj and Sahebganj were also found to be less attracted to the Project. They seemed to be less hopeful because they suppose that even if the Project was implemented, they would hardly get water passing through the long way along the would-be excessive water use prone upstream.

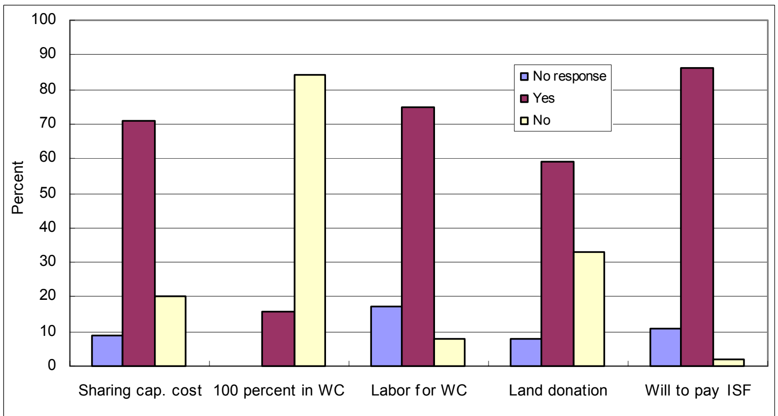


Figure 6.3.2 Response in Various Aspect of Sharing

The Figure 6.3.2 presents the response regarding willingness in carious aspects of cost sharing such as sharing capital cost, 100% sharing in watercourse (WC) construction, labor contribution for WC, land donation for WC, and willingness to pay ISF. It is observed that more than 60% of the respondent shows their willingness in different type of cost sharing in the questions asked except for the 100% contribution to WC construction, for which the positive response was only 16%. This shows a challenge on the ground to make farmers willing for contribution in various aspects of cost sharing. Furthermore, although about 90% farmers responded they were willingly to pay ISF, the amount they were thinking may be more or less same as SMIP's. Once they were asked to pay about 800 Rs/ha, proposed in Cost Recovery Study funded by the World Bank, they raised mixed response with the majority of not paying that much amount.

6.4 Agriculture Development

6.4.1 Issues to be considered

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

1) Sandy Soil Unsuitable for Paddy Crop but Suitable for Diversified Crop

Based on the result of Land Resource Mapping Project (LRMP) which was conducted as a technical cooperation by the Canadian International Development Agency (CIDA), most of the Study area is classified into the areas suitable for diversified crop due to the sandy soils except for limited spots scattered in Ghuski, Rajganj Sinuwari, Madhya Harsahi and Gautampur VDCs (see Figure 6.4.1). The sandy soil is found more as one goes to southern part of the Study area. The present land utilization, however, in the Study area during monsoon season is represented by paddy crop.

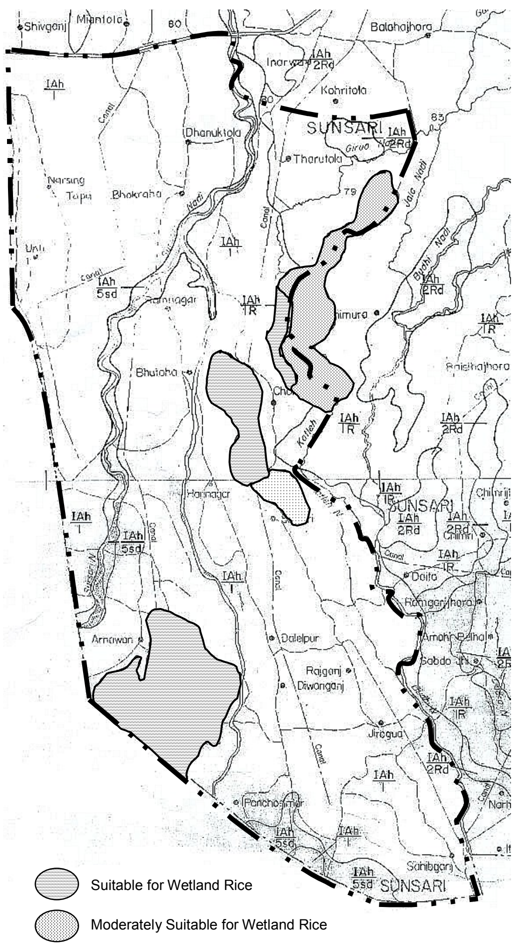


Figure 6.4.1 Areas Suitable for Paddy Crop

This fact shows there is a gap between rational land use in theory and farmers' intention of farming. Farmers who prefer to eat rice tend to grow paddy in monsoon season whether it can be harvested or not. Paddy crop requires a considerable bulk of water and the sandy soils stimulate further the increase of the water requirement. Under this situation, it would be difficult to formulate a land use plan or cropping pattern according to the farmers' full intention, unless otherwise available water in Sunsari river was found abundant.

Whether the sandy soil is a constraint or potential for agriculture development in the Study area is similar to both sides of a coin. Sandy soil is suitable for upland crops, which do not require much water for their growth. It is also useful that sandy soil with less moisture holding ability does not cause wet injury or root rot, which is serious limiting factor for growth of upland crops.

Fortunately, vegetables as secondary crop after monsoon paddy have been already familiar to the farmers 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 these reason, it seems that it is not so difficult to promote diversified crop production furthermore. 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.

2) Poor Marketing System but its Geographically Advantageous Position

There are three permanent markets (Ramnagar Bhutaha, Harinagara and Dewanganj) and three weekly markets (Harinagara, Dewanganj and Ghuski) in the Study Area (see Figure 6.4.2). It is common to transact agricultural products in the local markets or in Inaruwa and Biratnagar through middlemen or directly. Fortunately, there is a main trunk road that runs from north to south so that it is easy to carry agricultural products out of the Study area. However, feeder roads that connect between farmlands and the trunk road have not been well provided. During monsoon season, distribution network is often interrupted since heavy flood often cuts off some feeder-roads.

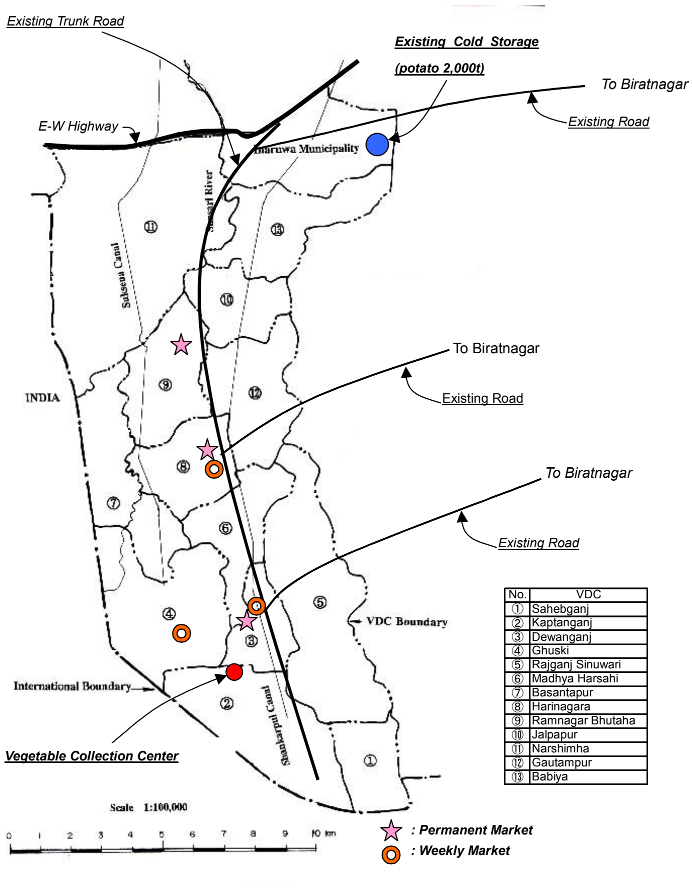


Figure 6.4.2 Location of Marketing Facility

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

There is, however, a very advantageous aspect that is where the Study area is located. There are several urban areas that have a large number of consumers; Biratnagar (population; 161,036 in 2001) which is ranked as the second largest city in Nepal and some neighboring cities like Inaruwa (population; 23,200 in 2001), Itahari (population; 41,210 in 2001) and Dharan (population; 95,332 in 2001). The trunk is connected to the East-West highway so that it is possible to transport perishables to Kathmandu within the same day. Supposed that marketing system including regulations, infrastructures and fair-trading is developed properly, there is every possibility for the Study area of being the center of vegetables production.

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

3) Poor Access to Extension Services

One Agricultural Service Center (ASC) and three Sub-Centers (SC) under DADO staffed with one officer plus 7 technicians (JT/JTA) in total are responsible for the provision of extension services in the Study area. This fact shows that one technician should cover around two thousand households [2]. Rural Socio-economic survey, carried out by the Team to about 200 HHs, shows that only 28 % of sample households received extension services. Most farmers pointed out that the problem of extension services is poor quality as well as poor access though there may cases they are bargaining.

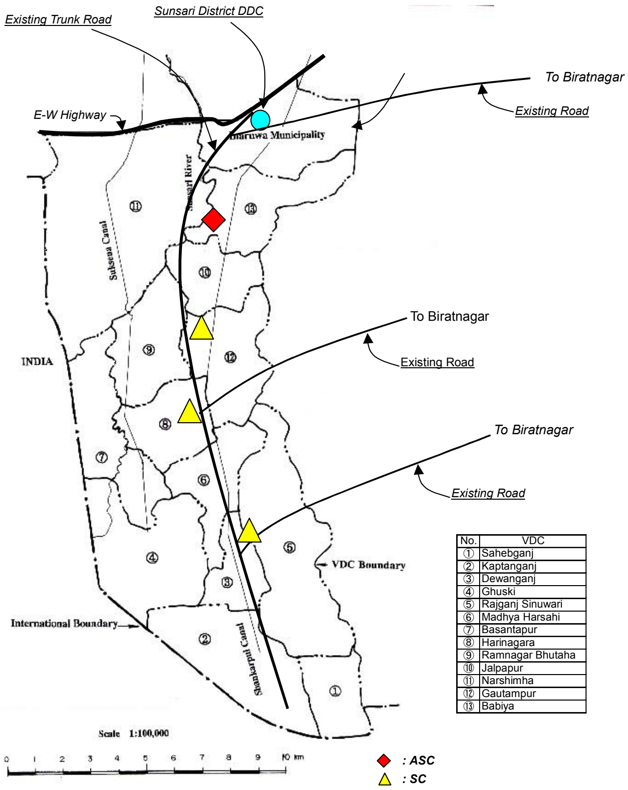


Figure 6.4.3 Location of ASC/SC

Group approach as a method of extension is now tried, raising up farmers participation. There are twenty-four farmers groups certificated by Sunsari DADO in the Study area. However, still the limited manpower makes extension system difficult to well function. To cope with the limited number of the staff, the group approach should further be strengthened or an approach involving water users association as the group should be sought.

6.4.2 Development Strategy and Framework

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

[2] In case of Japan, it is common one extension worker takes care of around 300 households.

of Nepal thanks to the implementation of SMIP.

The Study area, however, has difficulty to increase cereal production due to water shortage associated with incomplete irrigation networks and dominant sandy soil requiring much water for paddy growth. On the other hand, the Study area has an advantageous points such as potentiality of vegetable growth and its marketing. In consideration of the present condition in the Study area, two phased strategies for agriculture development are devised as follows:

1) Short-term Strategy

Food security in the Study area has not been established; there are 7,000 MT (equivalent to 70 kg per capita) deficits of food grains in the year 2001/2002. With this setback in mind, establishment of food security is given the first priority as the short-term strategy. Cereal requirement for the population in the Study area will be met by paddy and wheat. The year 2012 (assumed at 5 years after the commencement of the operation) will be targeted to reach the goal of short-term strategy.

2) Mid&Long-term Strategy

Not only is the Study area located at a position geographically advantageous for marketing activity, but also the Study area has favorable agricultural environment particularly for vegetable production that fits to the sandy soil as well as temperate climate throughout the year. Vegetable production will be promoted in order to improve the farmers' economy as the mid&long-term strategy. The year 2017, assumed at 10 years after the operation commencement, will be targeted to reach the goal of the mid-term strategy.

6.4.3 Development Plan

1) Land Use

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

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

- At some farmlands in Kaptanganj and Ghuski which are estimated at 880 ha in total, it is practically impossible to cultivate upland crops during monsoon season due to serious inundation problem (for detail inundation condition, see Sub-chapter 6.8 Flood and Inundation Mitigation). This farmland will be basically utilized for paddy and/or jute production that is tolerant to water logging during spring/monsoon season.

Total gravity irrigable area under the Project is estimated at 10,147 ha in net. In consideration of the present farming situation and differences of percolation rate within the

Study area, the northern area will be given priority on cereal production while the central and the southern area including upland area will be given priority on vegetable production. Also, the farmland for vegetable production that requires frequent operation during growing period will have to be arranged nearby residential area or access road.

2) Cropping Pattern

Proposed crops under the Project are basically same as the prevailing crops in the Study area; there is no idea to introduce new crops that the farmers may fail to well cultivate without functional extension services. The difference between the present cropping pattern and the proposed cropping pattern shows itself the cropping intensity of each crop. Proposed cropping pattern is considered from the point of view of cereal food security as well as the strategy of vegetable production promotion.

2.1) Cereal Production

Although farmers' intention of paddy production is strong in the Study area, it is obviously impossible to meet cereal requirement for the future population by only paddy production due to limited irrigation water from Sunsari river as well as prevailing sandy soils. Therefore this Study proposes that the cereal sufficiency should be met by both wheat and paddy production. Now, required cropping intensity of paddy under project condition will be calculated back based on the present and the expected production of wheat. Alternatives concerning the wheat as well as the assumptions of the calculation are as follows:

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

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

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

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

As the result of the calculation based on the three alternatives, required cropping intensity of paddy in order for achieving cereal sufficiency is estimated at 59.0 %, 47.3 % and 34.2 % respectively (see in Table 6.4.1). According to the water available in winter season, operation of facility will have to follow preventive irrigation method so that an increase yield of wheat will not be expected at least during the initial stage of the Project. Also, it cannot be expected that the cropping intensity of paddy becomes less than 50 % judging from the farmers' intention toward paddy. Consequently, proposed cropping intensity of paddy is set at 60 % in accordance with the Alternative A.

