6. PROJECT PLANNING

6.1 Principles for Planning

The priority project for the Feasibility Study shall be planned within the frame of the Master Plan set forth in PART-I of this report. Therefore, the principles established for the Master Plan shall be observed in this phase, too. However, some principles were reviewed based on the latest findings and discussions made through the study.

Principles discussed for the Master Plan study will not be repeated, but some principal matters are reviewed here.

(1) Flood Mitigation Budget and Project Size

Budgetary situation of HMG/N is outlined as follows on the expenditure basis:

(Budgetary Situation on Expenditure Basis: in million Rs.)

Descriptions	(1996/97)	(1997/98)
National total expenditure	50,724	69,693
DOI total expenditure	2,577.9	3,040.8
Local-level river training program	44.9	120.0
District-wise river training budget Sarlahi District	0.8	1.4

The above figures clearly show the severe financial constraints of HMG/N. Given the overall financial constraints, the budgetary allocation per district is small in size. The funding assigned to one river is even more limited, since each district has to distribute the funds among several rivers. For example, the 1996/97 funding for local river training was Rs.0.3 million for Lohandra river, Rs.0.4 million for Tinau River, and Rs.0.5 million for Babai. This budgetary situation must be kept in mind when planning the operation and maintenance of the project.

As of March 1998, DOI operates six national-level undertakings for river training. Some of the national river training works are stand-along projects, while other are part of DOI's national-level irrigation projects. A summary of these national-level river training works are provided in Table A6.1. Cost of these projects ranges from 28.5 to 370 million Rupees, which gives an idea on project size to be proposed.

(2) Continuous Dike

Continuous dikes constructed on the both banks along river courses are effective measures to prevent flood inundation. However, the continuous dike has difficulty in maintenance, especially in relation with the sediment control in watershed area. After due consideration and discussions with the competent officials of HMG/N and the Advisory Committee members of JICA, the continuous dike was not finally proposed for the flood mitigation Master Plan up to the target year 2017, mainly for the following reasons:

1) All the rivers in the Terai plain flow into the Ganges river in India. A continuous dike is possible when the plan is coordinated with and agreed to by India.
2) The continuous dike induces a concentration of flood water and sediment in the lower reaches, causing a possible rise of the riverbed and, in consequence, a disastrous breach of the dike when abnormally large flood occurs. The continuous dike, therefore, have to be planned considering the sediment from the watershed area. However, the sediment in the watershed is not controlled. The sediment control in watershed area will take time due to the poor geological conditions in the Siwalik hills and budgetary constrains.
3) A continuous dike generally requires a large amount of maintenance in order to sustain the function properly for the entire length of dike. Considering the present land use of the flood prone area, such costly measures would not be economically viable.
4) Considering the present tight budgetary situation, priority of flood mitigation should be given to bank protection and damage mitigation of villages. Villages can be protected locally instead of the continuous dike. Sheet flood flows in farmlands would not be so disastrous under the present land use.

The flood mitigation Master Plan discussed in PART-I has already been adjusted to this principle of no-continuous dike.

(3) Priority Project as Pilot Project

More than sixty rivers flow through the Nepal Terai plain, and all of these rivers are causing flood and sedimentation. Eight of these rivers were selected from different river classes and various locations throughout the Terai as technical models of flood mitigation for other river basins of a similar nature.

Two river basins, the Lakhandei and Babai rivers, were further selected as a priority project and are the subject of a Feasibility Study.

Considering the important roles as a model project, the priority work on the Lakhandei and Babai rivers should be intensively implemented as a pilot project. The experience and technical know-how obtained through the priority/pilot project could be applied to other rivers selected for the Master Plan study, and to the more than sixty rivers flowing through the Terai plain as well.

In view of the above considerations, the implementation schedules of the Lakhandei river was rearranged, so that the priority project could be completed by the year 2007 (by the end of 10th national plan).

(4) Classification of Component Measures

In order to carry the project in practical and sustainable manner, it is important to implement the watershed management and river control measures in combination with community development activities. Therefore, the flood mitigation works and activities are discussed dividing into three components, i.e., watershed management, river control and community development components.

The flood mitigation works and activities are classified into respective components as follows:

1) **Criteria:** The beneficiaries should take flood mitigation measures in principle for their own protection, except for those implemented by the central government such as;
   - Large scale works that local government and community cannot afford;
   - Basic flood mitigation facilities;
   - Works requiring an urgent implementation; and
   - Technical guidance, coordination and political arrangement to be taken from nation-wide viewpoint.

2) **Watershed management component:** Works and activities in the watershed area to be implemented by the central government. The watershed management component includes;

- Erosion control works,
- Afforestation/reforestation and land use regulation, and
- Publicity activities.

3) **River control component:** Works and activities in the plain area to be implemented by the central government. The river control component includes;
   - Channel treatment works,
   - Bank protection works,
   - Dike works,
   - Channel excavation works, and
   - Land use regulation.

4) **Community development component:** Works and activities to be implemented by the local community and VDC/DDC as well, for their own protection in the near-by area. The community development component includes;
   - Community mobilization,
   - Local coping strategy, and
   - Local flood mitigation works.

5) **Associate activities:** Aside from the above components of project works, the following activities are necessary to be performed by the central government and other authorities concerned;
   - Research/investigation
   - Technical guidance

6.2 Watershed Management Component

The major sources of sediment in the Lakhandei watershed are due to:

1) Hill-side erosion on the southern slope of Siwalik hills,
2) River-side erosion of the main Lakhandei river and main tributaries, and
3) Devastated forest in the whole watershed.

For the control and management of these sediments in the Lakhandei watershed, (1) construction of erosion control facilities, (2) encouragement of afforestation,

reforestation, and proper land use in the watershed are recommended as primary measures. In order to materialize the measures, (3) publicity activities are also essential mobilizing local communities and governmental and non-governmental organizations.

(1) Erosion Control Facilities

Two kinds of measures are necessary depending on the sediment sources as follows:

1) Measures for hill-side erosion in the southern slope of Siwalik hills:
   - Gully erosion control
   - Hill-side works
2) Measures for river-side erosion along the river:
   - Consolidation of riverbed
   - Protection of riverbank from scoring
   - Planting permanent crops along the riverbanks.

Various works applicable to these measures are shown in Fig. A6.1. In the Figure, a combination of structural works and bioengineering is also presented.

The effects of these works depend on the geology and mechanism of erosion. As yet, these are not investigated intensively in any part of the Siwalik hills. It is, therefore, proposed to conduct a experimental work, selecting test sites in the southern slope of the Siwalik and the river reaches along the main Lakhandei river. The experimental work is outlined as follows:

Experimental Work on Hill-side Erosion in Southern Slopes of Siwalik Hills

1) **Objective:** To analyze the flood and sediment runoff of a small basin in the southern slopes of the Siwalik hills, and to evaluate its effects in relation to rainfall intensity, flood and sediment runoff, using the records obtained at the test sites.
2) **Test sites:** Two basins (Basin-A and Basin-B of about 5 km^2 each) in the Chapani river basin.
   - Basin-A: Experimental works for gully erosion control, hill-side works, bioengineering, etc.
   - Basin-B: No work and remain as it is for comparison purposes.

3) **Observations:**
   - Rainfall: One set of recording rain gauge to be used commonly for two test basins and an ordinary rain gauge for each basin.
   - Discharge: By a recording water-level gauge at check dams to be constructed at the lower end of each test basin.
   - Sediment: By water sampling for suspended and wash loads. Bed load will be estimated analytically based on the observed flow records.
4) **Monitoring:** River survey and bed material sampling at the upstream and downstream reaches of the check dam, at the fixed sections for monitoring, twice a year, in April (before rainy season) and in October (after rainy season). For this purpose a survey bench mark should be installed at the check dam.

Experimental Work for River-side Erosion in Lakhandei River

1) **Objective:** To analyze the flood and sediment runoff of the main Lakhandei river basin, and to evaluate the effects of interventions in relation to rainfall and flood runoff, using the records obtained at the test sites.
2) **Test sites:** A river stretch along the main Lakhandei river for riverbed consolidation and riverbank protection works.
3) **Observation:**
   - Rainfall: One set of recording rain gauge and three common rain gauges.
   - Discharge: By a recording water-level gauge to be installed at a station
   - Sediment: By water sampling for suspended and wash loads. Bed load will be estimated analytically using the observed flow records.
4) **Monitoring:** River survey and bed material sampling on the test stretch, at fixed sections for monitoring, twice a year, in April (before rainy season) and in October (after rainy season). For this purpose a survey bench mark should be installed at the check dam.

(2) Afforestation and Land Use Regulations

1) Management of forests including planting trees and natural regeneration. Community forest management should be encouraged.
2) Designation of steep slopes for planting permanent crops only. Multi-year crops are also encouraged in the watershed areas.
3) Encouragement of planting commercial vegetation such as fruit trees, medicinal herbs, aromatic plant and dye plants. Well-managed cultivation of

medical and aromatic plants prevents land erosion in the watersheds and promotes sustainable watershed management activities with income generation. The cultivation of such medicinal and aromatic plants has been one of the main program of forestry policy of the Nepal. The root crops should not be chosen.

4) Fodder grasses and trees should be planted along the contour and on terraces. Livestock should be restricted within a permissible limit for the sustainable use of pasture and forest.
5) Wild medical herbs should be protected from over-collecting by practicing sustained yield management.
6) In wood deficit areas, firewood use can be decreased through improved cooking devices.
7) Training of local people should be provided in community forest management and the appropriate management of pasture and farm land in watershed areas.