Table 6.4.1 Required Cropping Intensity of Cereals With Project Condition

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

2.2) Vegetables and Other Crops

Proposed cropping intensity of other crops with project condition is determined as follows:

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

Vegetables; Vegetable production will be promoted aggressively according to the mid&long term development strategy, raising the farmers economic condition.

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

2.3) Proposed Cropping Pattern

Proposed cropping pattern with project condition is presented in Table 6.4.2 and Figure 6.4.4 together with the present cropping pattern in Figure 6.4.5. Total proposed cropping intensity is estimated at 180 % as a whole. The cropping pattern was once presented to the concerned farmers during Farmers' Consultation Workshops held at four places in the Study area, and most attendances agreed or at least not raised critical objections.

Table 6.4.2 Proposed Cropping Pattern With Project Condition

Season	Cultivated Area	Upland Area		Irrigable Area		TOTAL	
		397ha		10,147ha		10,544ha	
	Crops	Cropping Intensity (%)	Area Planted (ha)	Cropping Intensity (%)	Area Planted (ha)	Cropping Intensity (%)	Area Planted (ha)
Spring/Monsoon	Paddy	- %	-	60.0%	6,088	57.7%	6,088
	Jute	25.0%	99	15.0%	1,522	15.4%	1,621
	Vegetables (Summer[1)])	60.0%	238	10.0%	1,015	11.9%	1,253
	Pulse (Mungbean)	- %	-	5.0%	507	4.8%	507
Winter	Wheat	40.0%	159	50.0%	5,074	49.6%	5,233
	Potato	25.0%	99	10.0%	1,015	10.6%	1,114
	Vegetables (Winter[2)])	20.0%	79	10.0%	1,015	10.4%	1,094
	Oilseed (Mustard)	5.0%	20	5.0%	507	5.0%	527
	Pulse (Lentil)	5.0%	20	10.0%	1,015	9.8%	1,035
Through the year	Others (Sugarcane)	- %	-	5.0%	507	4.8%	507
TOTAL		**180.0%**	**714**	**180.0%**	**18,265**	**180.0%**	**18,979**

1): Cucumber and okra represent summer vegetables

2): Cauliflower and cabbage present winter vegetables

Figure 6.4.4 Proposed Cropping Pattern, CI=180%

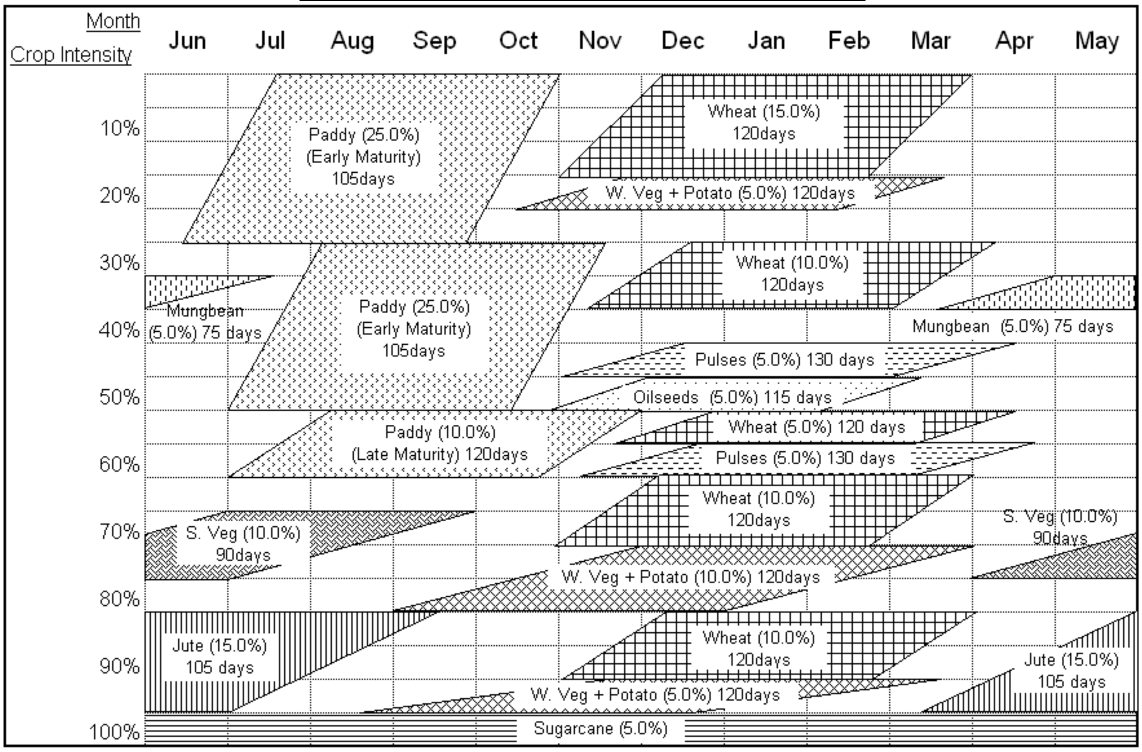
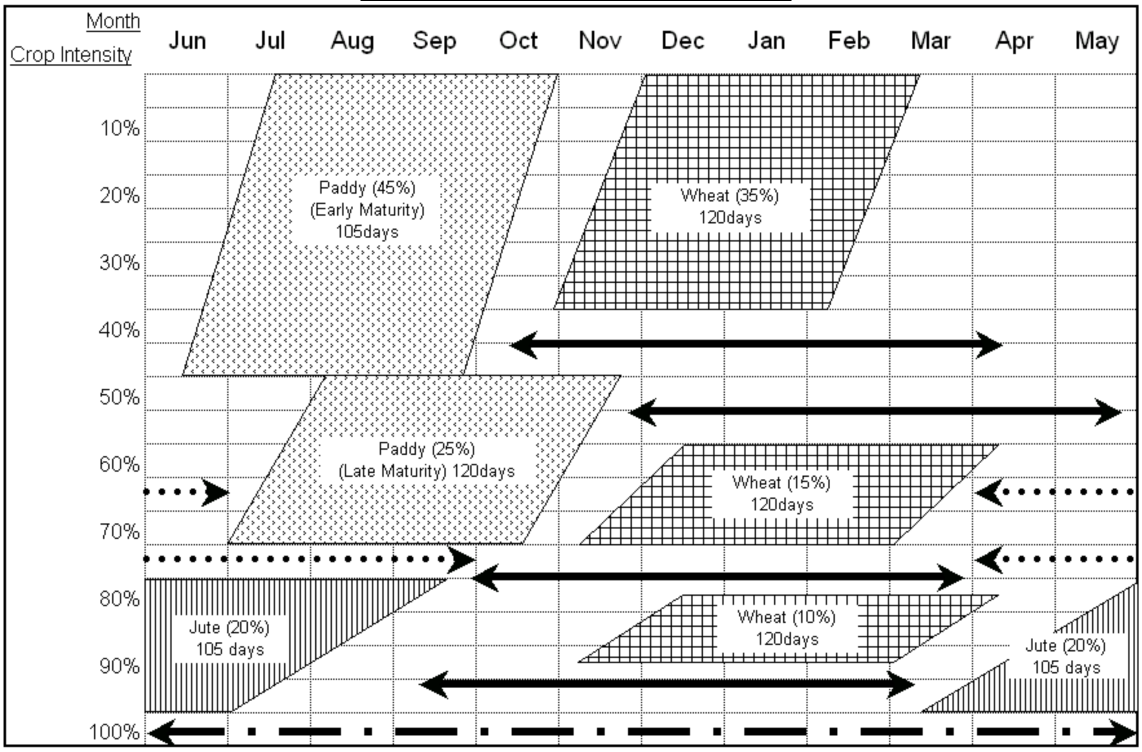


Figure 6.4.5 Present Cropping Pattern



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

6.4.4 Expected Yield and Production

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

Without project: It is expected that yield of each crop except vegetables will increase 10 % as compared with the present yield[3]. In case of vegetables that have nearly reached potential yield, it is considered that expected yield is same as the present yield.

With project: Expected yield of each crop except vegetables basically follows the figures that were targeted in the Stage III SMIP detail FS and also the actual results in areas of SMIP having enough water. Expected yield of vegetables refers to the experimental data from Regional Agriculture Research Station in Tarahara.

Table 6.4.3 shows expected yield and production without/with project condition. It is expected that yield of paddy and wheat will reach 4.2 MT/ha and 3.5 MT/ha respectively on condition that full irrigation and dissemination of improved farming practices are achieved. In case of pulses and oilseeds, which are seldom applied irrigation water and farm-inputs at present, will have increase to a large extent (Note that due to water scarcity during lean period as well as paper factory's effluent and fisheries issues, yield increase of winter crops will not take place at least for the initial stage).

Table 6.4.3 Expected Yield and Production Without/With Project Condition

Season	Crops	Without Project	With Project	Potential Yield
		Yield (t/ha)	Yield (t/ha)	(t/ha)
Spring/Monsoon	Paddy	2.5	4.2	3.5 - 6.0
	Jute	1.9	2.5	2.1 - 3.1
	Vegetables (Summer1))	18.6	20.0	20.0 - 30.0
	Pulse (Mungbean)	0.5	1.0	1.0 - 1.5
Winter	Wheat	2.2	3.5	4.0 - 5.0
	Potato	17.9	22.0	20.0 - 35.0
	Vegetables (Winter2))	19.7	20.0	20.0 - 30.0
	Oilseed (Mustard)	0.4	1.0	0.9 - 1.1
	Pulse (Lentil)	0.8	1.3	1.5 - 3.5
Through the year	Others (Sugarcane)	44.0	80.0	52.0 - 80.0

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

Marketable amount of perishables at full development stage is presented in Table 6.3.4. Marketable surplus of potato, summer vegetables and winter vegetables is estimated at 15,947 MT, 18,623 MT and 15,920 MT respectively. In turn, the population in 2017 of the Eastern

[3] The rate of increase referred to the SMIP Stage Ⅲ feasibility study. Yield of paddy in the Stage Ⅲ area, not yet provided with on-farm development facilities by the SMIP, in the year 2000 also increased by 8 % as compared with the year the feasibility study was carried out (source: Report on Agri-Economic Analysis of Sunsari Morang Irrigation Project Area, FY 2000 to 2001).

Terai that consists of 5 districts, namely, Jhapa, Morang, Sunsari, Saptari and Siraha, is projected at 4,770,657 based on the Statistical Year Book of Nepal 2001. Surplus of vegetables, composed of both summer and winter, will be able to meet the requirement for about 13 % of the projected population of the Eastern Terai (though, due to the water scarcity of Sunsari river, winter vegetable will remain same as the present at least for short-term development period).

The present surplus of potato, which is equivalent to 10,000 MT, is estimated to cover about 9.0 % of the total population in the Eastern Terai. Taking into the present condition of the potato marketing, the vegetable surplus could be in a marketable range but be handled regionally. It is also expected that shipment to Kathmandu, which has a large amount of urban population, will have to be increased.

Table 6.4.4 Marketable Surplus of Perishables With Project Condition

Crops	Production (MT)	Seed Use (MT)	Waste (MT)	Amount of Food (MT)	Per Capita Consumption (kg/year)[3]	Project Area Consumption (MT)[4]	Marketable Surplus (MT)
Potato	24,508	1,671	3,175	19,161	35.1	3,214	15,947
Vegetables (Summer)[1]	25,060	-	3,759	21,301	58.5/2	2,678	18,623
Vegetables (Winter)[2]	21,880	-	3,282	18,598	58.5/2	2,678	15,920
Vegetable (total)				39,899	58.5	5,356	34,543

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

6.4.5 Farm Management

Application of improved seed, fertilizer and chemicals is becoming very common in the Study area. Therefore it is considered that farm-inputs that have not reached the recommendable amount of application will be applied furthermore even without project condition. In case of present vegetable production, there is a tendency to apply farm-input excessively than the recommendable amount so that the present amount will be taken as the amount applied under without project condition. Labor force requirement without project condition is set same as the present condition (see Table 6.4.5).

Table 6.4.5 Proposed Farm-input Requirement Without Project Condition

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

Source: Consultants estimation

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

Table 6.4.6 Proposed Farm-input Requirement With Project Condition

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

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

Eggplant: A Summer Vegetable in the Study Area (early Aug., 2002)

Cucumber Family (A Summer Vegetable) growing next to Paddy Field (Some farers are getting familiar to producing not only winter vegetables but also summer vegetables)

6.5 Surface Irrigation Development (Sunsari River)

6.5.1 Issues to be considered

Issues this Study has to take into account, aside from conventional ones, are; 1) priority use of surface water with groundwater being the supplemental, 2) disparities in water supply, 3) useless extensive network of gate/turnout, 4) irrigation system management jointly by the Government and the WUAs, 5) sustainable O & M and water management, 6) institutional development, 7) cost recovery mechanism, etc. This sub-chapter undertakes the irrigation planning with due attention to the issues of 1) to 3). Issues of 4) – 6) are discussed in Chapter 8 and issue of 7) cost recovery is in Chapter 9.

1) Priority Use of Surface Water

There are three water sources available for the Sunsari River Irrigation Project (SRIP); surface water, shallow groundwater and deep groundwater. In terms of economic return, shallow groundwater development usually shows higher benefit as compared to surface water development and deep groundwater development. EIRR [4] for shallow groundwater development usually shows at least 30 % to as much as over 50%, while surface water development and deep groundwater development 15 to 30 %.

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

Shallow tubewell needs diesel oil and deep tubewell requires electric power to operate. One litter diesel is 27 Rs and unit cost of electricity is 3.5 Rs/kw/hr[5] (plus 200 Rs monthly base case). Given this condition, water price produced by shallow tubewell ranges 0.56 to 0.80 Rs/cum according to the yield usually ranging from 20 to 14 l/s while the price by deep tubewell comes to around 0.45 to 0.50 Rs/cum (yield 50 to 40 l/s). As these costs show, operating tubewells requires at least double cost to as high as 10 times more cost as compared to the one required for surface irrigation system.

This Study, therefore, puts the highest priority on Sunsari river for its irrigation development. The initial cost required for Sunsari river development may be the highest or almost same as deep groundwater development. However, surface irrigation system requires least operation and maintenance cost as mentioned above. Though shallow tubewell usually shows the highest economic return, it requires diesel which is imported. It is also justified that the

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

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

Nepal's own resource, surface water, shall be put higher priority than the one dependent on the imported material.

2) Disparities in Water Supply

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

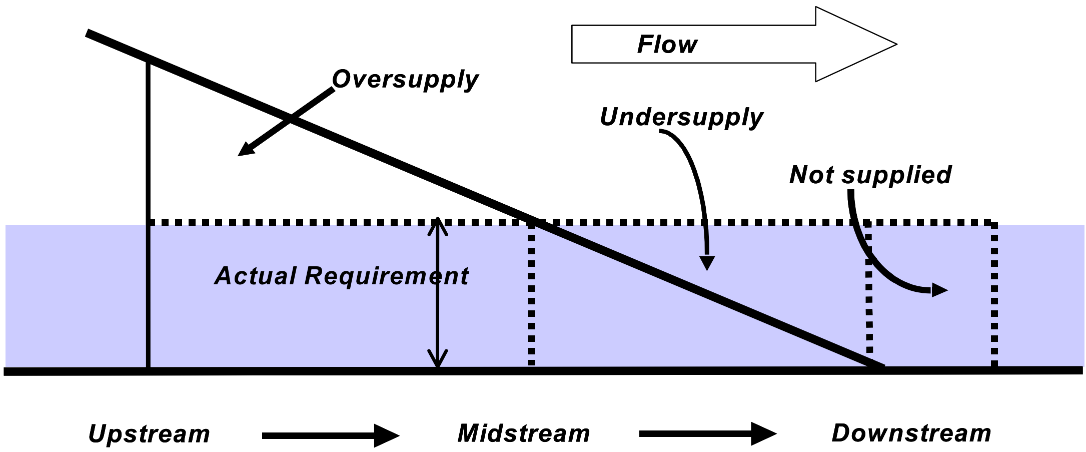


Figure 6.5.1 Typical Inequitable Water Supply along a Canal

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

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

3) Useless Gate/Turnout

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

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

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

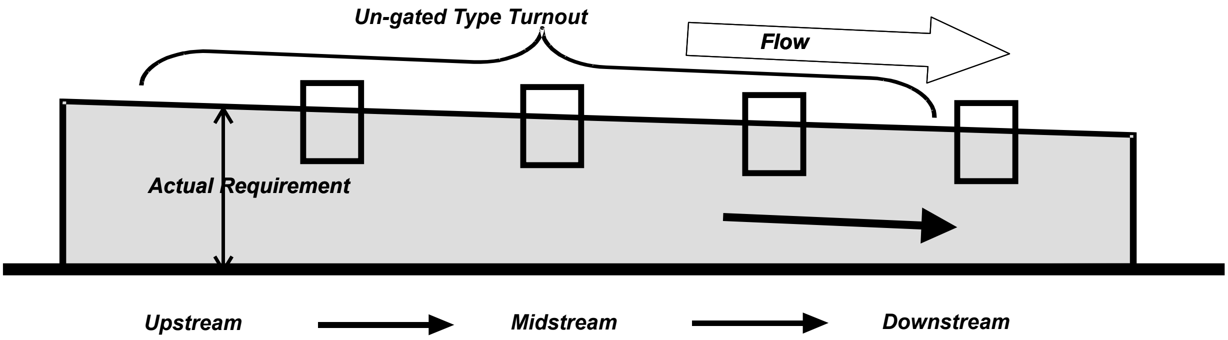


Figure 6.5.2 Concept of Un-gated Type Turnout

6.5.2 Development Strategy

Taking into account above issues together with the issues to be discussed in Chapters 8 & 9, this Study refers the following as the irrigation development strategy:

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

6.5.3 Delineation of Irrigable Area

This Study deals with 13 VDCs, total gross land area of which is 16,800 ha. In estimating irrigable area, this Study primarily refers to the taxation area given by Inaruwa Census Office. The total taxable area is 12,530[6] ha, and this is considered to be equal to the gross irrigable area in most cases. To estimate net cultivated land only, homestead areas and levees have to be deducted. This Study applies 7% deduction to estimate net cultivated land from the gross irrigable area.

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

Northern areas that will not be covered by the canal network are located in Narsimha and Babiya VDCs. There is a little elevated area in Kaptanganj VDC, which is the most southern part of the Study area. The area is about 397 ha in net (455 ha in gross), and this cannot be gravity fed by the canal. Sahebganj VDC, located at the most south-eastern part of the Study area, is now provided with irrigation water by Chanda Mohana system, so that the area falling in this VDC is no longer counted. Taking into account these areas, the net irrigable area which can be covered by the barrage planned is now 10,147 ha (see Table 6.5.1).

Table 6.5.1 Maximum Irrigable Area by Sunsari River Irrigation Project

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

6.5.4 Water Requirement

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

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

Penman method were collected from the Biratnagar Airport for a period of 1971 to 2000 (Station No.1319).

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

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

1) Crop Evapotranspiration (ETo)

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

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

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

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

Table 6.5.2 Potential Evapotranspiration (ETo) Unit: mm/day

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

2) Crop Coefficients

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

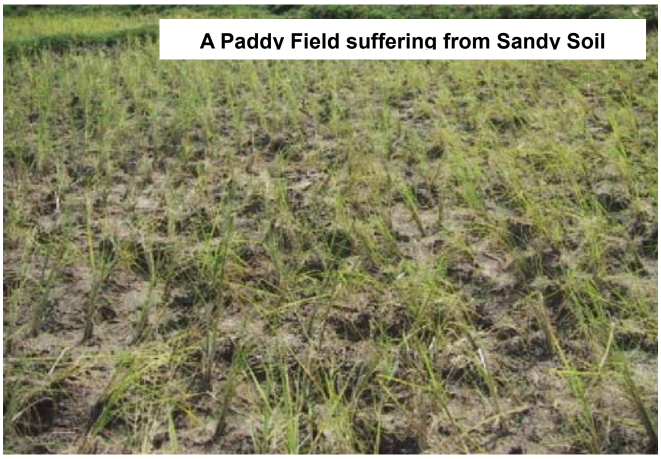
Table 6.5.3 Crop Coefficient (Kc)

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

Note: One growing stage = 10 days

3) Percolation Losses

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



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

Table 6.5.4 Design Percolation Rate; mm/day

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

4) Puddling Water Requirement and Nursery Water Requirement

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

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

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

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

5) Raw Rainfall and Effective Rainfall

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

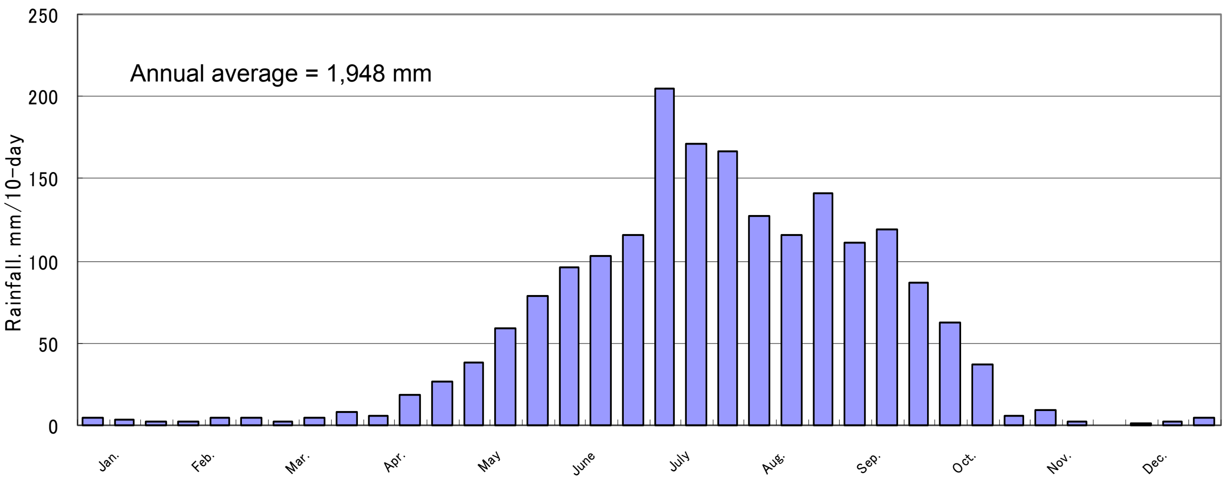


Figure 6.5.3 Mean 10-day Rainfall at Biratnagar Airport based on 1971 - 2000

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

5.1) Paddy Field

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

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

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

Table 6.5.5 10-day Effective Rainfall for Paddy by Probability

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

5.2) Upland Field

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

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

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

Table 6.5.6 Effective Rainfall for Upland Crops by Probability

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

6) Irrigation Efficiency

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

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

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

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

Table 6.5.7 Irrigation Efficiency

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

7) Water Requirement

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

Paddy: GR = NR / OE

NR = CU + P – ER + NW + PW

where GR: Gross water requirement,

NR: Net water requirement,

OE: Overall irrigation efficiency

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

P: Percolation rate,

ER: Effective rainfall,

NW: Nursery water, and

PW: Puddling water requirement

Upland crop: GR = NR / OE

NR = CU- ER

where: GR: Gross water requirement,

NR: Net water requirement,

OE: Overall irrigation efficiency,
CU: Crop water consumption, and
ER: Effective rainfall

6.5.5 System Reliability on Sunsari River Potential

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

In case of available water being not able to cover all the prospective irrigable area, it is not just an engineering issue but also highly political one to decide if the irrigable area should be reduced or the system reliability be lowered. One example is SMIP; the system reliability is not 80 % but 70 %. The design intake discharge of 60 m^3/s cannot cover all the prospective irrigable area of 73,000[7] ha with 80 % reliability, so that the system design was made with 70 % reliability and thereby no prospective irrigable area was excluded in the design.

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

Table 6.5.8 Water Balance on Sunsari River for Paddy (D/S release 1.8 cum/s considered), cum/s

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

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

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

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

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

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

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

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

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

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

According to the estimated self sufficiency done in Chapter 6.4 “Agriculture Development”, 60 % area of paddy can support the local people’s cereal sufficiency together with present wheat production (about 50% area with the present yield). Table 6.5.9 shows the gross water requirement under the proposed cropping pattern in Chapter 6.3, 60 % paddy and the rest being upland during summer, together with surplus or deficit on Sunsari river under system reliability 80%. The maximum gross unit requirement is 1.688 l/s/ha which is the design irrigation module. Figure 6.5.4 illustrates the gross water requirement by 10-day, and Figure 6.5.5 shows the balance by 10-day on Sunsari river after subtracting 1.8 cum/s for the downstream regulatory release.

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

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

Table 6.5.9 Estimation of Crop Water Requirement under the Propoased Cropping Pattern with System Reliability of 80 %