(3) Publicity Activities

Efforts have been made to conserve forests and uplands in the watersheds at various places throughout the country. However, the results of these efforts are not always available to the people who could benefit from them. In order for communities, NGOs, and local/central governments to benefit from this experience, the following activities could be promoted.

1) Produce information on best practices, suitable species and market opportunities.
2) Train trainers from agriculture (both pastoral and arable) and forestry in watershed management techniques. Send trainers to on-going projects to learn from on-the-job training and then into the field to train the people.
3) Conduct study tours to on-going project sites to learn from these efforts.
4) Campaign through the mass media for tree-planting. Have regular radio programs describing success and failures of various initiatives.
5) Introduce or extend education in conservation, management and tree-planting activities in school.
6) Combine forest management and tree planting project with tourism and local development projects using natural resources.
7) Establish a special "tree planting day" as a national and/or local level event and conduct campaign for forest management, conservation, afforestation, reforestation and farm tree planting.

8) Undertake commemorative tree-planting activities for ceremonies and memorial events of residents, and local and national leaders.
9) Enact a commendation system for excellent conservation activities such as afforestation projects, agro-forestry projects, natural forest management, and community development activities executed in watersheds.
10) Organize tree-planting volunteer groups both local/national and international.
11) Establish a foundation and receive contribution to encourage the planting of trees.

6.3 River Control Component

6.3.1 General

Scope of Structural Design: The structural design shall be carried out for all the structures proposed in the River Control Component. The standard design is applied to the design of structures. However, the detailed computations for structural analysis are not made in this phase of the study.

Design Criteria: There are some design criteria for river and drainage channel structures in Nepal. Deliberating over the collected criteria and standards, and through discussions with related organizations, the criteria from the following publications were applied for structural designing.

1) Design Manual for River Training Works in Nepal; prepared by Ministry of Water Resources, Nepal.
2) Technical Standard for River and Sabo Facilities; prepared by the Ministry of Construction, Japan.

In addition to the above criteria, the following basic design concepts were considered:

1) In designing structures, locally based materials are to be used as much as possible in consideration of the cost performance.
2) Structures are to be designed considering previous and ongoing flood control plans.

6.3.2 Preliminary Facility Design

(1) Spur (Groin)

Spur works are the primary bank protection measures. Generally these are constructed in group. They deflect the flow towards the center of channels, so that scouring is transferred away from the banks and sediment deposition is accelerated near banks.

There are two types of spurs, permeable and impermeable ones. Generally permeable spurs are used for river channels with gentle bed slope, while impermeable spurs are adopted for river channels with steep slope. Considering the results of river survey and investigation of river bed materials, the following combinations are proposed:

River Name	Section (km)	Spur Type
Lakhandei	0.0 ~ 25.0	Permeable
	25.0 ~ 51.0	Impermeable

The length, height and spacing of spurs depend on local conditions, the purpose of the spur, materials to be used, etc. The length of spur is generally less than 20% of the river channel width.

Basically the height of spur depends on the flow depth during floods. In addition, characteristics of each segment such as riverbed materials, flow velocity, and actual results in Nepal should be taken into account when determining spur height. According to the empirical relation, the spurs with height of 50 % of flow depth are adopted for segment 2-2, 70 % for segment 2-1 and 100 % for segment 1 except for sections in the lower reach of the Lakhandei river. The flow depths in the lower reaches of the Lakhandei river are so shallow, due to the spread of river flow, that the principles mentioned above cannot be applied. Considering the effect of river improvement through the project, spur height of one (1) m is proposed for these sections.

Spacing between spurs is related to the length of the spur. It usually ranges from one to six times the length depending on the degree of channel curvature, flow velocity and structural features of each spur. According to the empirical relation the interval-length ratio is set at 2 for segment 2-2, at 3 for segment 2-2 and at 4 for segment 1.

The major dimensions for the proposed spurs are, therefore, as follows:

River Name	Section (km)	Length(m)	Height(m)	Span(m)
Lakhandei	0.0 ~ 25.2	20.0	1.0	40.0
	25.2 ~ 39.4	20.0	1.5	60.0
	39.4 ~ 51.0	20.0	3.0	80.0

A pile spur for the permeable type and a gabion spur for the impermeable type are proposed for this project.

A pile spur consists of four (4) lines of reinforced concrete (RC) piles arranged at intervals of one (1) m each. Considering the local conditions of the Lakhandei river, Type Pa as shown in Fig. A6.2 was adopted. The crown of piles should be inclined toward river center so that the resistance against the flow decreases gradually.

A gabion spur consists of gabion mattress with boulders. They are classified into two (2) types, namely Type-Ia and Ib as shown in Fig. A6.3. The slope gradient of both the upstream and downstream sides of spur are set at 1:1.5 (1.0 vertical to 1.5 horizontal) for slope stability. Sufficient gabion apron is provided at the head of spur to cope with local scouring at the spur head. The crown of spur should be also inclined toward river center.

(2) Revetment

Revetment works are proposed along river channel banks where there is a great impact of running water and along dike slopes where slope protection works are inevitable against scouring and wave wash.

To cope with each site condition, the following two types of revetment are proposed as shown in Fig. A6.4.

Type Ra consists of boulder pitching and backfill gravel, supported by a base concrete. The base concrete should be embedded deep enough to cope with the scouring. This type is designed to prevent not only scouring but also seepage. It is employed as a slope protection at both upstream and down stream of a sluice crossing a dike. Adjusting to the dike shape, the slope gradient is set at 1:2 (1.0 vertical to 2.0 horizontal).

Type Rb is widely employed at sections where bank erosion is active and spur works are not applicable due to an insufficient channel width. This type consists of a gabion mattress. Each gabion should be wired together and log anchors are provided at the head of gabions to cope with slippage. Considering the stability of slope and lack of space, 1:1.5 (1.0 vertical to 1.5 horizontal) slope gradient is proposed.

Sufficient width of gabion apron is provided at the foot of each revetment to cope with the scouring of the riverbed. Crown elevation of revetment is set at the same level as the design high water level.

(3) Forest and Grass Belts

Forest and grass belts are proposed along the river course to temper flood flow over the land and to trap the sediment. In principle, these belts are aligned on the river boundary line (RBL). Where the river course shifts frequently, like in the lower Lakhandei river, grass belts are planned on both banks to stabilize the river course and provide enough sediment transport capacity for the river.

The width of the forest and grass belts is tentatively designed at 50 m. This may be revised, if necessary, after monitoring the functions in the field. Figure A6.5 shows schematically the layout of forest/grass belt and the RBL.

(4) Earth Dike

Ring dikes, dike roads and closing dikes are proposed as dike structures. Typical sections of each dike are shown in Fig. A6.6. Representative dimensions of dikes are designed in accordance with the following criteria:

Freeboard: Considering wave run-up and set-up, floating debris, etc., sufficient freeboard shall be provided above a design high water level to prevent overtopping during flood events, because earth dikes are fragile structure against water overtopping. The table below shows the freeboard to be adopted corresponding to the magnitude of the design discharges. The crest elevation of the dike is determined by adding the freeboard onto a design high water level. In accordance with the table, 0.8 m of freeboard is proposed for Lakhandei river.

Design Discharge (m^3/s)	Freeboard (m)
Less than 200	0.6
200 to less than 500	0.8
500 to less than 2,000	1.0
2,000 to less than 5,000	1.2
5,000 to less than 10,000	1.5

Crown width: The crown width of the dike is designed to keep sufficient section for stability and seepage protection. The table below shows the crown width to be adopted corresponding to the magnitude of design discharges.

Design Discharge (m^3/s)	Crown width (m)
Less than 500	3.0
500 to less than 2,000	4.0
2,000 to less than 5,000	5.0
5,000 to less than 10,000	6.0

Considering the road supply for daily inspection and flood protection activities, a crown width of five (5) m is recommended.

Side slope: The side slopes of dike shall be designed to resist erosion during normal river flow, rainfall and flood events. Gentle slopes are desirable to prevent seepage through the embankment body or foundation. Side slopes of 1:2 (1.0 vertical to 2.0 horizontal) are generally satisfactory for a well-compacted embankment.

Maintenance road: Roads shall be provided on the dike crown for inspection, maintenance and flood protection activities. The dike crown metaled with gravel of at 4.0 m width can be used as a maintenance road and it may be used as public roadway for inhabitants of villages.

(5) Sluice

Sluices are proposed at the downstream end of ring dikes to conduct drainage water through the earth dike. The basic structure to be designed with reinforced concrete is composed of a floor slab supported with a log pile foundation, piers, an operation deck and a wing wall. The culvert section is planned with concrete pipes supported by base concrete and log-pile foundations. A gate structure is proposed at the outlet of the culverts to protect against external floods. A slide gate type is employed for the gate structure because of easy operation and prompt and precise water stoppage. To cope

with the scouring of the channel bed, a gabion mattress is provided at the inlet and the outlet sides of the sluice.

A typical section for a sluice is shown in Fig. A6.7.

6.3.3 Studies on Alternative Schemes

(1) Route of Lakhandei River between Laksmipur and Belhi Villages

Problem: In the stretch between Laksmipur and Belhi villages, the Lakhandei river changes its route frequently and the channel system is complicated. Many villages are located close to the river along this stretch. They are Laksmipur, Sundarpur, Belhi, Padariya and Sivanagar villages. All of these villages have suffered repeatedly from flood and sediment disasters.

Alternative schemes: The stabilization of the river course is the primary concern along this stretch. Considering the existing river course and the distribution of villages and houses, the following alternative routes were considered (Fig. A6.8).