		Jan			Feb			Mar			Apr			May			June			July			Aug			Sep			Oct			Nov			Dec			Remarks	
		F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L	F	M	L		
Paddy Net WR, P80%ER, mm/10days	105days																8.4	60.9	90.6	96.7	124.4	144.4	147.5	156.3	134.6	150.8	124.8	111.3	87.3	57.0	21.1							1,516	
Paddy Net WR, P80%ER, mm/10days	120days																		14.0	100.1	129.9	146.6	141.0	151.3	134.6	152.2	145.0	163.2	176.7	191.4	158.3	104.1	51.3					1,960	
AF x Upland Crop Net WR, P80%ER, mm/10days																																						Net WR, mm	
Wheat		27.4	29.1	32.2	35.4	33.5	33.3	24.8	15.5	12.5	8.9	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	4.6	6.4	9.7	15.0	24.5	319	
Pulses		21.4	25.3	29.4	32.3	33.5	39.9	19.9	9.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	4.3	6.0	7.9	10.4	17.2	260	
Oilseed		24.9	25.3	25.2	21.5	16.8	6.2	5.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	6.5	9.8	14.8	18.1	22.1	203	
W.Vegetable+Potato		20.7	16.6	13.7	12.9	11.7	11.7	10.4	8.1	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	13.5	18.6	23.3	26.5	28.0	25.1	23.2	271	
Mungbean		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	10.8	13.0	19.8	30.3	27.2	31.4	15.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	153	
S.Vegetable		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	5.1	6.3	6.3	2.7	2.5	0.5	3.2	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32	
Jute		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	4.1	7.3	9.1	11.7	25.9	18.6	10.2	18.6	10.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	118	
Sugarcane		13.7	13.9	15.4	20.0	26.8	36.6	46.2	56.1	62.1	67.6	65.9	62.4	59.4	49.1	34.8	22.8	15.7	7.7	0.0	0.0	0.0	1.0	5.8	0.0	5.1	1.1	12.1	20.1	26.8	34.6	32.0	29.3	23.8	18.9	15.7	14.7	917	
Average		21.7	22.0	23.0	24.2	24.3	24.7	20.8	17.2	12.6	12.1	10.9	17.5	23.5	23.6	19.9	11.6	7.2	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	12.5	22.8	9.4	11.7	13.3	15.3	16.7	20.4	446	
Gross Water Requirment, cum/s	ha																																					Max. cum/s	Max. l/s/ha
Paddy(105days)	5,074	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	5.50	8.18	8.73	11.24	13.04	13.32	14.12	12.16	13.62	11.27	10.05	7.89	5.15	1.91	0.00	0.00	0.00	0.00	0.00	0.00	14.12	2.7839
Paddy(120days)	1,015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	1.81	2.35	2.65	2.55	2.73	2.43	2.75	2.62	2.95	3.19	3.46	2.86	1.88	0.93	0.00	0.00	0.00	0.00	3.46	3.4077
Wheat	5,074	3.22	3.42	3.79	4.16	3.93	3.91	2.91	1.82	1.47	1.05	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.54	0.75	1.14	1.76	2.88	4.16	0.8190
Pulses	1,015	0.50	0.59	0.69	0.76	0.79	0.94	0.47	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.10	0.14	0.19	0.24	0.40	0.94	0.9244
Oilseed	507	0.29	0.30	0.30	0.25	0.20	0.07	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.12	0.17	0.21	0.26	0.30	0.5856
W.Vegetable+Potato	2,029	0.97	0.78	0.64	0.61	0.55	0.55	0.49	0.38	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.63	0.87	1.10	1.25	1.32	1.18	1.09	1.32	0.6484
Mungbean	507	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.13	0.15	0.23	0.36	0.32	0.37	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.7270
S.Vegetable	1,015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.12	0.15	0.15	0.06	0.06	0.01	0.08	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.1464
Jute	1,522	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.14	0.26	0.32	0.41	0.91	0.65	0.36	0.65	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91	0.5991
Sugarcane	507	0.16	0.16	0.18	0.23	0.31	0.43	0.54	0.66	0.73	0.79	0.77	0.73	0.70	0.58	0.41	0.27	0.18	0.09	0.00	0.00	0.00	0.01	0.07	0.00	0.06	0.01	0.14	0.24	0.32	0.41	0.38	0.34	0.28	0.22	0.18	0.17	0.79	1.5648
Total Gross, cum/s	**18,265**	**5.14**	**5.25**	**5.60**	**6.01**	**5.78**	**5.90**	**4.47**	**3.12**	**2.53**	**2.18**	**1.73**	**1.43**	**1.62**	**1.87**	**1.49**	**1.58**	**6.42**	**8.94**	**10.54**	**13.59**	**15.69**	**15.88**	**16.93**	**14.59**	**16.43**	**13.91**	**13.14**	**11.31**	**9.07**	**5.81**	**3.53**	**3.09**	**2.53**	**3.04**	**3.58**	**4.80**	**16.926**	**1.6681**
																																						Min. cum/s	
Sunsari Discharge, P80%, cum/s	cum/s	4.05	4.19	3.84	3.90	3.95	3.84	3.69	3.72	4.09	4.14	4.38	5.79	6.46	8.69	10.12	13.48	21.23	21.18	32.70	30.06	35.12	26.51	29.93	24.46	22.44	26.81	19.65	14.87	12.64	7.36	5.60	4.93	4.06	4.28	3.96	4.08	3.69	
Sunsari Discharge, P80% - 1.8cum/s(50%)		2.25	2.39	2.04	2.10	2.15	2.04	1.89	1.92	2.29	2.34	2.58	3.99	4.66	6.89	8.32	11.68	19.43	19.38	30.90	28.26	33.32	24.71	28.13	22.66	20.64	25.01	17.85	13.07	10.84	5.56	3.80	3.13	2.26	2.48	2.16	2.28	1.89	
Sunsari Discharge, P80% - 0.7cum/s(20%)		3.35	3.49	3.14	3.20	3.25	3.14	2.99	3.02	3.39	3.44	3.68	5.09	5.76	7.99	9.42	12.78	20.53	20.48	32.00	29.36	34.42	25.81	29.23	23.76	21.74	26.11	18.95	14.17	11.94	6.66	4.90	4.23	3.36	3.58	3.26	3.38	2.99	
																																						Min. Bal., cum/s	
Balance, P80%, cum/s	cum/s	-1.10	-1.06	-1.76	-2.11	-1.83	-2.05	-0.77	0.60	1.56	1.95	2.65	4.36	4.85	6.82	8.63	11.90	14.81	12.24	22.16	16.47	19.43	10.63	13.00	9.87	6.01	12.90	6.51	3.56	3.57	1.55	2.06	1.84	1.53	1.24	0.38	-0.72	-2.11	
Balance, P80% - 1.8cum/s(50%)		**-2.90**	**-2.86**	**-3.56**	**-3.91**	**-3.63**	**-3.85**	**-2.57**	**-1.20**	**-0.24**	**0.15**	**0.85**	**2.56**	**3.05**	**5.02**	**6.83**	**10.10**	**13.01**	**10.44**	**20.36**	**14.67**	**17.63**	**8.83**	**11.20**	**8.07**	**4.21**	**11.10**	**4.71**	**1.76**	**1.77**	**-0.25**	**0.26**	**0.04**	**-0.27**	**-0.56**	**-1.42**	**-2.52**	**-3.91**	
Balance, P80% - 0.7cum/s(20%)		-1.80	-1.76	-2.46	-2.81	-2.53	-2.75	-1.47	-0.10	0.86	1.25	1.95	3.66	4.15	6.12	7.93	11.20	14.11	11.54	21.46	15.77	18.73	9.93	12.30	9.17	5.31	12.20	5.81	2.86	2.87	0.85	1.36	1.14	0.83	0.54	-0.32	-1.42	-2.81	
																																						Min. in %	
% covered by P80%	%	79	80	68	65	68	65	83	119	162	189	253	404	400	464	679	853	331	237	310	221	224	167	177	168	137	193	149	131	139	127	158	160	160	141	111	85	65	
% covered by (P80% - 1.8cum/s(50%))		44	46	36	35	37	35	42	62	90	107	149	279	289	368	558	739	303	217	293	208	212	156	166	155	126	180	136	116	120	96	107	101	89	82	60	48	35	
% covered by (P80% - 0.7cum/s(20%))		65	66	56	53	56	53	67	97	134	157	212	355	357	427	632	809	320	229	304	216	219	163	173	163	132	188	144	125	132	115	139	137	133	118	91	71	53	
																																						Min. in ha	
Area covered by P80%	ha	7,985	8,095	6,950	6,589	6,937	6,615	8,393	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	8,635	6,589	
Area covered by (P80% - 1.8cum/s(50%))		4,435	4,619	3,688	3,549	3,780	3,518	4,303	6,245	9,183	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	9,709	all	all	9,053	8,273	6,128	4,829	3,518	
Area covered by (P80% - 0.7cum/s(20%))		6,604	6,743	5,681	5,407	5,709	5,411	6,802	9,825	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	9,246	7,155	5,407	

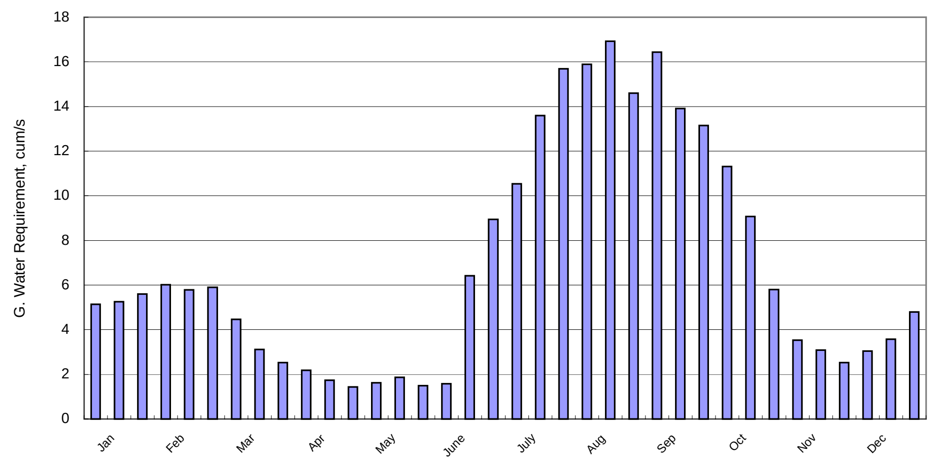


Figure 6.5.4 Gross Water Requirment of 60% Paddy and Upland Crops

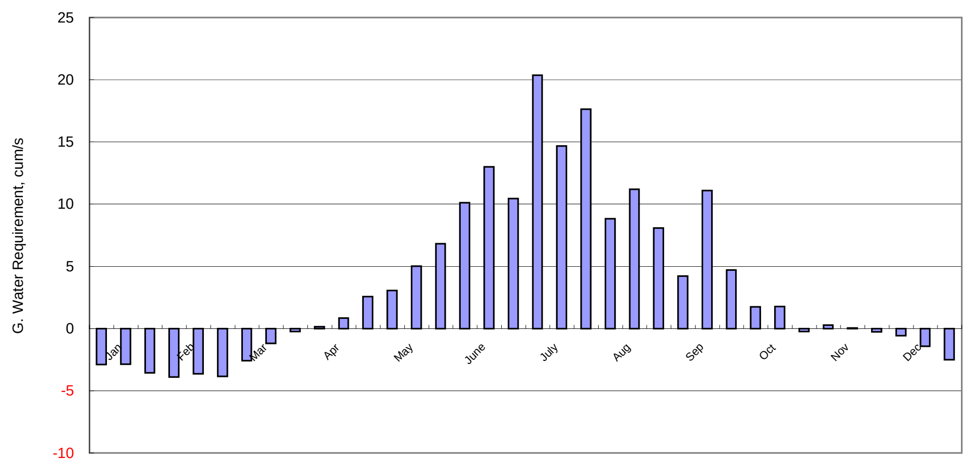


Figure 6.5.5 Surplus/Deficit on Sunsari River, 60% Paddy and Upland Crops (DS Rlse 1.8 cum/s)

6.5.6 Preventive Irrigation

The concept of preventive irrigation, sometimes called supplemental irrigation, can be seen in the original SMIP irrigation duty of 0.66 l/s/ha. The preventive irrigation has been carried out in countries where vast cultivable land is available while water resources are so limited that cannot cover whole the prospective land. No formula has been established to estimate preventive irrigation requirement, but we can refer to actual examples practiced in the field. The example is STW irrigation. The farmers, in most cases, apply a minimum amount of water to save diesel cost[8].

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

Table 6.5.10 Preventive Irrigation Requirement

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

Note: STW capacity assumed at 20l/s

Table 6.5.11 below shows: 1) coverage area based on Penman requirement, and 2) coverage area by preventive water requirement, with three cases each depending upon how much water should be released to the downstream. The first case is no downstream release, second is release 50% of minimum probability 80% volume (1.8 cum/s release), and the third one is release 20 % of minimum probability 80% (0.7 cum/s release). The table tells us:

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

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

How much water the Project should release to downstream is very much dependent on how the paper mills located just downstream of the proposed headwork site proceed in terms of establishing an effluent treatment plant (ETP). Since the present water quality has already been deteriorated by the mills' effluent, this Study considers no water extraction during winter season as the base case. Though it is very difficult to forecast how much the paper mills can

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

deal with, this Study considers 50% downstream release, 1.8 cum/s release, as expecting case 1, still requiring the factories to establish ETP that reduces the effluent by 80% (at present DANIDA intervention is on-going). Then, 20% release, 0.7 cum/s, is also considered as expecting case 2 on condition that the factories meet the Nepalese Industry Effluent Standard (for detail downstream release, see Chapter 11) and also fishermen's compensation is met. Based on this, this Study proposes the following irrigation development:

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

Winter: Base case: No river water is extracted (downstream release is 100% as present). Irrigation in winter is carried out with STW as the present situation.

Winter: Expecting case 1: proposed cropping pattern under rotational irrigation between Suksena and Shankarpur by year with preventive irrigation (downstream release is minimum 1.8 cum/s, 50% of minimum P80% flow)

Winter: Expecting case 2: proposed cropping pattern under rotational irrigation between Suksena and Shankarpur by year with conventional irrigation, requirement of which is estimated by Penman method (downstream release is minimum 0.7 cum/s, 20% of minimum P80% flow)

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

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

Table 6.5.11 Conventional and Preventive Irrigations during Dry Season

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

6.5.7 SMIP Water Release

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

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

Table 6.5.12 SRIP Area Coverage with SMIP Supplemental Water Release

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

6.5.8 Major Facilities' Design

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

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

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

- Position of headworks — 600m downstream from E-W High Way
- Type of headworks — Barrage (fully manual movable gate type)
- Catchment Area — 300 km^2
- Design High Flood Discharge — 650 m^3/sec
- Width of headworks — 72 m
- No. of Spillways — 5 Nos.
- No. of Under Sluices — 4Nos. (on both sides of the headworks)
- Size of Under Sluice Gates — 6.2m x 3.85m
- Size of Spillway Gates — 6.2m x 3.60m

- Design Water Intake Discharge 16.93 m^3/sec
- River Maintenance Flow about 1.8 m^3/s (50% of minimum P80%)
- Related Structure Fish Pass (on both sides of the headworks)

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

Table 6.5.13 Design Flood Discharge

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

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

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

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

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

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

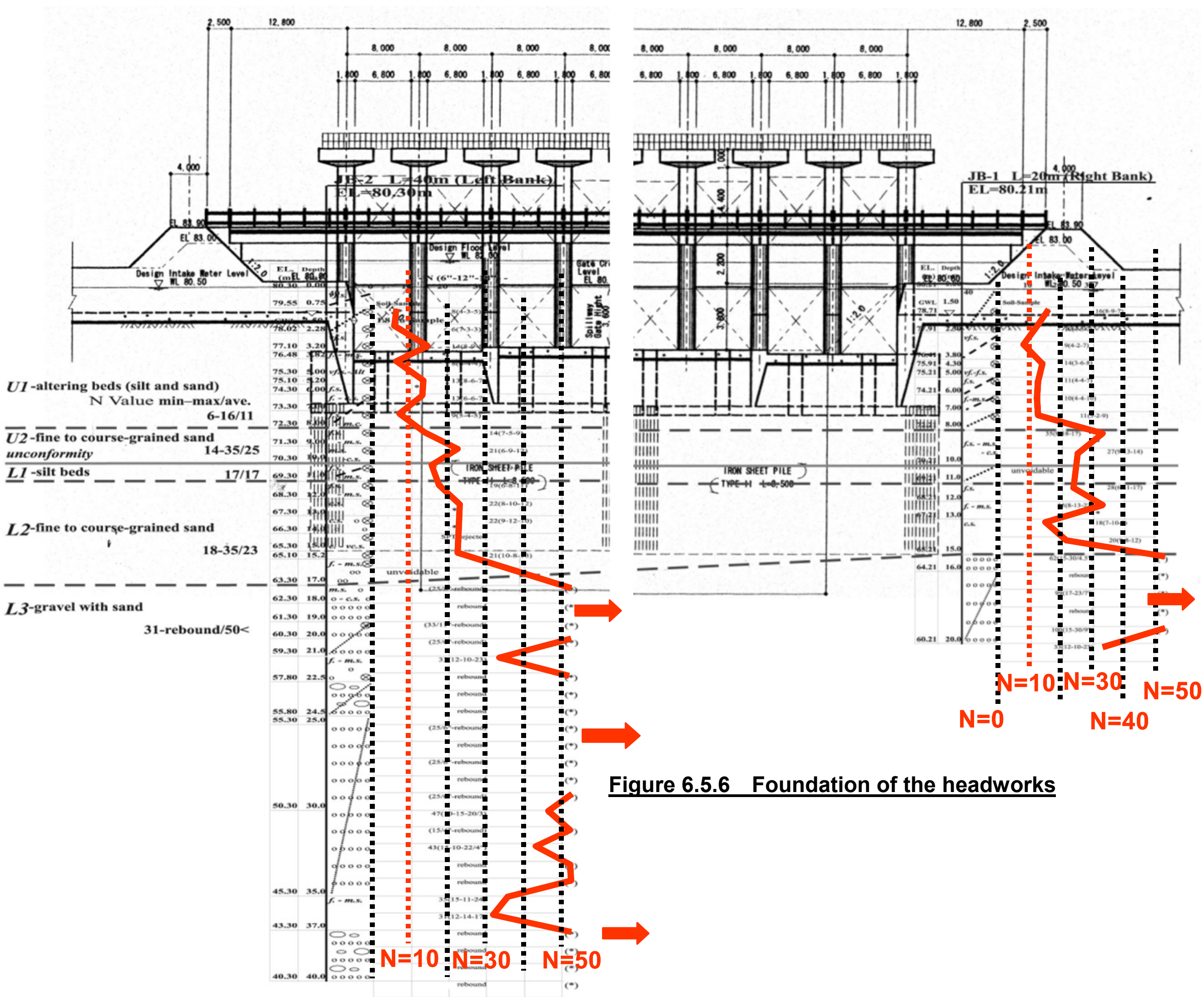


Figure 6.5.6 Foundation of the headworks

6.5.9 Canal Design and Irrigation Network

Canal design refers to the said manual, SMIP experiences and the existing conditions of the present canal network. To meet with the present cross section of the canals, the new design section basically follows the existing cross section so that additional land acquisition can be minimized. Though the present canals are all unlined, the main canals of Suksena and Shankarpur plus the biggest secondary of 4SRR are concrete-lined since the embankment material available around the site is very much sandy. Schematic diagrams for the canal network with the design discharge are shown on Figures 6.5.7 & 6.5.8.

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

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

A Water Course constructed by sandy soil, requiring frequent maintenance

<u>Conveyance Canal (The drawing is shown as No. CN-1 in separate volume, "DRAWINGS")</u>

1) Suksena Conveyance Canal

• Command Area	5529 ha		
• Design Discharge	9.23 – 8.05 m3/sec		
• Canal Length	3.32 km		
• Canal Slope	1/4310		
• Cross Sections	Bed Width	6.80 – 5.90 m	
	Side Slope	inside	1:1.0
	(Ver. : Hor.)	Outside	1:1.5
	Lining	Concrete Lining	t=10cm

2) Shankarpur Conveyance Canal

• Command Area	4619 ha
• Design Discharge	7.70 – 7.64 m3/sec

- Canal Length 2.01 km
- Canal Slope 1/5000
- Cross Sections Bed Width 6.00 m
  Side Slope inside 1:1.0
  (Ver. : Hor.) Outside1:1.5
  Lining Concrete Lining t=10cm

Main Canal (The drawings are shown as No. CN-1 to No. CN-16 in DRAWINGS)

1) Suksena Main Canal

- Design Discharge 8.05 – 0.73 m3/sec
- Canal Length 15.20 km
- Canal Slope 1/4000 – 1/3000
- Cross Sections Bed Width 5.20 – 2.00 m
  Side Slope inside 1:1.0
  (Ver. : Hor.) Outside1:1.5
  Lining Concrete Lining t=10cm

2) Shankarpur Main Canal

- Design Discharge 7.64 – 0.81 m3/sec
- Canal Length 15.30 km
- Canal Slope 1/2800 – 1/2500
- Cross Sections Bed Width 4.50 – 2.00 m
  Side Slope inside 1:1.0
  (Ver. : Hor.) Outside1:1.5
  Lining Concrete Lining t=10cm

Secondary and Tertiary Canal (The drawing is shown as No. CN-2 in DRAWINGS)

1) Along the Suksena Main Canal

Secondary Canal

- Design Discharge 0.20 –3.00 m3/sec
- Total Proposed Length 34.72 km
- Canal Density 4.66 m/ha (Net command area is 5529ha)

Tertiary Canal

- Design Discharge 0.1-0.5 m3/sec
- Total Proposed Length 100.01 km
- Canal Density 18.08 m/ha (Net command area is 5529ha)

2) Along the Shankarpur Main Canal

Secondary Canal

- Design Discharge 0.2 – 3.0 m3/sec
- Total Proposed Length 25.8 km

- Canal Density 5.58 m/ha (Net command area is 4619ha)

Tertiary Canal

- Design Discharge 0.1-0.5 m3/sec
- Total Proposed Length 72.4 km
- Canal Density 15.67 m/ha (Net command area is 4619ha)

6.5.10 Distribution System

An Example of Proportional Distribution in SMIP

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

The proportional distributors and farm turnouts are set along the secondary/tertiary canal to distribute the irrigation water properly. These drawings are shown as No. AF-7 and AF-8 in DRAWINGS.

Figure 6.5.7 Schematic Diagram of Suksena Main Canal (Right Bank of Old Sunsari River)

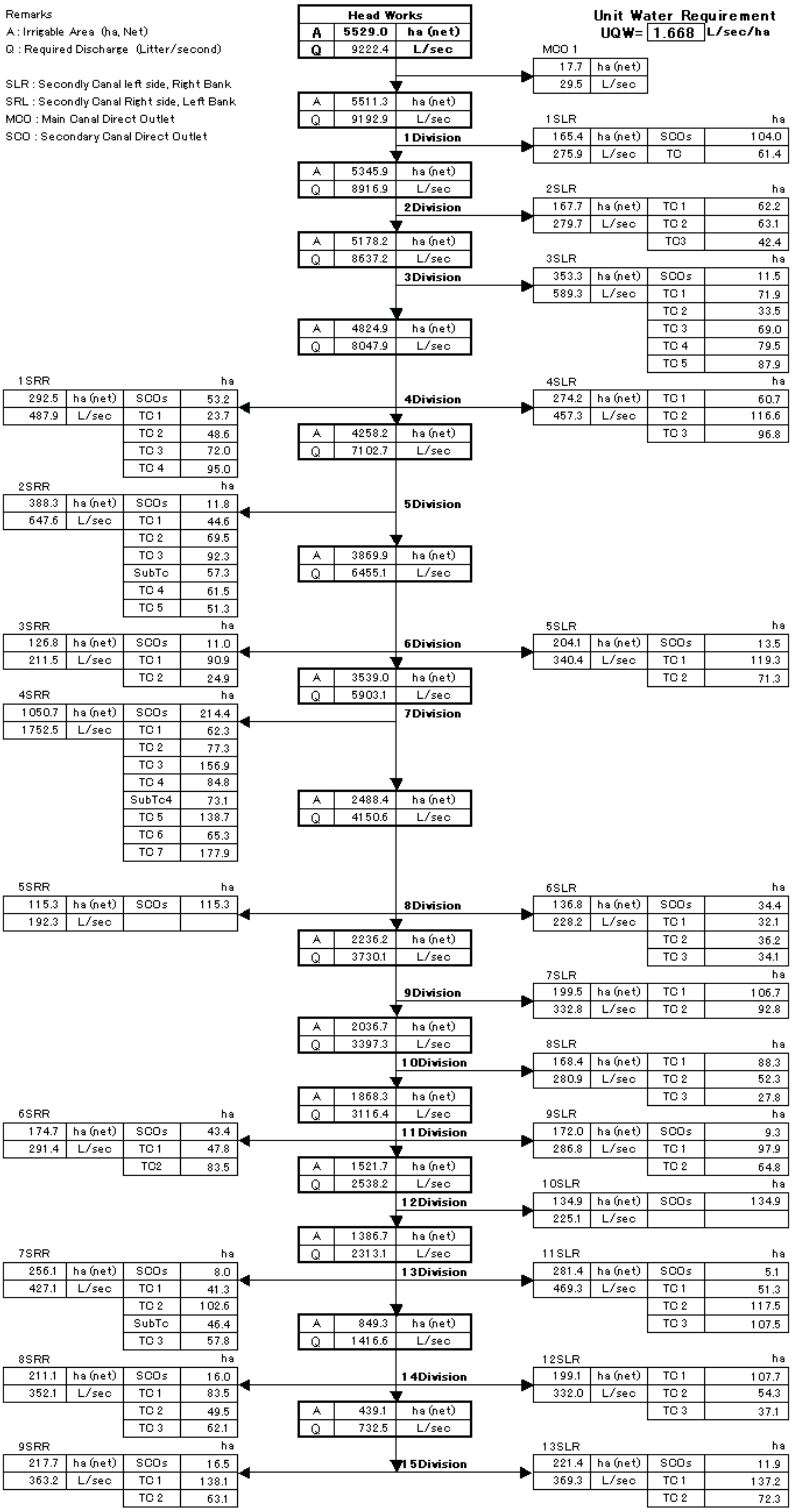
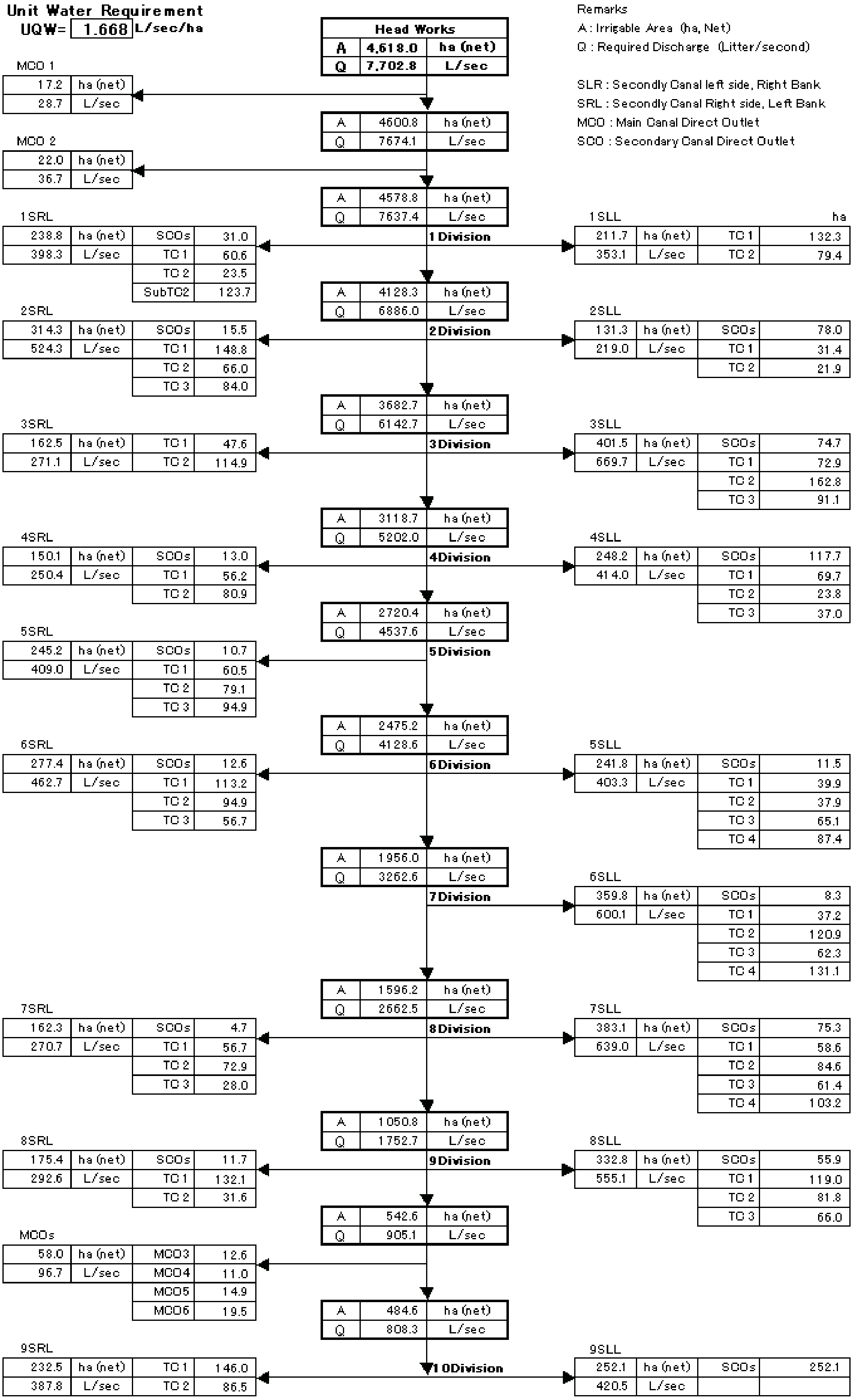


Figure 6.5.8 Schematic Diagram of Shankarpur Main Canal (Left Bank of Old Sunsari River)



6.6 Groundwater Development

The southern most area in the Study area, 397 ha in net, cannot receive gravity irrigation water from Sunsari river due to its high elevation. This area is designed to have groundwater development. Designing the groundwater development refers to the result of the test well carried out by this Study, existing 5 deep tube-wells and 9 shallow tube-wells in the Sunsari district.