1) Alternative-1: Existing route
2) Alternative-2: Eastern route
3) Alternative-3: Western route

These alternative schemes were compared from various aspects and evaluated as shown in Table A6.2, to select the optimum scheme. The costs of these alternative schemes are also shown in Table A6.3.

In conclusion alternative-2 (Eastern route), which takes the smoothest alignment and requires the least cost, was selected.

(2) Route of Lakhandei River Downstream from Phulparasi Bridge

Problem: The Lakhandei river bifurcates in the downstream from the Phulparasi bridge of Hulaki road near Inaruwa village, and in the upstream and downstream sections near Sakaraul village. In order to promote flood mitigation measures in these reaches, it is necessary (1) to stabilize the river course and (2) to select a route for the main river channel.

Measures to stabilize river course: Major cause of river course shifting is the silting the riverbed due to the spilling floodwater over the banks. It is necessary to confine floodwater and sediment within the river channel with enough sediment transport capacity.

For this purpose, a grass belt is proposed along the river channel, so as to promote formation of natural levees on the both banks.

Alternative routes: There are several conceivable routes for the main Lakhandei river, i.e., (1) Existing route passing by Sakaraul village, (2) Inaruwa route (right branch) passing by Inaruwa village, and (3) new left route (left branch) newly branched this year. Out of these, existing route is proposed mainly for the following reasons:

1) Although the Inaruwa route has the smoothest alignment, this route is not recommended, because it passes by the villages of Inaruwa, Simara and Phenhara and other houses scatter along the riverbanks. This route may lead to flooding in this populated area. In addition, the VDC closed this branch with an earth dike this year.
2) The new left route has not yet form a channel, and this new route will have difficulty in reaching a consensual agreement from the affected people.
3) According to the topographic map of about 40 years ago, the main channel of the Lakhandei river took this existing route. Thus, in all probability, this route has been the main channel for more than 40 years. Hence, this route is most reasonable as main river course. Except for Sakaraul village, no houses are found along the river course.

Excavation of pilot channel: The existing channel capacity of the Lakhandei river is extremely low in the reaches from Sections No.0 to No.9. The existing bank-full capacity in this stretch is, on average only 9 m^3/s, ranging from 0 to 28 m^3/s. In order to ensure the stabilization of the river course, it is necessary to excavate a pilot channel. The pilot channel section was designed assuming the following conditions:

1) The design discharge is 38 m^3/s, taking the average channel capacity in the adjacent upstream reaches from No.10 to No.14.
2) The channel depth is designed at 1.0 m so that the shear velocity (U.) of the new channel is almost the same as those of adjacent channel sections.
3) Finally, the pilot channel is designed with 50 m of top width and 1 m depth

for a total length of about 7.6 km.

6.3.4 Construction Plan

The construction plan is worked out taking into consideration the scale of works, hydrological and meteorological conditions in the project area, the results of topographic and geological investigations and other factors related to the implementation of the proposed project.

(1) Conditions for Planning

The essential factors for planning were collected and selected through a number of field reconnaissance, in addition to information from similar projects implemented in and around the study area. The following information is basic to the preparation of a construction schedule.

Number of workable Days: The number of workable days is estimated based on rainfall data recorded in the study area. Sundays, national holidays and religious events are considered as non-workable days. National Holidays are listed in Table A6.4. Allowable workable days estimated are as follows:

Work Items	Workable Days
Concrete Works	230
Embankment Works	210

Workable days are calculated based on the following data and assumptions:

1) **Rainfall Data:** Following rainfall-gauging station within the study area is selected and eight-year daily rainfall records are picked up for analysis. The selected station is shown below:

Rainfall Station No.	Location	Project Site
1111	Jankpur Airport	Lakhandei River

2) **Number of Rainy Day and Suspended Day:** Daily rainfall of more than 15 mm is counted as a rainy day for both concrete work and earthwork. Suspended days are dependent on the amount of daily rainfall, as shown below.

Daily Rainfall (mm)	Suspended Day	
	Concrete Works	Earthworks
0-4	0	0
5-14	Rainy Day x 1.0	Rainy Day x 1.0
15-29	Rainy Day x 1.0	Rainy Day x 2.0
> 30	Rainy Day x 2.0	Rainy Day x 3.0

Monthly rainy days classified by the amount of daily rainfall of the selected stations are listed in Table A6.5.

3) **Monthly Workable Day:** By using the above data, monthly workable days both for concrete work and earth work are worked out. These are shown in Table A6.6 for concrete work and in Table A6.7 for earthwork.

Daily Working Hours and Work Shift: All construction work will be implemented in a single 8-hour labor.

(2) Work Plan

Construction Method: The work plan must be established considering safety and costs, bearing in mind the scale of the work and site conditions. The standard construction methods for the main work items are described as follows.

1) Excavation for on-land works is basically planned to be carried out by a combination of manpower and hauling machines. Additionally backhoe will be adopted for the excavation works in submerged portions.
2) Embankment work including moisture control, spreading and compacting of the materials are planned to be carried out basically by a combination of man-power and suitable compaction machines.
3) Other construction work such as gabion work, concrete work, masonry work, afforestation work, etc. generally will be performed by conventional methods. In addition, small-scale temporary work, such as river diversion cofferdams and dewatering work, will be adopted depending on the condition of the sites.

Construction Materials: The major construction materials for flood mitigation structures are explained as follows:

1) **Embankment Materials:** The earth materials along the length of the

Lakhandei and Babai rivers are mostly usable as embankment material when constructing earth dikes. The excavated soil from the construction of other flood mitigation structures can also be utilized as embankment material.

2) **Boulder:** A large quantity of boulders will be required for gabion and masonry works. According to the result of investigation of riverbed materials, procurement of boulder is possible at the upper reach of the Lakhandei river. As to the Babai river, although it is possible to get boulder at upper reach in Babai river, the hauling distance is considerably long from viewpoints of economy and construction schedule. Therefore, quarry site in Karnali river located next of Babai river is applied for this planning.

3) **Coarse and Fine Aggregate:** Specific gravel size is required as the coarse and fine aggregate for concrete works. From the result of investigation, it is judged sufficient quantity of coarse and fine aggregates is available from the Lakhandei and Babai rivers.

4) **Other Construction Materials:** Other materials required for the construction of flood mitigation structures, such as cement, reinforcing bars, gabion wire, etc. have to be purchased at local markets or obtained from neighboring districts.

Construction Schedule: The target year of completion of the priority project is set for 2007. After completing the preparatory work such as feasibility study, fund arrangements, definite plan/detailed design and preservation of land, the construction phase will start in 2002. After considering the conditions mentioned above, the construction schedule of the priority project is detailed in Fig. A6.9.

6.4 Community Development Component

This section highlights distinct features of the local communities along Lakhandei river that need be considered in implementing the "Community Development" component. The basic framework of the "Community Development" component will be adjusted accordingly, to meet the particular situations along the Lakahdei river. Table A6.8 shows main features of community development activities for Lakhandei river. A map showing locations of different VDCs is provided in Fig A6.10.

6.4.1 Community Mobilization

(1) Training of Local Government Institutions (LGIs)

One crucial issue to be discussed along Lakhandei river is how to coordinate the varying interests of different localities. Since the course shifts very actively, especially in the lower reaches, it may take more time, along Lakhandei, to forge a consensus among various VDCs where to fix the river. The workshop will therefore intend to enable VDCs to fully understand the potential benefits of the flood mitigation project.

One major limitation of the present VDC leaderships is that most of the Chairmen are only concerned with keeping the river as far away from their villages as possible. Once the VDCs will be able to begin to see the totality of the project (e.g., enhanced securities through flood control, socio-economic benefits through community development), it is expected that they will be able to forego their immediate concerns.

Accordingly, the Workshops for LGIs along Lakhandei will include one additional subject on "cost-benefit of flood mitigation project". This session is intended to enable the VDC leaderships to weigh the costs and benefits of the project, so that they will be ready to compromise with one another to collectively gain the benefits.

(2) Creation of Organizational Bases at the Community

<u>Formation of Community Organizations (COs)</u>

In contrast to the organizations along the Babai river, there is hardly any tradition of self-organized activities that can be tapped for Lakhandei flood mitigation. As Table A6.9 shows, there are few traditional community groups that manage natural resources, especially towards the south. Moreover, there is not much external support in forming community organizations.

The field surveys revealed that, while the communities are usually knowledgeable, at least vaguely, of "what" structural solutions are available (e.g., spurs, embankments), they are far less aware of "how" they can collectively involved in installing such structures. More time will be required, therefore, in dialoguing with local communities along Lakhandei river, before getting them organized for flood mitigation activities.

At the same time, there are exceptions. Some localities have practiced organized approaches to flood mitigation, which, however, have not taken firm root (e.g., Patharkot VDC, Janaki Nagar VDC, Pidari VDC, Padariya VDC). Local communities should be assisted in "revisiting" such precedents, to become motivated to repeat similar approaches. Such learning opportunities will help overcome the lack of participatory traditions along Lakhandei river. Such outstanding success stories are described in Section 6.4.5 of this Report.

Creation of Public Awareness, Knowledge & Skills

Technicalities of Flood Control Measures: Table A6.10 shows the results of the community interviews with different localities along Lakhandei river, concerning a) what they perceive to be the main causes of the flooding, and b) what measures they consider should be taken.

It indicates that what they consider to be the major cause is increased run-off and erosion from the upper watersheds. CO Training along Lakhandei will inform the people that the forest/grass belts have been designed in such a manner to trap the sediment flows. Moreover, the residents will learn that the test works are planned, to initiate appropriate measures in the upper watersheds. Moreover, a majority of the localities expressed their hopes for continuous dikes, which are not planned for Lakhandei. The CO training should deal with the reasons why continuous dikes are not opted (e.g., much higher costs for maintenance and repair, the potential danger in case part of the dikes are breached, and the difficulty in coordinating with India).