6.6.1 Standard Design of Tubewell

The wells' standard design is as follows, taking into existing practices in Nepal:

- **Depth:** The STW is designed to tap the unconfined Aquifer I, so the depth is fixed to be 30m. Similarly the DTW is designed to tap confined Aquifer II and Aquifer III, so the designed depth is fixed to be 100m.
- **Diameter:** The diameter of shallow tube-well and deep tube-well will be 100 mm and 250 mm respectively. These diameters are fixed by referring to the existing standard tube-well data and availability of the materials e.g. pipes.
- **Screen length:** To fix the screen length of STW, it is considered the maximum value 9 m (with 12-15% opening area) among the three shallow tube-wells STW5, STW8 and STW10. Similarly in case of deep tube-well the screen length is fixed to be 25 m (12-15% opening area) considering the maximum value in DTW-15 and DTW-16.

6.6.2 Hydro-geological Contents

Together with the standard design of wells mentioned above, following hydro-geological contents are employed in estimating well capacity:

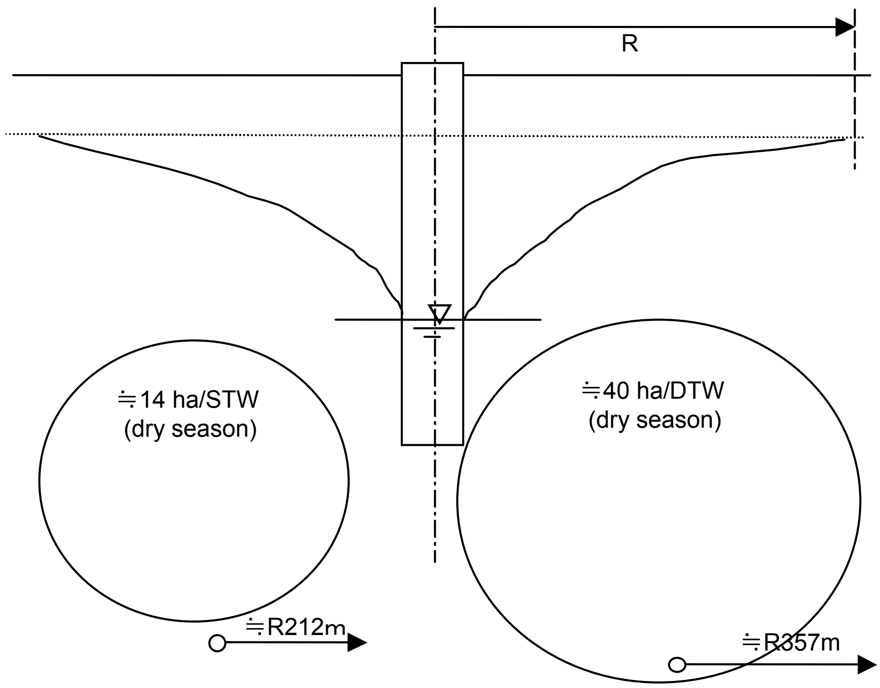
- **Transmissivity (T):** The transmissivity is calibrated by using the Logan's Approximation Method and found 1200 m^2/day for shallow tube-well design and 1800 m^2/d for deep tube-well design.
- **Discharge (Q):** The required discharge is designed to be 14 l/s and 40 l/s for shallow tube-well and deep tube-well respectively. 14 l/s is available by presently used engine driven centrifugal pump for shallow tubewell irrigation. 40 l/s is designed taking into account O & M of the system including pump repayment available in Terai as well as farmers' manageability. However, according to the result of deep test well, the discharge can be increased to 100 l/s and even more than that.
- **Storage Coef't (S):** A range of storage coefficient is selected as 0.05-0.3 (unconfined aquifer) for shallow tube-well and 0.0005-0.005 (confined aquifer) for deep tube-well.
- **Drawdown (d):** The drawdown for shallow tube-well is fixed at 1.5 m considering the lowest static water level of STW-8 in the years 1992 and 1995

and maximum suction capacity of centrifugal pump. In the case of deep tube-well, the drawdown depth is fixed at 3 m considering the maximum deep value from the existing data.

- **Operat'n Time (t):** The operation time for both shallow and deep tube-well is selected to be 0.5 day by practice.
- **Radius of Infl'ce (R):** Radius of influence is calculated by using the Thies Method. Considering the maximum value of storage coefficient (0.3 for unconfined aquifer and 0.005 for confined aquifer), it gives the radius of influence (R) of 67 m for STW and 600 m for DTW. If the average storage coefficient (0.175) for STW and (0.003) for DTW is selected, the radium of Influence R will increase to 88 m and 800 m for STW and DTW respectively.

Table 6.6.1 Standard Design and Capacity of the Irrigation Tubewell

Specification	STW	DTW
Well depth	30 m	100 m
Diameter of well)	10 cm (6")	25 cm (10")
Screen (≒thickness of aquifer	9 m	25 m
Transmissivity	1200 m^2/d	1800 m^2/d
Discharge	14 l/s/ (1210 m^3/d)	40 l/s/ (3450 m^3/d)
Storage Coefficient	0.05 - 0.3 [0.175]	0.0005 - 0.005 [0.003]
Drawdown (s)	1.5 m	3.0 m
Operation Time	0.5 day	0.5 day
Radius of Influence	67 m - [88 m]	600 m - [800 m]



6.6.3 Well Development

The soil of the southernmost area is very much sandy. Paddy planting in this area is not practical. Even if some farmers try to plant paddy, they seldom apply groundwater to paddy.

Pump irrigation usually does not meet with the paddy water requirement from the economical point of view. Therefore, the southern most area is to have upland crop only. The water requirement of upland crops are given of the Table 6.6.2:

Table 6.6.2 Irrigation Duty of Upland Crops

Crop	Duty, l/s/ha	Remarks
Wheat	0.82	Say 1 l/s/ha
Pulses	0.92	
Oilseed	0.59	
Potato	0.65	

In planning STW development, arrangement applied in ADB/CGISP is taken into account. CGISP considerers that usually 4 to 5 farmers can well form a shallow users group as guarantor each other in order to take loan to construct the well. In this case, the coverage becomes about 5 ha equivalent to about 5 l/s yield, though the STW can often have a yield of more than the design discharge of 14 l/s. In planning DTW, 60 l/s and 100 l/s discharge are also undertaken since if the discharge is limited to 40 l/s, no advantage of DTW is foreseen as compared to STW from the view point of initial investment as well as operation cost. The required number of wells is as follows:

Table 6.6.3 Estimation of Shallow and Deep Tubewells

Shallow TB		Deep TB		Deep TB		Deep TB	
Yield, l/s	Nr	Yield, l/s	Nr	Yield, l/s	Nr	Yield, l/s	Nr
5	80	40	10	60	7	100	4

This Study proposes the promotion of STW, total 80 numbers, since the initial cost is very preferable. Dissemination of CGISP program should be made to the farmers, or otherwise DOI should facilitate the farmers to construct the STW by a group or taking loan from ADBN. After the farmers get used to the operation of the groundwater and the depreciation has been made, they may proceed to the deep groundwater with 60 to 100 l/s yield which covers bigger area than the standard of 40 l/s, which is economically justified. Power line has been progressing to the southern most area, and within 5 years the line is expected to cover the last 5 km. Together with the power line established, the DTW development can be made as a mid & long term development of the area.

The area is solely practiced for upland irrigation. There may be a possibility to establish simple drip irrigation system. Drip irrigation system requires about 40% less irrigation water leading to 40% less diesel cost. The area is disadvantaged because of the geographical distance. If there is a pilot farms equipped

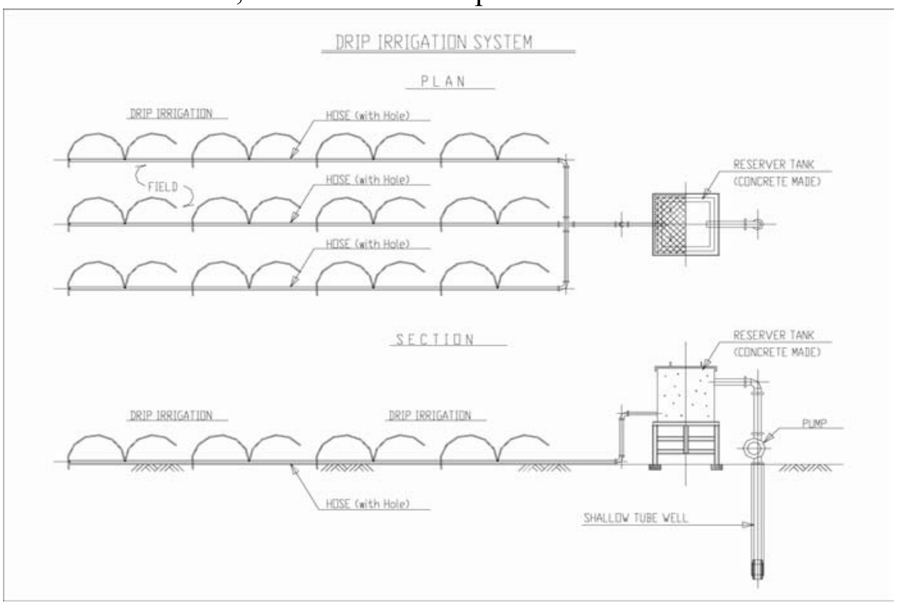


Figure 6.6.1 Illustration of Drip Irrigation Method

with a STW including simple drip system, nearby farmers and visitors would be attracted, and modern technique may easily be introduced (see Figure 6.6.1).

6.7 Drainage Development

6.7.1 Conventional Drainage

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

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

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

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

Table 6.7.1 Annual Maximum Daily Rainfall (Unit: mm/day)

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

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

Assumptions: Design rainfall is 194 mm/day
Effective water depth in the paddy field is 110 mm
Standing water depth in the paddy field is 30 mm

Calculations: Q = q × A

q = RE24 × 10 m^2/(3,600 sec × 72 hours) = 114 × 10/(3,600 × 72) = 4.3 l/sec/ha

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

Q = Design drainage water requirement (m^3/sec)

q = Unit drainage water requirement per ha

A = Drainage area

R24 = Design rainfall, 194 mm/day

D1 = Effective water depth in the paddy field, 110 mm (assumption)

D2 = Standing water depth in the paddy field, 30 mm (assumption)

RE24 = Excess rainfall to be drained, 114 mm

The proposed drainage system consists of collector, tertiary or secondary, major existing streams and drain to the Sunsari river, Old Sunsari river and Budhi river. The function of a collector drainage canal is to receive excess rainwater from the irrigated areas. It will then carry the excess water to the tertiary, secondary drain or in some cases directory natural stream. The smallest unit of on-farm, about 20 ha each under water course, will have at least one access point to the either collector or tertiary. The tertiary drainage canal will then be connected to secondary or existing streams. The tertiary and secondary drains are as far as possible designed to run along irrigation tertiary and secondary canals (The drawing of this concept is shown as No. CN-17 and DR-1 to DR-4 in DRAWINGS).

6.7.2 Mariya Dhar (Old Sunsari River) Utilization

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

The causeway can work as a weir to store the drainage water coming from the Project area. Then, the drainage water can be diverted into a tertiary canal downstream. Taking into account topographic condition, the drainage water can be provided to TC3 of 11 SLR of Suksena canal, irrigable area of which is about 500 ha. This Study proposes the development of Mariya Dhar to be done as a mid term development, say 6 – 7th years after the Project commences the operation (The drawing of this concept is shown as No. MD-1 and MD-2 in DRAWINGS).

6.8 Rural Infrastructure Development (Road)

Transaction in kind is still an important mean in the economy of the Study area. Paddy is used for paying land rent to the land owner and also agricultural income is still mainly in a form of kind for self-consumption and small part of agriculture produce is exchanged to cash. According to the results of Rural Socio-economic Survey conducted by the Study Team, self-consumption ration of paddy is estimated at around 60% of the total produce.

Self-consumption of cereals is, on one hand, a good way of avoiding any risks from marketing. Yet, the people require cash for their daily necessary expenses. Cash generation measure for the people in the Study area is primarily to sell farm produce. Selling farm produce will be enhanced by improving access to market, namely improvement of road network. The road improvement will ease the constraints for marketing and encourage the farmers to grow more vegetables, leading to the realization of the benefit from the irrigation development.

6.8.1 Major Road Improvement

As it has been mentioned, the road condition in the western part of the Study area is poorer and that may have also caused the current little development interventions to the areas. Therefore, the improvement of road network condition in the western part of the Study area will be put in high priority. To improve current road network situation, connection of village roads and canal maintenance roads is proposed for effective transportation in the areas.

To establish effective road network in the western part of the Study area, three sections of existing village roads will be necessary to improve. These sections are: 1) Dewanganj – Ghuski, the length of 5 km, 2) Harinagara – Basantapur with the length of 1.3 km, and 3) Ghuski – Basantapur with the length of 5.5 km. The roads of 2) and 3) require new construction of bridges apart from existing road improvement. If these roads are improved, the people in Basantapur and Ghuski can more easily access to Dewanganj and Harinagara to connect to Inaruwa and Biratnagar and there is also vegetable collection center at the right south of Dewanganj. The width of the road with gravel pavement is 5 m including the shoulder (The drawing is shown as No.RI-1 in DRAWINGS).

Canal maintenance road will be designed with five meters width (four meter for passing), wide enough for tractors and four-wheel vehicles to pass and the terminal or crossings of the canal maintenance road will be connected with the main village roads. Canal maintenance roads along both the Suksena canal and a branch canal running through the center of Basanterpur will be utilized for the road networking.