Skills in Masonry and Gabion-Netting: According to Table A6.11 on the availability of skilled laborers, one third of the affected VDCs have people with capabilities in masonry and gabion netting, but only a few in each village. The Table A6.11 confirms that almost all the affected villages are interested in receiving skills training for river training. Some representatives from each CO will be given training, who will then be hired for the contraction of flood control works. Their skills will also be crucial for the COs in maintaining the structures at later stages.

Community Participation in Flood Mitigation: As mentioned already, although there is hardly any strong tradition of self-organized activities along Lakhandei, not much external support in forming community organizations, there are several exemplary cases

of locally initiated flood mitigation. The local communities will revisit those samples, to draw lessons how best the people can be involved in flood mitigation.

One of the major issues along Lakhandei is that many local leaders are yet to embrace the importance of broad-based participation. For example, towards the downstream areas, a number of villages use structures with bamboo piles (e.g., Shripur VDC, Belhi VDC, Padariya VDC, Phul Parasi VDC, Sakaraul VDC). However, most of these localities only "hire as laborers" only a limited number of (especially less advantaged) beneficiaries, while other people (especially those from well-off families) do not participate.

Instead, the people should learn to practice the "equity" principle (i.e., the larger benefits, the larger contributions") which is integral to "participation". It is to be noted, still, some localities have experience in "equity" practice (e.g., Patharkot VDC, Janaki Nagar VDC, Pidari VDC, Belhi VDC). These exceptional cases will serve as models for flood mitigation along Lakhandei.

There are other types of commendable efforts by the local communities (e.g., Gurkauli VDC, Netragunj VDC, Haripur VDC), which will be used as model sites during the plan implementation. These are described in Section 6.4.5 of this Report.

<u>Generation of Financial Resources by COs</u>

Unlike Babai, it will require a sizeable amount of awareness-raising along Lakhandei river, since there are hardly any local systems of group savings. On the other hand, some VDCs have been assisted in forming women's groups with group saving schemes (see Table A6.10). Such schemes may potentially be evolved into group savings for flood mitigation purposes. Regardless of the existence of external support for women's groups, vegetable farming and livestock raising are important sources of cash income for women throughout Sarlahi district. The program can attempt to tap into the women's incomes. It is to be noted, however, where there have been no external supports, it will require substantial efforts to draw them into such public activities.

6.4.2 Local Coping Measures

(1) Flood Proofing

Along Lakhandei river, agricultural land is often covered by infertile sand after floods.

Certain initiatives (cultivation of groundnuts, cucurbit, sweet potato, etc.) have already been taken in some areas (e.g., Netragunj VDC, Sakaraul VDC). Other areas also should be encouraged to grow the types of crops that can be grown on sand-deposited land, in areas which suffer from sedimentation (i.e., almost all settlements along Lakhandei river). Table A6.12 shows a list of such "catch crops" that can potentially be adopted in different localities along Lahndei river.

In case the agricultural land is covered with sediments with fine particles, it is often possible to continue paddy plantation. In such circumstances, many farmers along Lakhandei find it difficult to secure new seedlings. The farmers who potentially face shortage of paddy seedling will be encouraged to produce a reserve of extra seedlings (e.g., Pidari VDC, Shripur VDC, Sundarpur VDC, Padariya VDC, Simara VDC, Bhadsar VDC).

Given the magnitudes of overflow problems, there are a large number of localities along Lakhandei, with felt needs for more durable housing structures (e.g., Netragunj VDC, Gurkauli VDC, Janaki Nagar VDC, Sundarpur VDC. Laksimipur VDC). This will e addressed through the plantation of the species that produce quality timber. Local trees/bamboo measures, to augment the artificial mounds for the houses, are found in several villages (e.g., Belhi VDC). These will be refined and disseminated in these and other places.

In almost all the villages, except a few (e.g., Shripur VDC where bamboo-made stands to store grain above the flood level), there is hardly any effort to safeguard grain. This is partly because the people may not have a large reserve of grain during monsoon season before harvesting. At the same time, it is possible to introduce simple measures such as raising storage sheds on stilts, to encourage those who hope to safeguard grain. Moreover, the dike roads and ring dikes, to be constructed under the "River Control Component", will also be used for temporarily storing grains and valuables, during emergencies.

(2) Forecasting, Warning, & Evacuation

Forecasting, warning, and evaluation are among the priorities of most of the villages along Lakhandei river. Although some indigenous forecasting systems are observed in a few places (e.g., observing natural clues in the river in Patharkot VDC), it is difficult to develop systematic forecasting systems along Lakhandei,

due to the very short lead time before flooding. Emphasis will therefore be placed on warning and evacuation, rather than forecasting.

There is ample scope to promote organized approaches to warning and evacuation, building upon the existing strategies found in a few villages (an organized evacuation system in Haripur VDC, collective efforts to watch rivers in Janaki Nagar VDC). Moreover, new initiatives will be promoted using the existing facilities, e.g., mosque speakers for warning. Table A6.13 shows existing facilities/offices in different parts along Lakhandei, including mosques. There are mosques in most of the affected VDCs (Netragunj, Ghurkauli, Pidari, Pipariya, Sundarpur, Phuk Parasi, Sakaraul, Bhadsar).

One issue facing a number of settlements is that road networks are disconnected in many places during the monsoon, which disrupt the people's movements to potential evacuation sites (e.g., Pidari VDC, Shripur VDC, Padariya VDC, Sakaraul VDC, Bhadsar VDC). In order to facilitate evacuation, road improvements will be undertaken, through installing culverts and constructing bridges, etc. This will also serve to enhance the people's mobility throughout the year, thus helping the resident daily lives during the dry season as well.

(3) Flood Fighting

Along Lakhandei, there have been some community-based efforts to install bamboo piles for emergency bank protection purposes (e.g., Shripur VDC, Phul Parasi VDC, Padariya VDC, Laksmipur VDC). Other localities attempted a permeable type of log spurs (e.g., Phul Parasi, Gurkauli VDC). However, there is much room to strengthen such local structures, since certain materials are not readily available. In those places, the communities will be assisted to augment their locally initiated structures, by making available materials that are not available locally (e.g., boulders to be placed between the bamboo piles, or). There exist a number of brick factories along Lakhandei river. Another possibility is to reuse the bricks too defective to be used for their original purposes., to supplement the local structures.

Some localities cannot implement their ideas of flood fighting, due to the lack of wooden materials for the structures (Gurkauli VDC). In such places, the local communities will be encouraged to plant such types of trees and shrubs that can potentially be used for their flood fighting structures.

Sarlahi district in which Lakhadei flows, is among the target districts under the Government's Sericulture Policy. In this regard, plantation of mulberries, which silkworms feed on, will also be promoted for the forest/grass belts. Mulberry is also good for soil erosion control. While there needs lots of other groundwork before sericulture can be started in Sarlahi, mulberry plantation will be a useful step not only for flood control but also for sericulture development in the district.

6.4.3 Community-based Sustainable River Control Measures

(1) Forest and Grass Belt

Along the Lakhandei river, there exist a range of local trees and grass that can be used as fuel, fodder, timber, roofing, etc (Table A6.14). As the community surveys revealed (Table A6.15), different localities exhibit unique variations in their needs and wants of trees, shrubs and grass, the selection of the species should be tailored to a particular situation surrounding each community.

Especially relevant in the context of flood mitigation is the fact that some of the local communities feel the need for more durable housing materials, to cope better with inundation problems. In such places, the "Forest/grass Belt" component can be linked to the "Flood Proofing" component, by planting the trees/bamboo that produce quality timber. Also, the Program will promote trees with an objective of creating safe refuge areas.

(2) Preventive Bank Protection Works

A certain type of shrub (i.e., Behiya) is planted by the communities as stand-alone "protection" work in some localities near the East West Highway (e.g., Netragunj VDC). Some are successful, while others are not. One major reason for the failure is the sheer force of the water which shrubs alone cannot counteract. In such places, support can be extended to combine shrub planting with other simple measures, such as spurs made of bamboo nets and sandbags.

In areas of both success and failure, support will be extended to change the species from Behiya, whose use is rather limited, to other more versatile species of shrubs or grasses. The latter include Amlisso (used for fodder and broom-making, etc.) and Khar (roofing, paper-making etc.)

Such practice of bioengineering will be disseminated to other villages where river control works such as revetments and spurs are proposed under the "River Control Component" (e.g., Patharkot, Gurkauli, Haripur, Pidari, Janaki Nagar, Shripur, Padariya, Belhi, Sundarpur, Laksmipur, Sakaraul). This can be achieved by encouraging the local communities to plant shrubs/grasses at the back side of the revetments/spurs, and at the sand deposit areas of the spurs.

(3) Access Improvements using Flood Control Facilities

As the name "dike roads" indicates, some dikes that are proposed for the two sites (i.e., one running inside Padariya VDC, and the other connecting Sundarpur VDC and Phul Parasi VDC) will be designed and constructed as rural roads. In some places, the dikes alone can serve as access roads when widened and/or graveled. Where the accessibility between the settlement and the dike is no good, short-distance unpaved roads (gravel, or earthen) will also be provided, to enable people to use the dike as part of their road networks.

Moreover, in places where closing dike works are proposed (e.g., Patharkot VDC, Laksimipur VDC, Janaki Nagar VDC, Belhi VDC, Sakaraul VDC, Simara VDC), the people will be assisted in enhancing mobility where the structure will possibly serve as roads. This will be done e.g., through provision of short-distance unpaved roads (gravel, or earthen) to link the closing dikes with other roads.

It is to be noted that road development is usually among the priorities of the villagers. Although not directly related to flood mitigation, support may be provided in building roads which are the priorities of certain VDCs (e.g., Gurkauli VDC, Janaki Nagar VDC, Sundrapur VDC).

(4) Bed Material Collection as Channel Excavation Works

Along Lakhandei river, quality bed materials can be collected only in a limited number of villages near the East-West Highway (e.g., Patharkot VDC, Gurkauli VDC). However, there is no clear-cut rule whether DDC or VDC has the authority to approve of sand/gravel extraction. In consequence, except for Patharkot VDC, there is no village which awards contracts for bed material collection. The DDC and the VDC will be engaged in dialogue to negotiate clear-cut rules and procedures for sand/gravel extraction.

Another constraint is the lack of access roads to markets. This limitation may be overcome, by graveling about 2-3 km of dirt roads to be linked with the East-West Highway.

It is to be noted that tighter control should be exercised over contractors and local communities who tend to limit their extractions to accessible locations (near riverbanks or bridges). Generally speaking, it is necessary to dig in the middle part of the river where the sediments are deposited. This may cause the diversion of the river flow towards the banks. For this purpose, guidelines should be developed and enforced to enable and encourage village and district authorities to monitor and regulate extraction activities.

(5) Operation and Maintenance (O&M) of Flood Control Structures

For both gabion spurs and permeable types of pile spurs, similarly, it is important to monitor the level of the riverbeds. In case the surface of the riverbeds is washed off, it is crucial to stabilize the foundation of the spurs by placing stones and rubbles on the riverbeds. Moreover, the local residents should see to it that any objects hooked to the piles or the gabion should be removed. In case of gabion spurs, it is also desirable to plant grass or shrubs on the sand-deposit areas, which will serve to stabilize the land adjacent to the structures.

Dike works are subject to scouring of their slopes, given its objective to counteract the forces of flood water. It is therefore critical to ensure that the local communities undertake timely repairs of slope failures. Moreover, it is expected that the dikes are also used as rural roads throughout the year. In this respect, another maintenance task required is to watch the conditions, and whenever necessary to flatten the bumps of the dike roads.

(6) Land Use Management

Along Lakhandei river, bank erosion has been aggravated by improper land use. More than 85 % of the land adjacent to the Lakhandei river is used for agriculture, while 7 % respectively for forest and barren land. The main issue concerning land us along Lakhandei is cultivation right on the riverbanks. This practice is observed throughout all the flood-prone VDCs.

Lakhandei River (Terai): 1998

River	Agriculture	Forest	Barren/ Sand	Other	Total
Lakhandei (ha)	16,660	1,410	850	480	19,400
%	85.9	7.2	4.4	2.5	100

To ensure continued stability of the engineering structures, the people residing in the river basins will be encouraged to stop over cultivation. This has to be promoted in tandem with the introduction of high-yield varieties, and alternative sources of incomes.

In addition, those individuals residing close to the rivers, who will recover cultivable land through river training, should be assisted in adopting proper land use practice in future. It is envisaged, as a result of river training, a substantial amount of new productive and safe land will be available.

6.4.4 Location-specific Strategies

The "River Control" component envisages additional flood control measures (i.e., mainly spurs and dike works) at critical points along Lakhandei river. This section will describer what "Community Development" strategies will be taken in those specific sites, within the overall framework provided in the above section 2.9.

(1) Patharkot VDC

There exist a DIO-supported revetment work to protect an irrigation headwork serving about 800 ha of land. In this locality, two types of support will be provided to augment the existing structure. The ground adjacent to the revetment work is partly eroded, thus worsening stability of the control work. First, the local residents will be encouraged to stop open grazing at the back side of the existing structure. Second, the irrigation group will plant shrubs/grass, both at the backside of the revetment, as well as at the sand deposit areas.

The above-mentioned structure has been installed in collaboration with the local irrigation group, which drew the participation of all the beneficiary households. This "participatory" tradition will be disseminated in the other two sites where there is no strong local community organization.

In the latter two sites, part of the settlements get inundated during monsoon, against

which local residents have developed their own way of "warning" by observing changes in the water flow. It is necessary for support the local communities to retain those practices, even after revetment works are completed.

(2) Gurkauli VDC

Only in Ward 1 (Chhedatole) of the VDC, some farmers plant a type of shrub (i.e., Bihiya) on the riverside to alleviate bank erosion. This practice will be encouraged to other localities in the VDC, to supplement the bank protection work. In doing so, several alternative species of shrubs/grasses will be introduced, other than Bihiya which can be used only for fences; there are other types which can be used for a variety of purposes (e.g., Khar, & Amlisso).

The VDC produces various vegetables (e.g., tomato, gourd, and cucumber), for which VDC hopes to improve accessibility to markets (for selling vegetable and other purposes) along the East-West Highway. The proposed bank protection work (of about 1.5 km long) will stabilize the river bank thus potentially serving as a road. At the same time, linkage should be strengthened between the riverbank and the existing intra-VDC road network. This is done, in some places, by developing new short roads, while in others, by graveling earthen roads.

The road improvements can potentially boost bed material collection in the village. Currently, sand and gravel extraction is not undertaken, primarily due to lack of roadways leading to the river. Support will also be extended, to enable VDC and DDC to sort out which agencies will be responsible for bed material collection. At present, the existing legislation/bylaws provide no definite guidelines as to which agency is responsible, either DDC or VDC.

(3) Haripur VDC

There are two bank protection works proposed for Haripur VDC. One "Community Development" that will be undertaken in both the two sites, is to assist farmers to adopt "catch crops" to cope with sand deposits. Currently, some farmers do plant (e.g., lentil) after their farmland is covered by mixed sand, while they take no action when topped with thick sand. The farmers will therefore be exposed to other crops that can be grown on thick sand.

Overflow problems are new phenomena in most of the VDC; except for Ward 9

(Haripur) subjected to flooding for years, overflow problems started only in recent years in Ward 1, 7 & 8. These Wards should be provided opportunity to learn from Ward 9 where Ward Chairman/Members have traditionally taken charge of warning & evacuation of the local residents.

In the past, the VDC received support in fighting with floods using bamboo and sandbags. In some years, they have even purchased bamboo and sandbags to install flood-fighting structures. In view of the local willingness to supplement the proposed structures with this local flood fighting, support can be extended to communities to plant bamboo themselves. Bamboo can be grown along the riverside, which also serve to curtail flood flows.

Near the site planned for the southern structure, there exists one Government forestry on the riverside. It will be desirable to convert this into a community forest, to enable people to utilize tree products

(4) Pidari VDC

Two bank protection works are planned in Pidari VDC, for both of which a similar set of "Community Development" actions can be taken. First, it is desirable to provide the local residents with an opportunity to revisit the old dike work which lies in-between the two proposed sites. The dike is an exemplary case of people's participation, since it mobilized all the affected households to contribute on the equity basis (in this case, workloads allocated in proportion to the size of their lands). Since recent flood control activities simply hire laborers, instead of mobilizing the beneficiaries, the old dike would serve as a useful aid to promote community mobilization.

In both the sites, a major issue during monsoon is damages to the east-west roads which are linked to north-south highway leading to the district center (Malangwa municiplity). These east-west roads serve as routes for the local residents to move to evacuation sites during emergencies. Improvements in road conditions (through installation of culverts, bridges, gravel, etc.) will not only facilitate the people's mobility, but also enable people to shift their valuable using carts and other means. During "normal" times, these roads meet various purposes which require travel outside VDC, the most important of which may be sales of sugar.

Many farmers in the VDC suffer from sedimentation problems, although they only attempt to transplant paddy after the land is covered by sediments. While in cases when covered by silt, they can restart paddies plantation, farmers should be encouraged to grow crops that can be grown even on sand, when necessary. It is also possible to those with relatively large landholdings can be encourage to convert their crops to sugarcane also, to recover from sand deposition.

(5) Janaki Nagar VDC

Bank protection works are proposed in two different sites. Farmland in the north of the VDC is washed away. In the northern site, farmers are ready to provide land for revetment construction, as well as voluntary labor on the basis of equity (i.e., contribution based upon the size of landholding). One potential impediment to community actions will be the lack of level roads. In order to facilitate transportation of boulders etc. which the local residents are willing to take on, support should be provided to gravel the existing earthen road (about 3 km in length, running north-south) leading to the Bagmati Irrigation siphon.

In the northern site, there has been no overflow from the river itself, and instead, the lack of proper agricultural drainage has caused inundation problems. Support will therefore be extended to the local community to upgrade the drainage system for agriculture.

Unlike the northern site, some of the VDC areas in the south suffer from flood flows. There exist a tradition of collective river watching during monsoon, for which about 50 households form a group. The local community will be encouraged to retain and improve upon this tradition, by also having the same group to take upon wider disaster management responsibilities, e.g., the maintenance of the revetment work.

In the southern site, forests that existed between the settlement and the river have almost been depleted. It is therefore necessary to provide support the local community in reforestation, which will serve to curtail overflows. For this purpose, it will be necessary to convert the "forest" into a community forest. Support should be provided to promote the types of trees that can provide durable housing materials (e.g., sal). Local residents expressed their hope to strengthen their housing structures; they lack sal trees in recent years, which forces them to substitute with other materials.