Connection between above two roads and canal maintenance roads will also improve the accessibility to the E-W highway, north direction from Basantapur and Ghuski. By this road networking, the mobility of the people in the areas will be improved and they could be encouraged to grow vegetable for marketing as well. Also development supports by the government as well as the donor agencies will have more access to these areas. Figure 6.8.1 shows the proposed road network in the western parts of the Study area.

The village roads of 1) Dewanganj – Ghuski and 3) Ghuski – Basantapur have been actually identified as priority roads in the District Transport Master Plan (DTMP) prepared by the DDC of Sunsari in 2001. The road of 1) Dewanganj – Ghuski has been under maintenance work by the DDC for the beginning of some 600m in year 2002[9]. To connect Ghuski and Basantapur, a bridge to cross the Sunsari river will be needed and as of October 2002, the contract has been already awarded to a local contractor. As DTMP states the improvement of the above roads, this Study also proposes to put highest priority on the three roads

[9] DTMP estimates the possible fund for road improvement for the total Sunsari district at 2.37 million Rs per year from 2001/02 to 2005/06. The source of funds are identified as Rural Road Grants at 400,000Rs, DDC grants at 200,000Rs, VDC grants at 800,000Rs, Agriculture Road Program at 300,000Rs, DOR funds at 670,000Rs.

including the construction of the bridge. This Study considers the construction of the road as a part of the SRIP project but the construction of the bridge is allocated to the said program (means road construction is included in the cost estimation but bridge is excluded).

6.8.2 Feeder Road Improvement

While the road network for marketing and improving living standard is proposed above, hauling crops from the farm to major roads has to be taken into account to mitigate the constraints of transportation. Referring to the plan formulated by an ADB study for Community Groundwater Irrigation Sector Project, village road improvement in a manner below is also proposed.

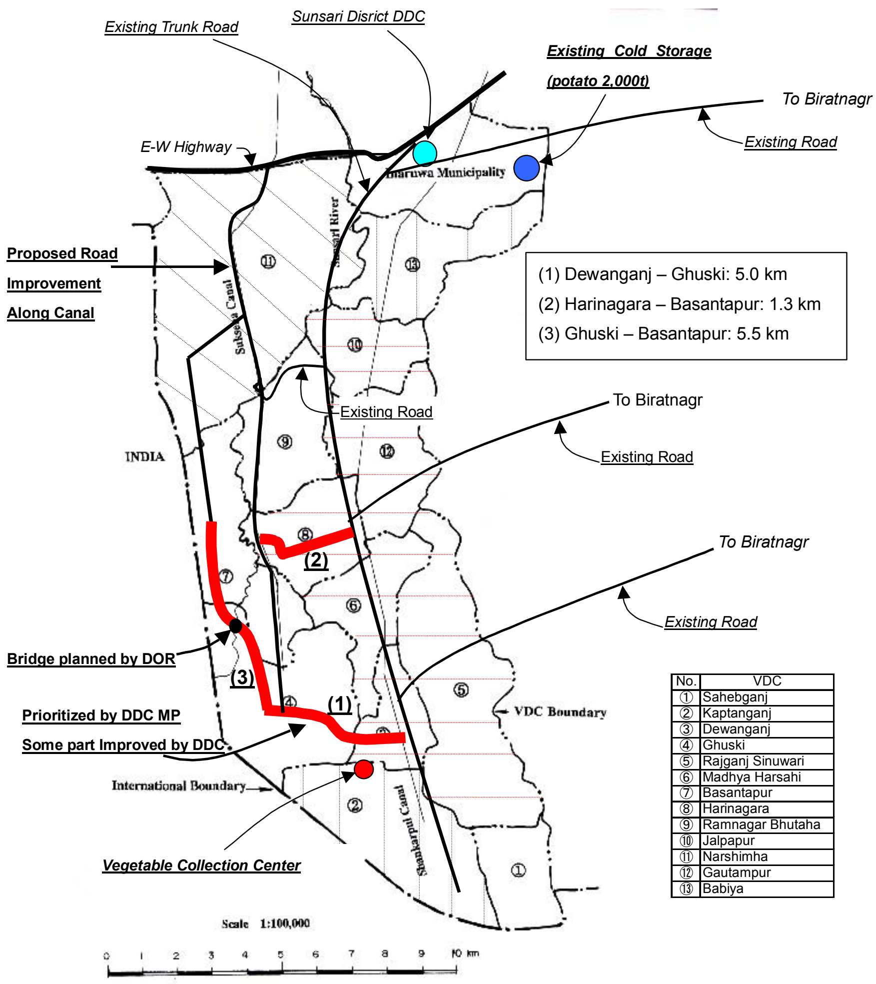


Figure 6.8.1 Proposed Road Network in Western Part of the Study Area

The process of village road improvement is described as: the Project (DOI) will help WUA to 1) identify, prioritize and select farm-to-market road segments (access and village roads) that need improvement, 2) reach an agreement with DOI on the design and cost estimates of the proposed roads, and 3) implement minor rehabilitation works by relevant WUA or VDC, while DOI will implement major road improvement works.

Concerning the major road improvement works above by DOI, this Study proposes densely networked tertiary canals. The tertiary has a width of 3 m road in all the cross sections which is enough for bull-cart passage, and the total length reach to as long as 172 km. This tertiary arrangement will obviously facilitate the transportation of the agriculture produce. Aside from this densely networked tertiary canals, secondary canals having same 3 m road width and about 60 km total length will also facilitate the transportation of the product. Thus, the arrangement proposed by this Study for feeder road improvement is:

- The Government (DOI) will construct extensive road network together with tertiary and secondary canal networks in addition to the main canals of Suksena and Shankarpur.

- The WUAs are requested to construct small feeder road from their field to the nearby tertiary or secondary by utilizing their own labor, cash appropriation from their ISF income and maybe an allocation from VDC budgets if available.

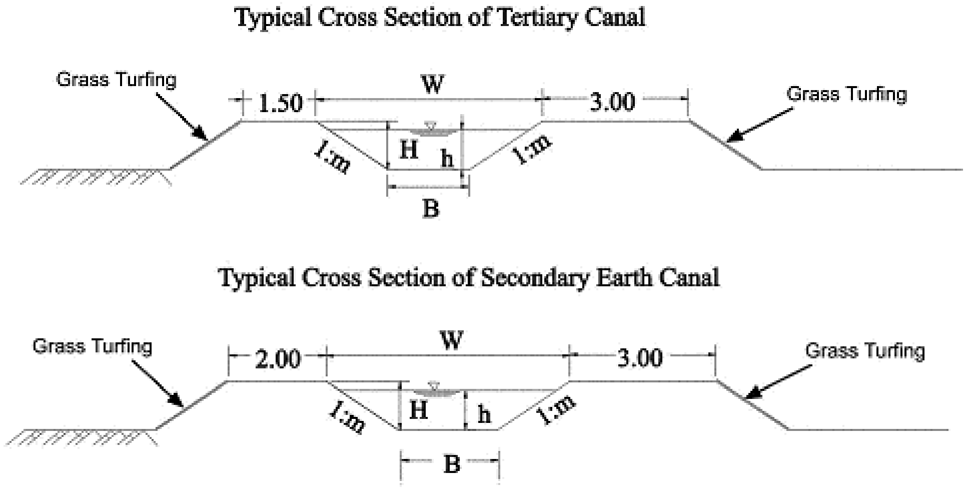


Figure 6.8.2 Canal Maintenance Road working as Feeder Road

6.9 Flood and Inundation Mitigation

6.9.1 Flood and Inundation

As Figure 6.9.1 shows, 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.

Inundation of the Study area is characterized by flood type and submergence type. Water in the flood type flows from river into downstream pass through the cultivated land and residential land over gently sloping alluvial surfaces during the heavy rain. But in case of submergence type, the water is piled up over the areas at a nearly level valley floor during heavy rain and after that some time. These inundation areas are summarized as follows:

1) Babiya VDC N0.1

Around Miyatol / gently slope to south / Flood covers about 1 km^2 for 1 to 2 days in every rain-season with a depth of 30 to 50 cm above surface. The water flows from NW to SE, and the banks of Shankarpur Canal is sometimes eroded.

2) Babiya VDC No.2

East side of Jalpapur Batartol / along west bank of Budhi river / Flood covers about 1 km^2 with 0.5 km width and 2 km long 1 to 2 days in rain-season. The Budhi river gives floods during heavy rain.

3) Rajganj Sinuwari VDC

Between Sinuwari and Rajganj / a nearly level valley floor / This area is submerged about 3 km^2 with 0.3 meter above surface for 15 to 30 days in rain-season. Flow is from N-W.

4) Sahebganji VDC

Between Dhanuktol and Teliyaritol Suritol / a nearly level valley floor / This area is submerged abut 2 km^2 with a maximum of 1 meter above surface for 7 to 10 days in the rain-season. The Budhi river gives the floods during heavy rains.

5) Narshimha VDC No.1

Between Narsimha and Jhabatol / a nearly level valley floor / This area is submerged abut 3 km^2 with 1 to 1.5 m above surface for one week in a rain-season. The Sunsari river floods during the heavy rains.

6) Narshimha VDC No.2

Soniyahi Miyatol / a nearly level valley floor / This area is submerged about 5 km^2 with maximum 1 meter above surface for 10 days in rain-season. The Sunsari river floods during the heavy rain.

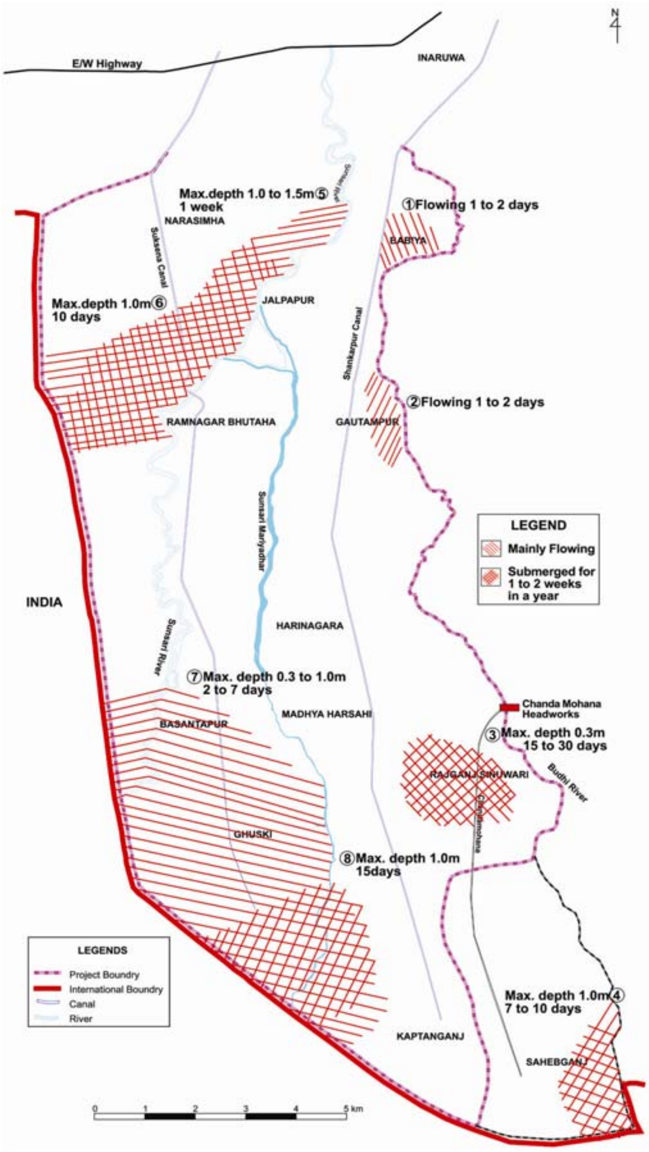


Figure 6.9.1 Inundation Condition in the Study Area

7) Basantapur VDC - Ghuski VDC

Between Suksena to Kabilasa Daksintol / along east bank of the Sunsari river / Flood covers abut 10 km^2 with 0.3 to 1.0 meter above surface for maximum 10 days in the rainy season. The Sunsari river floods during the heavy rain.

8) Kaptanganji VDC

Around Shivaganj Raghunathpur / a nearly level valley floor in poorly drained area along the Sunsari river with Indian-border / This area is submerged about 6 km^2 with maximum 1.5 meter above surface for about 15 days in rain-season. The Sunsari river floods during the heavy rain.

6.9.2 Mitigation

Submergence condition is associated with the location of rivers and conditions of either prolonged or high intensity rainfall. Submergence and flood cannot be accurately predicated, however river training together with embankment as well as repairing/strengthening the existing banks along the areas where the runoff tends to concentrate could reduce the possibility of the probable damage.

Concerning the Sunsari river, there was an Indian mission in January 2002 to discuss about the river training. Though there is already an embankment along the Sunsari river in Indian territory, Nepalese side has not yet constructed the bank in some areas of upstream and most of the mid to downstream reach in the Study area. Therefore, a flood taking place in Nepalese side is giving a damage to some extent to Indian side in spite of the embankment already there in Indian side. Though concrete agreement between the two Governments has not yet come up, this Study proposes the river training should be undertaken by the prospective arrangement and separated from this proposed SRIP.

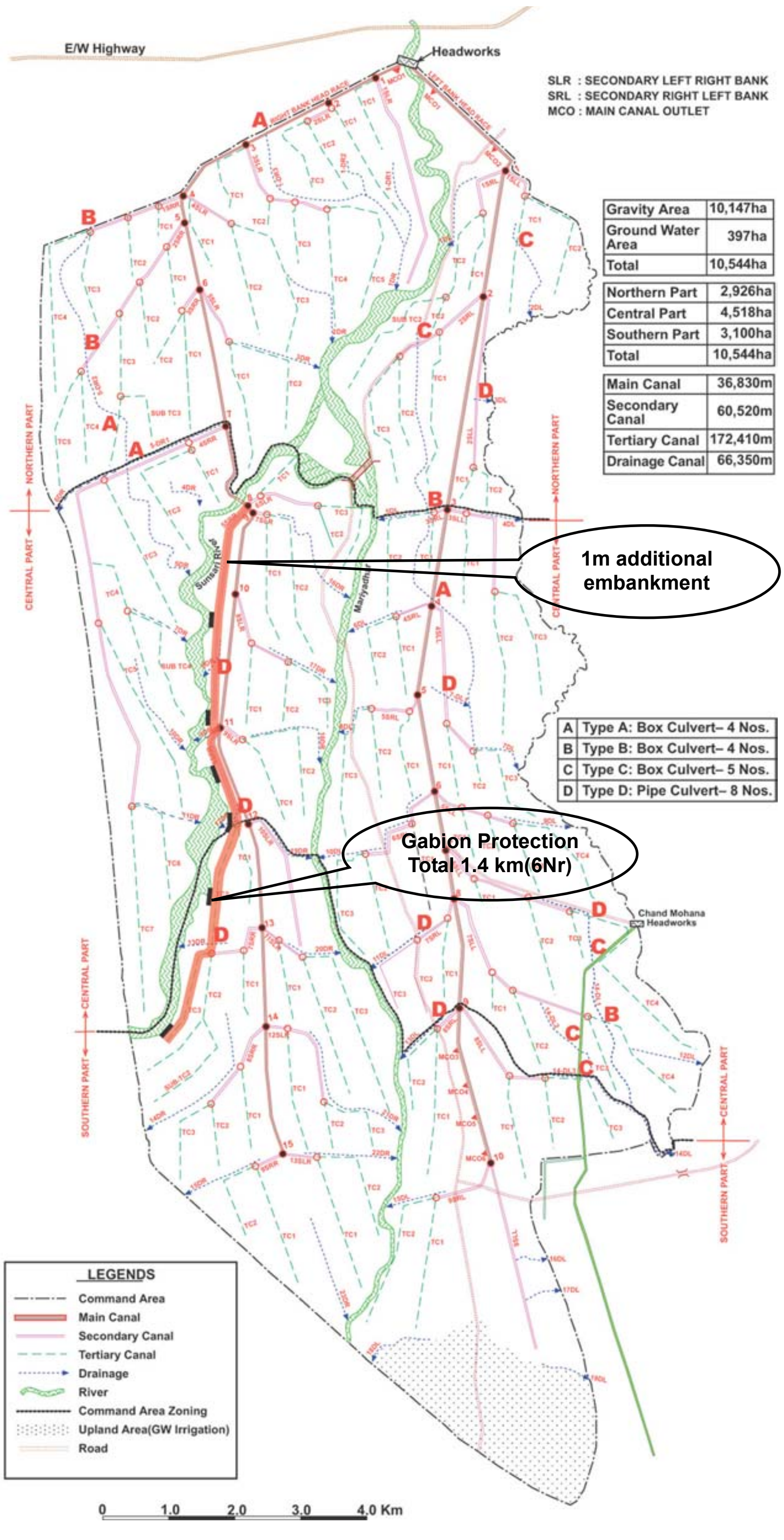


Figure 6.9.2 Proposed flood Protection and Crossing Drainage

Instead, this Study proposes bank strengthening of canals running along the Sunsari river as shown in the Figure 6.9.2, so that flood would not spill over to the mid and southern part of the Project area. The strengthening consists of 1 m width additional embankment almost all the reaches after the siphon point of Suksena and a part of gabion protection. This arrangement would mitigate the severest inundation taking place in No.7 & 8 in the above figure.

Aside from the strengthening of canal embankment, no protection works are planned in this Study since additional civil works for flood mitigation would not be justified from the economic point of view. Rather, smooth draining of flood is planned. As many farmers raised concerns during interviews and Farmers Consultation Workshops, canal network sometimes hiders smooth flood recession, causing lasting submergence. This situation in worst cases results in breaching the canal intentionally by the local villagers to run the retarding water away. To mitigate this situation, say get the retarding water away in a short period, this Study designs drainage siphons crossing canal networks as shown in Figure 6.9.2 (as A, B, C, D).

In addition to those measures above, a proposal from agricultural aspect is also pursued. Under inundation condition, most crops except jute and paddy have difficulty to grow well. Therefore, the areas prone to flood and inundation are proposed to plant paddy and/or jute as most farmers are already practicing.

6.10 Agriculture Supporting Services

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

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

This Study follows these policies in providing appropriate agricultural supporting services to the beneficiaries together with irrigation water. Now, a structure of agricultural supporting services under the Project is proposed below:

6.10.1 Extension Services

It is proposed that water users association, to put it concretely a committee in charge of agriculture promotion as a planning branch of the association, should play a role of a window to receive supporting services instead of setting up new farmers organization. Supporting services will be provided on demand or needs of farmers basically. After that, water users association will disseminate the supporting services to the concerned members in conjunction with the facilitation by the extension staff, JT and JTA.

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

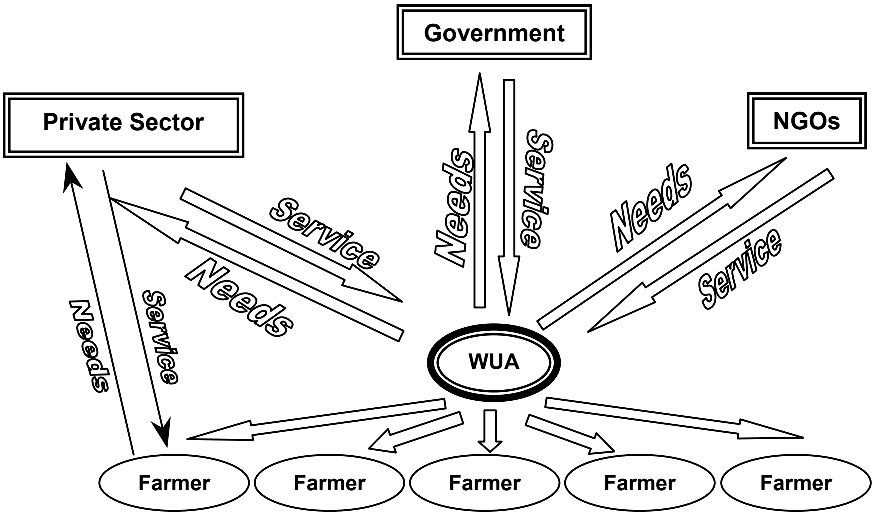


Figure 6.10.1 Structure of Agricultural Supporting System under the Project

One of the most important aspects for farmers is the variety of choices. To apply for the agricultural technologies in their different circumstances, it is an advantage that farmer could have choices in extension services to employ in their farming no matter where the services come from. The government has, therefore, the role to present the choices of technologies in wide range in corporation with NGOs and private sectors.

Better communication between the above service providers and farmers should be emphasized in the extension system, as well. As mentioned, there is the lack of communication aggravated by the lack of extension personnel. Extension services have not really based on farmers' needs and also the feedback from farmers toward better services have not been effective, so the farmers remain only to express their dissatisfaction with the services. Two-way communication will contribute to increasing the appropriateness and quality of the services.

1) Extension for Variety of Crops Utilizing Existing Knowledge

Vegetables such as cauliflower, cabbage, cucumber, okra, and potato, have been already familiar to the farmers in the Study area. There are some commercial vegetables growers who have already established production procedure, as well. It is expected that existing commercial vegetable growers play a role of the core farmers to distribute their skills to the newcomer of commercial vegetable production through the agency's extension services. As mentioned, the most reliable source of the knowledge for farmers is farmers. Extension services providers should keep this in mind and utilize the local knowledge in extension activities.

As well as vegetables, cereals like spring paddy or basmati rice can also be included in the list of extension, though the cereals like spring paddy can only be grown in some upstream reaches and basmati rice is not popular in the Study area. Farmers in upper stream reaches of the SMIP area have ever grown spring paddy. Their knowledge can be transferred to the farmers in the Study area with the assistance of the extension personnel.

2) Consideration on Women's Status

Various kinds of vegetables are also introduced for kitchen gardening led by women. The status of women could be improved by strengthening women's ability to earn. On the other hand, as it has been mentioned, because the most of work on farm are carried out by women labor, to focus on women to add income generation activities may cause too much burden on them. Therefore, the extension service suppliers should also monitor the labor division in extending various crops in various ways.

3) Dissemination of Appropriate Application Method of Fertilizer and Chemicals

Although application of fertilizer and chemicals is common in the Study area, the way of the application depends on farmers' experiences. Commercial vegetables growers tend to apply farm-input excessively so that the content of some soil nutriments in the vegetables farmland exceed the recommendable level as shown in a soil analysis survey carried out by this Study.

The problem is application of chemicals rather than that of fertilizer. Application of chemicals without proper knowledge causes not only residual toxicity to product but also harm to growers. Way of fertilization and pest & disease control directly affects not only the productivity but also the quality of the product. Therefore the extension services in the Study area should focus on appropriate application method of fertilizer and chemicals in line with the promotion of vegetables.

4) Acceleration of Research on Low-input Farming Practice

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

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

6.10.2 Post-harvesting and Marketing System

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

However, it is undesirable that the Government intervenes in marketing activities such as controlling distribution system, supporting minimum price etc. Needless to say, state intervention often hinders the growth of private businesses. In practice as well, it is very difficult for the Government to support marketing business financially. Therefore it is proposed that the role of the government in this field should be limited to the provision of software services such as dissemination of market price information, strengthening inspection system in order to control illegal inflow of farm-inputs, etc.

1) Arrangement of Collection Point

There is one collection point in Kaptanganj VDC that was constructed with assistance of Department of Cooperatives under MOAC. This facility has not well functioned yet due to misarrange of middleman and/or merchant. Although the first consideration is to make this collecting point function, it is proposed that an additional collecting point be arranged along the main trunk road in the central area in order to make it convenient to ship the product. Construction cost of simple facility that has tin roof and concrete floor is estimated at 50 USD per square meter, which is equivalent to 3,850 Rs per square meter.

2) Arrangement of Cold Storage

One private cold storage in Inaruwa starts its full operation in year 2002. Capacity of this storage is as much as 2,000 MT of potato, which is equivalent to 10 % of total production of the potato in the Study area. Potato as well as vegetables often suffers from sharp fluctuation in price so that there is a potential to utilize cold storage that makes it possible to control shipping time.

There is little possibility of constructing and managing storage facility by farmers organization including water users association since it requires a large investment for construction as well as a lot of maintenance cost. Existing facility in Inaruwa costed 65 million Rs for construction and annual electricity cost is estimated at 2.4 million Rs. Therefore it is expected that arrangement of cold storage will have to proceed by the vitality of the private sector.

6.10.3 Supporting Program

This Study proposes the following two programs; 1) Extension Program for Vegetable Production, and 2) Promotion Program for Vegetable Marketing. The former program is almost same as conventional extension services but centering on vegetable promotion. The extension workers will make contact with water users associations as their entry point.

Same manner as group approach being undertaken by DAO applies to this program, regarding WUA or WUG which is the lowest layer thereof as the target group. The program envisages pilot field devoted for proper utilization of fertilizer and chemicals.

The latter program undertakes mainly information dissemination for which the vegetable produced in the project area will be advertised by way of local newspaper, local gazettes, radio, etc. The program also invites prospective private venders, retailers, wholesalers to the Project area. Inviting the businessmen will also motivate the farmers to produce high qualitative vegetables.

Table 6.10.1 Program Digest: Extension Program for Vegetable Production

Program Title	Extension Program for Vegetable Production
Objectives	This program aims at promoting vegetables production throughout the year through disseminating appropriate farming practice and strengthening farmers' faculty.
Program Area	12 VDC, Sunsari district Northern area: Babiya, Narsingha, Jalpapur Central area: Ramnagar Bhutaha, Gautampur, Rajganj Sinwari, Madhya Harsahi, Harinagara Southern area: Basantapur, Dewanganj, Ghuski, Kaptanganj
Implementation Agency	Responsible Agency: Ministry of Agriculture and Cooperatives(MOAC) Executing Agency: Sunsari District Agriculture Development Office (DADO)
Proposed Date of Commencement of the Program	FY2008 (1st year of SRIP operation)
Proposed Duration	Five Years
Activities	1) Management of Demonstration Field/Farmers Field School (6 places) 2) Dissemination of appropriate fertilization, chemical use, etc. 3) Introduction of Integrated Pest Management (IPM)
Required Personnel	1) Extension Worker; 180 M/M (3 personnel x 12 months/year x 5years) 2) Assistant; 360 M/M (6 personnel x 12 months/year x 5 years)
Equipment	1) Motorcycle, 6 Nr 2) Extension Kit, 90 Nr
Remarks	1) Experienced extension workers should be recruited. 2) Existing JTA are appointed as assistant. 3) Existing JT/JTA will take over duty of supporting services related to vegetables production after the Program.

Table 6.10.2 Program Digest: Promotion Program for Vegetable Post Harvesting and Marketing

Program Title	Promotion Program for vegetable Post harvesting and Marketing
Objectives	This program aims at promoting vegetables post harvesting and marketing specially by inviting private businessman.
Program Area	Cities/towns in Eastern Region specially along E-W highway, Kathmandu
Implementation Agency	Responsible Agency: Ministry of Agriculture and Cooperatives(MOAC) Executing Agency: Eastern Regional Agriculture Directorate
Proposed Date of Commencement of the Program	FY2008 (1st year of SIP operation)
Proposed Duration	Five Years
Activities	1) Information dissemination to private venders 2) Field observation/site visiting by private venders 3) Study tour for the farmers to progressed area for vegetable marketing 4) Training to farmers for post-harvesting and marketing management
Required Personnel	1) Information officer;60 M/M (1 personnel x 12 months/year x 5years) 2) Assistant; 60 M/M (1 personnel x 12 months/year x 5 years)
Remarks	1) Information officer will station in Eastern Agriculture Development Directorate and takes charge of disseminating the Project information to private venders and inviting them to see the vegetables. 2) Extension worker and assistant in charge of extension program for vegetable promotion will collaborate this program.