(6) Shripur VDC

Many farmers in the VDC suffer from sedimentation problems, although they only attempt to transplant paddy after the land is covered by sediments. In cases when covered by silt, they can restart paddy plantation. However, farmers often face shortage of paddy seedlings. It is therefore desirable to encourage farmers to produce extra seedlings to prepare for overflow. Farmers should be encouraged to grow crops that can be grown even on sand, when necessary.

In the proposed bank protection site, some farmers have installed bamboo piles with a view to minimizing sedimentation onto their farmland. It is desirable not only to disseminate this practice among other farmers in the village, but also to encourage the farmers to strengthen the structure by utilizing such external materials as boulders.

(7) Padariya VDC

Two bank protection works are envisaged in Padariya VDC. In the northern proposed site (called Shivanagar), the road leading to a nearby major market is disconnected during monsoon. This road serves as a route for the local residents to move to evacuation sites during flooding. Improved accessibility (through installation of culverts, bridges, gravel, etc.) will facilitate the people's mobility, in addition to enabling them to shift valuable using carts and other means.

Villagers in Shivanagar have attempted to fight with floods by installing bamboo piles. At the Shivanagar site, support the farmers will be encouraged to strengthen the bamboo structure by introducing such external materials as boulders. Moreover, this improved local practice will be introduced to the southern proposed site (called Padariya).

One major issues facing villagers in the southern Padariya side is shortage of fuel wood. It is envisaged that the proposed river training will make available a substantial portion of barren land for productive purposes. The villagers will be encouraged to use part of such land to plant mango, as required by the residents. Mango could provide fuel wood which the villagers currently purchase from markets outside the VDC. Mango trees could also be used as evacuation sites that the villagers dearly required during emergencies.

A few farmers in the southern Padariya side plant "Sarpat" which is effective for soil erosion control. The grass is also effective in flood flow control with its strong stems,

and also can be used for a range of purposes, i.e., roofing and fencing. The farmers will be assisted in planting this alongside the revetments, so that the soil could be stabilized, and at the same time, the farmers could derive other benefits.

(8) Belhi VDC

In Belhi VDC, one closing work is proposed, to divert the river away from the VDC. It is envisaged that the proposed river training will make available a substantial portion of barren land for productive purposes. There is shortage of fuel wood in Belhi VDC. Like Padariya VDC which lies at the opposite side of the river, the villagers should be encouraged to plant trees, e.g., Sissoo and Mango. Mango trees could also be used as evacuation sites that the villagers dearly required during emergencies.

In the VDC, some families attempt to raise the level of houses using artificial mounds with some bamboo and woods as reinforcement work. The bamboo and wood structures also help protect natural drainage surrounding the houses, during normal times. As part of "Community Development", assistance will be provided to encourage other households to adopt the similar practices, to promote flood proofing of the village.

(9) Sundarpur VDC

In Sundarpur a closing work with revetments are proposed, as a diversion scheme for Ward 1. The VDC lies at the confluence of Dhengrana (one tributary) and Lakhandei rivers. Dhengrana flow from northeast into the VDC, which cuts through the road linking the VDC with outside markets. It is necessary to assist in installing small-scale embankments for about 2 km from the confluence, to prevent overflow from disconnecting the road during monsoon.

Residents of Sundarapur VDC generally feel the need of improving warning. For this purpose, mosque speakers could be used for sending out messages, which would enables warning signals to be relayed more effectively and efficiently. The PCO (Public Call Office) that exists within Ward 1 could also be used to obtain prior information well in advance, from upper portion

Farmers in the Sundarpur attempt transplant paddy after sediments cover their farmland. One issue facing the farmers is the occasional shortage of paddy seedlings. It is therefore desirable to encourage farmers to produce extra seedlings to prepare for

overflow. Farmers should be encouraged to grow crops that can be grown even on sand, when necessary.

(10) Laksmipur VDC

For both the two bank protection works, a similar set of "Community Development" actions can be taken to address several issues facing the VDC. Firstly, the villagers face health problems during monsoon, since they rely on wells for drinking water which get contaminated during rainy season. In order to address this problem, "Community Development" activities in the village could support in the installation of tube wells within the VDC.

Secondly, substantial portion of barren land in Laksimipur will become productive, by straightening the river. As proposed by several villagers, support could be provided to use part of such land to plant trees (e.g., sal and mango). Sal could be promoted as construction materials, since many villagers feel the need to make houses more durable. Mango could provide fuel wood which the villagers currently purchase from markets outside the VDC. Mango trees could also be used as evacuation sites during emergencies.

Farmers in the Lakisimipur rarely attempt alternative crops when their farmland is covered by sand, except for transplanting paddy several times. While this paddy transplantation works in cases their farmland is covered by silt, it does not when covered by sand. Farmers they should therefore be encouraged to grow crops that can be grown even on sand, when necessary.

(11) Sakaraul VDC

In Sakaraul VDC, two structural measures are proposed, i.e., one closing work and a bank protection measure. The closing work will close a new river course which has disconnected a pathway leading to Kaudena VDC, which the Sakaraul villagers use to reach market centers, and to receive services such as education and medical treatments during "normal" times. More importantly, the road used to serve as an evacuation in times of flooding. In this connection, support should be extended not only to CLOSE the channel, but also to complete a road linking the Sakaraul settlements and Kaudena VDC.

A few farmers in Sakaraul have already experimented agricultural adjustments on

farmland covered by sand, i.e., planting vegetable, e.g., sweet potato, cucurbits, watermelon. This practice will be disseminated among more farmers as their recover strategies.

6.4.5 Examples of Community-based Actions for Flood Mitigation

(1) Patharkot VDC

DIO assisted Ward 3 (Cheda Tol) to install revetment structures, to safeguard the irrigation intake. For this purpose, the local irrigation group mobilized all the beneficiary households, and arranged for voluntary labor, in accordance with each household's benefits (on the principle of "equity", i.e., the more benefit one farmer receives, the more labor contribution the farmer makes)

(2) Netragunj VDC

Some of the farmers in Ward 1/7 (Sakaraul) have adopted agricultural recovery strategies to plant "catch crops" when agricultural land is covered by infertile sand after floods. Certain initiatives (Groundnut, Lentils etc.)

(3) Ghurkauli VDC

Ward 1 (Cheda Tol) suffers from rapid loss of farmland because of bank erosion. Those who have land adjacent to the river plant one type of shrub (i.e., Behiya) to contain the extent of bank erosion (although this works only in those places with low velocity of river flows)

Some farmers practice a traditional way of reclaiming their agricultural land after covered by infertile sediments. This is done by planting one type of grass (i.e., Khar) to be decomposed in a few years' time to recover the soil fertility.

(4) Haripur VDC

In Ward 9 (Haripur), warning and evacuation are organized by the Ward chairman/ members. While Ward members will be responsible for watching the river, the Ward chairman lead evacuation activities, including calling on other neighboring Wards to assist in shifting people and properties to safe areas.

(5) Pidari VDC

In the fiscal year 1989/90, Ward 1-8 (Pidari) received government's support in constructing embankments. For this construction, the community contributed "matching fund" for which each beneficiary contributed a sum of money on an "equity" basis (100 rupees per bigha of landholding). Large landowners also donated some of their land for embankment construction.

(6) Shripur VDC

Some farmers have installed fences with bamboo piles, with a view to minimizing sediment flow onto their farmland. This structure, according to the farmers, can withstand most of flooding, thus serving to prevent their crops from being damaged due to sedimentation (although it cannot counteract big flooding).

(7) Belhi VDC

In Ward 5, 7, 8 & 9 (Belhi), some houses are built on artificial mounds, which are further augmented with trees/bamboo structures.

In Ward 7 & 8, all the beneficiary households are mobilized to install flood fighting structures made of bamboo and sandbags. While well-off households provide cash and material (e.g., bamboo) contribution, the poor households instead make voluntary labor contributions.

(8) Phul Parasi VDC

To protect Ward 5-9 (Inaruwa), VDC constructed earthen dike, to accompany the DIO-provided spurs. On the dike, the local residents planted one type of pulse (i.e., Alaha) on the dike slope, which serve to stabilize the earthen structure, and also as a source of additional income for the beneficiaries.

In Ward 1-4 (Phul Parasi), the local residents install local bank protection structures, using bamboo piles and sisoo branches, when the monsoon starts. While bamboo is provided by VDC, the local residents contribute branches of the sisoo trees that are planted along their irrigation canals.

(9) Sakaraul VDC

Some of the farmers in Ward 1/7 (Sakaraul) have adopted agricultural recovery strategies to plant "catch crops" when agricultural land is covered by infertile sand after floods. Certain initiatives (Groundnut, Cucurbit, etc.)

6.5 Proposed Project Works

As a summary of project planning in the previous sections, general location map and general plans of the project works are shown in Fig. A6.11 through A6.13 for the Lakhandei river.

The community surveys have revealed unique variations among different localities, in terms of requirements for "Community Development" activities. Instead of formulating straightjackets, therefore, VDC- or ward-wise strategies should be developed based upon the overall framework provided in the following Table A6.16. Moreover, several villages have their own peculiar needs that are not common to other localities. It should be noted that such unique cases are not included in the summary table presented below, but will be presented in the final report. At this stage, the VDC-/ward-wise "Community Development" strategies are briefly presented in the Fig A6.13, which shows some examples of how the "Flood Control Component" and the "Community Development Component" can be combined to work toward "Comprehensive Flood Mitigation".

6.6 Project Implementation Program and Maintenance Plan

6.6.1 Project Implementation Plan

(1) Sequence of Works

The priority project is proposed for implementation by the year of 2007 considering the roles of the project as pilot work. The project works must be carried out effectively in orderly manner, and the people shall enjoy the effect of the project even in the course of project implementation. In view of these, consideration was given to the work sequence.

Preparatory Works: Upon completion of the Feasibility Study, the following activities should be taken immediately:

1) **Fund arrangement**
2) **Definite plan/detail design:** A definite plan of the flood mitigation works, including establishment of river boundary line (RBL), will be drawn up after getting consent of the agencies and communities concerned. A detailed design will be prepared of the project facilities.
3) **Environmental study:** In parallel with the definite plan and detail design, environmental study will be conducted in accordance with the procedures stipulated in the Environmental Conservation Rules to get approval of MOPE for project implementation.
4) **Preservation of Lands:** Population in the Terai is growing rapidly. Because of this, more and more people are living in flood prone areas close to the rivers. Therefore, it is essential to preserve the lands for flood mitigation facilities. This should start immediately after the preparation of definite flood mitigation plan. Appropriate land use should also be encouraged as outlined in the definite plan and detail design.
5) **Coordination among agencies and communities:** Coordination should be started as soon as possible after completion of the Feasibility Study, in order to mobilize agencies and communities concerned toward project implementation.

Community Development:

1) Community development activities should precede the implementation of the river control works.
2) Community mobilization and local coping strategy should go first in parallel with the definite plan study. Community mobilization is a key for the successful project implementation.
3) Local flood mitigation works will be executed in line with the definite plan.

Watershed Management:

1) Afforestation and land use regulation and publicity activities can be started immediately.
2) The erosion control test works in the Lakhandei river will be commenced upon completion of the detailed design.

River Control:

1) Flood hazard map will be prepared refining those prepared in this stage during the definite plan stage.
2) The river control works will be started upon completion of the detailed design.

3) Sequence of implementation among the component works is not important. Any work can be started basically at any places where the inceptive procedures are ready.

Associate Activities: The following associate activities are required to be started soon. These activities will support the effective project implementation.

1) **Research and Investigation:**
   - **Flood and sediment runoff:** Study on flood and sediment runoff especially for class III rivers originating at Siwalik hills. Observations on a designated model basin would serve this purpose.
   - **Bank erosion mechanism:** Characteristics of bank erosion in the Terai have yet to be investigated. Erosion mechanisms, erosion speed and width, etc. should be investigated in relation with the river segment, riverbed and bank materials, river flow condition, etc.
   - **Bank protection works:** Various types of bank protection works should be introduced and investigate the works fit with the conditions of rivers in the Terai. Hydraulic model tests in the laboratory and prototype in field will evaluate the effect of bank protection work.
   - **Bioengineering technology:** In order to introduce bioengineering technology as a component of flood mitigation, research works are necessary mainly for the selection of plant species, type and function of work applicable, cultivation techniques, and contribution to income generation.
   - **Construction materials:** Effective and economic use of local materials such as boulders, sands, bamboo, trees, etc. should be investigated.

2) **Technical Guidance:**
   - **Publicity of existing technical know-how:** Accumulation of experience and know-how related to the flood mitigation, and supply them to the implementing agencies and organizations.
   - **Consultation on technical problems**
   - **Training:** Training of local leaders for basic techniques necessary for the river training and bank protection works, etc.

(2) Time Schedule

1) Implementation of the works for the Lakhandei and Babai rivers are scheduled in advance to the other river basins for M/P study as pilot project.
2) Period of definite plan/detailed design for the Lakhandei river was scheduled one year longer. The Lakhandei river includes route alternatives and it is anticipated that longer time period would be necessary to reach to a consent among the peoples and VDCs concerned.
3) Time schedule for the Lakhandei river is outlined as follows (Fig. A6.14):
   - June, 1999-June, 2001: Fund arrangement, definite plan, and other inceptive procedures
   - June, 2000-June, 2002: Definite plan, detailed design, environmental study, and community mobilization
   - June, 2000-June, 2007: Intensive implementation of community development activities, though the activities should be continued ever since.
   - June, 2002-June, 2005: Civil works for river control component
   - June, 2001-June 2007: Intensive implementation of local flood mitigation works, the works should be continued ever since.

(3) Roles of Agencies/Organizations Concerned

Various agencies and organizations are incorporated in implementation of the project works. The following are the proposed roles of concerned agencies/organizations in the project implementation (Fig. A6.15):

1) Overall coordination by DOI.
2) Technical guidance by DOI, DOSCWM, DPTC, and other institutes as required.
3) Works to be implemented, in principle, by the beneficiaries such as local communities and VDC/DDC.
4) Large scale works and basic facilities for flood mitigation to be implemented by DOI or DOSCWM.
5) Urgent works to be implemented by DOI, DOSCWM, and other organizations.

(4) Required External Input

Considering the financial constrains of the MHG/N and necessity of intensive

implementation of the work as pilot project, the following external inputs are required for the project implementation:

1) Financial assistance, especially for the river control component
2) Technical assistance for watershed management, river control and community development components. Especially for the community development, it is proposed that an expert group stations in the community and promotes the activities collaborating with the community peoples. The expert group should include various field of expert such as community development, forestry, agriculture, and flood mitigation.

6.6.2 Organization for Project Implementation

(1) Coordinating/Implementing Agencies

The flood mitigation program will be managed by the DOI Project Management Office (PMO) to be set up at the district level. The PMO will comprise three divisions, i.e., an Upper Catchment Conservation Division, Flood Control Division, and Community Development Division. As shown in Fig.A6.16, it is expected that DOSCWM will depute its staff to work as the Chief of the Upper Catchment Division, while DOI staff will fill all the other key posts.

The River Control Division will take the lead in the design and construction management of the River Control Component. At the same time, the local government institutions (LGIs) also play an important role to match the DOI's resources with local communities. The LGIs will assist DOI in aggregating local information required for the design of the physical facilities, and also will encourage community organizations (COs) to make in-kind (labor, land, and material)/cash contributions to the construction of the flood control facilities. During the maintenance phase, also, LGIs will assist COs, when necessary, to liaise with DOI and other agencies to provide external skills and resources for the rehabilitation of flood control facilities. The River Control Component will draw largely upon bioengineering measures. The River Control Division will therefore seek, as and when necessary, technical as well as material inputs (e.g., seedlings and samplings) from technical line agencies such as the DOF and DOSCWM.

The Community Development Division will implement the Community Development Component. The Division will maintain close coordination with the LGIs. Under the

overall coordination and supervision of the PMO Division, the LGIs will undertake community mobilization to assist communities to organize themselves, and will assist their community organizations (COs) to implement community-based flood mitigation measures. The community development activities envisage a range of activities which no single agencies can handle on its own. Accordingly, the Community Development Division will mobilize technical line agencies, e.g., DOSCWM, and DOA to provide technical and material inputs for community development activities.

A District-level Coordination Committee (DCC) will also be established, to provide coordination between the PMO and other relevant agencies which will participate as Cooperating Agencies (the details of the Cooperating Agencies' roles are provided in the following section). As shown in the figure on the implementation arrangement, the DCC will draw membership from the District Development Committee (DDC) as well as other line agencies. The latter include the Departments of Soil Conservation and Watershed Management (DOSCWM), Forest (DOF), and Agriculture (DOA). The Chief District Officer (CDO) will also serve as a DCC member.

At present, all the district-level DOI's resources for flood control are channeled through the District River Training Coordination Committee (DRTCC). On the other hand, the master plan will replace DRTCC with DCC, since the latter has the following advantages over DRTCC:

- **All the flood-prone villages will be directly represented in DCC**, to provide an open and transparent forum for interactions between the district and the villages (whereas DRTCC is composed only of district-level representatives, which often is the cause of irrational allocation of funding).
- **DCC will draw members from pertinent line agencies**, i.e., DOSCWM, DOF, and DOA for a more comprehensive approaches to river training (whereas DRTCC does not include any line agencies, which makes it difficult to coordinate river training, with other related developmental activities).

(2) Cooperating Agencies

The DCC member institutions will participate in the program implementation, as the cooperating agencies. The flood mitigation program is a multi-sectored undertaking which no single agencies can handle on its own. Accordingly, DOI will mobilize technical line agencies as well as local government institutions, who will take on the tasks and responsibilities explained below.

Technical Line Agencies

DOSCWM:

1) Initiate programs aimed at soil conservation in the Chure range.
2) Provide seed and seedlings, as well as technical support for soil conservation.
3) Offer technical advice and also provide seedlings to protect infrastructure, soil erosion and flooding.

DOF:

1) Assist in establishing green belts along riverbanks.
2) Provide seed and saplings, as well as technical support.
3) Hand over forest /riverbed management to local communities wherever feasible.
4) In the watershed – hand over management of the forests to the local communities wherever feasible, and assist in their management.

DOA:

1) Provide technical advice on safe cultivation on the riverside.
2) Offer awareness building and seedlings to support in crop production that would minimize river cutting and flood damage.

CDO:

1) Resolve conflicts when DDC/VDCs alone cannot handle.
2) Make available district-level Natural Calamity Fund for community-level flood management.
3) Coordinate relief activities with the overall Flood Mitigation Plan.

Local Government Institutions (LGIs)

DDC:

1) Undertake the "Community Development" component, in collaboration with the VDCs, and communities.
2) Contribute some funding/other resources for "Community Development", in accordance with financial capacity.
3) Promote inter-VDC coordination, and/or coordination between DIO/other line agencies and the VDCs.
4) Shoulder the responsibility of regular monitoring and minor repair in

partnership with the VDC/municipality.

5) Resolve conflict among different VDCs.
6) Include the program as a priority sector in district planning.

VDC / Municipality:

1) Collaborate with the DDC and local communities to conduct the "Community Development" component.
2) Contribute some funding/other resources for "Community Development", in accordance with financial capacity.
3) Undertake regular maintenance and minor repair.
4) Mobilize community participation.
5) Set criteria of community/individual contribution on the basis of equity.
6) Control encroachments/inappropriate practices along riverbanks.
7) Take the main role to minimize and resolve conflicts, if any.

In view of upgrading the LGIs' capabilities to undertake these crucial roles for "community development", a series of training workshops will be undertaken at the inception of "community development" activities, as mentioned in the section on "Community Development" component/

6.7 Project Cost

6.7.1 Basic Conditions for Cost Estimates

Price Level: All unit costs are expressed under the economic conditions prevailing in October 1998.

Currency Exchange Rate: Currency exchange rates are assumed as follows:

US$1.00 = NRs.67.93 = Y115.14 (NRs.1.00 = Y1.69)

Composition of Project Costs: Project costs are composed of construction base cost, compensation cost, administration cost, engineering service cost, physical contingency, price contingency and value added tax. Calculation is carried out based on the following:

1) Construction base cost: Unit cost basis
2) Compensation cost: Unit cost basis
3) Administration cost: 5% of [(1) + (2)]

4) Engineering service cost: Lump sum basis
5) Physical Contingency = 10% of [(1) + (2) + (3) + (4)]
6) Price contingency (Financial cost only): At annual escalation rate of 3 % for the foreign currency, and 10 % for the local currency portions

Labor Wage: Basic labor wages were obtained from government agencies and the private sector. These rates were carefully examined and the agreed rates are shown in Table A6.17.

Unit Operation Cost of Heavy Equipment: Unit operation costs of heavy equipment are shown in Table A6.17. Operator, fuel and other administrative fees such as insurance, maintenance and so on are not included in the costs.

Unit Prices of Materials: Unit prices of construction materials available at the site and those that have to be delivered from other districts through suppliers or dealers are determined using current market prices. The construction material costs are listed in Table A6.18.

Foreign Currency and Local Currency Portion: Project cost consists of the foreign currency portion (F.C.) and the local currency portion (L.C.). The components of the major work items are given as follows:

Item	F.C. (%)	L.C. (%)
1. Labor wage	0	100
2. Owing cost of heavy equipment	100	0
3. Material unit cost		
- Cement	50	50
- Aggregate	60	40
- Fuel	50	50
- Deformed reinforcing bar	80	20
- Timber	10	90
4. Compensation cost	0	100
5. Administration cost	0	100

Financial Cost and Economic Cost: Financial cost is estimated as an actual expenses of the project owner on the market price basis, whereas economic cost for project evaluation is reckoned in terms of net usage of sources. The transfer cost such as tax and duty, and contractor's profit are, therefore, not considered in the economic costs. Hence, the economic project costs were estimated from the financial project costs

deducting 10% for transfer costs and contractor's profit.

6.7.2 Estimation of Project Cost

Project cost is estimated based on the design and construction schedule described in the previous chapters.

(1) Unit Cost of Construction Works

Construction base cost is estimated by multiplying the unit cost and the corresponding work quantity. Preparatory and miscellaneous works are estimated on lump sum basis as 10 % of main works. The unit cost for each work item consists of the cost of materials, labor and equipment. Contractor's indirect cost is also incorporated in the unit cost of each work item.

Unit costs, by work item, are established by analyzing the data of similar works implemented in recent years. The local conditions in study areas are also taken into consideration. In addition, the fittest unit prices of materials estimated through the detail research in study areas are applied. The unit work costs are shown in Table A6.18.

(2) Project Cost of River Control Works

The project costs of the proposed river control works for Lakhandei river was estimated as shown in Table A6.19 and summarized below:

Item	Lakhandei river (million NRs)
1. Construction Base Cost	280.5
2. Compensation Cost	45.4
3. Administration Cost	16.3
4. Engineering Cost	56.1
5. Physical Contingency	39.8
6. Value Added Tax	43.8
7. Grand Total	481.9

Note: Price Contingency is not included.

(3) Project Cost for Erosion Control Experimental Works

Several erosion control test works are planned in main channel, tributaries and whole watershed area in Lakhandei river. The project costs of proposed erosion control works are estimated to be Rs 52.3 million, excluding price contingency, as shown in Table A6.20.

(4) Operation and Maintenance Cost

The annual operation and maintenance costs include the salaries of project administrative and operation staff, the material and labor costs for project facilities. The annual O&M costs were estimated to be 0.5 % of the total construction base cost.

6.7.3 Annual Disbursement Schedule and Fund Required

Annual disbursement of investment costs was estimated on the basis of the implementation schedule. The disbursement schedules of financial costs for Lakhandei river is shown in Table A6.21. The funds required for the project implementation are estimated at Rs.689.3 million for the Lakhandei river as summarized below.

Items	Lakhandei river (million NRs)
Project cost	481.9
Price contingency	207.5
Fund required	689.3

6.8 Evaluation

6.8.1 Economic Evaluation

Economic viability was examined for the flood mitigation projects proposed for the Feasibility Study. Flood damage reduction benefit, bank protection benefit and indirect benefit were considered for the evaluation.

Flood Damage Reduction Benefit: At the beginning of the Feasibility Study stage, topographic mapping and river survey were conducted for the Lakhandei river. Therefore, the flood damage reduction benefit was estimated based on the simulation results of flood flows in these rivers. The flood reduction benefit is defined as a balance of flood damages under the conditions without and with project.

Bank Protection Benefit: The bank protection benefit was estimated as a loss of land and properties on it.

Evaluation: Cash flows of the project cost, maintenance cost and benefit were prepared according to the proposed implementation schedule. Annual disbursement schedules were prepared according to the implementation schedule proposed for the Lakhandei river, i.e., detail design in 2001 and construction works 3 years from 2002 to 2005.

Cash flows of the project cost, maintenance cost and benefit are shown in Table A6.22. As indexes of the economic viability, the EIRR, B/C and NPV-values were worked out in the table. The results are summarized below.

River	Existing basin			Future basin		
	EIRR (%)	B/C	NPV (10^6Rs)	EIRR (%)	B/C	NPV (10^6Rs)
Lakhandei	9.5	0.95	-14.6	20.8	2.05	308.0

(Note) B/C and NPV were calculated under the discount rate of 10%.

Methodology and procedures of economic evaluation of the project are compiled in SUPPORTING REPORT-C.

6.8.2 Environmental Screening

(1) General

An environmental screening was undertaken following the JICA environmental screening process, since there is no statement for environmental screening in Environmental Conservation Rules (ECR) of Nepal. The screening is termed an "initial environmental examination" by JICA. However, it should not be confused with the IEE as specified in Environmental Conservation Rules of Nepal. This latter is a detailed and prolonged environmental assessment, where as the former is an environmental screening to determine which specific projects or areas within a project require detailed environmental studies. Thus in order to avoid confusion the JICA "initial environmental examination" will be termed as "Environmental Screening (ES)".

(2) Results of Environmental Screening

The flood mitigation plan for the Lakhandei river is to align and demarcate the two river

banks along the length of the river in the Terai so as to minimize flood damage. These banks will then be stabilized by vegetative means (forest and grass belt). Occasionally, riverbanks will be reinforced and perhaps one or two bends straightened. There are no listed wetlands along this river.

Screening forms filled as a result of environmental screening evaluation are shown in Tables A6.23 through A6.25 for social environment assessment, natural environment assessment and pollution assessment, respectively.

(3) Overall Evaluation

The flood mitigation interventions on the Lakhandei river basin in the Terai are overwhelmingly environmentally positive. Flood mitigation interventions will occur along the whole length of the river in the Terai. In particular, the two river banks will be realigned and demarcated so as to minimize flood damage. These new alignments will be reinforced by physical and/or vegetative means, namely dikes, river training, and the planting of trees and grasses. These interventions will minimize flooding, decrease soil erosion from river banks and farmer's fields, minimize river course changes, reduce the deposition of coarse gravel, sand and soil particles on farmland and curtail house flooding and subsidence.

Some houses may have to be relocated and some farmland taken if they are on the new river boundary line (RBL) or on the river side of the new RBL. These measures cannot be undertaken without the consent of and compensation for the affected people. However, by stabilizing the river course and minimizing flood damage, existing land (and houses) near to the river will be protected from degradation and previously degraded land can be reclaimed. So there should be a considerable net benefit. Also, the land on the riverside of the RBL may still be farmed during the "dry" season.

These interventions cannot be successful without the approval and active participation of the people living along or in the vicinity of the rivers. Flood mitigation measures, including repair and maintenance of the existing and proposed structure are ongoing activities. If the people are not involved in and approve of these activities from the outset, then the chances of successful flood mitigation measures will be minimal. Village Development Committees, Municipalities and District Development Committees must be a party to the plans and play an active role in their formulation, amendment and approval. The plans should also be dynamic and subject to alteration, addition and improvement as a result of learning from interventions in this and other

river systems. However, the overall plan should not be subject to a rigorous environmental examination. This should be reserved for "fragile" areas that may be affected adversely as a result of the interventions.

There is need to undertake IEEs in areas where large-scale mechanical (structural) river bank protection is required (one kilometre or more), such as dikes, river bank protection work and channel cutting. However, it is debatable. An IEE has to be undertaken, if river side houses have to be removed. As there are no registered wetlands on this river, there will be no need to undertake any environmental impact assessment (EIA).

(4) Environmental Study in Lakhandei Sub-Watershed.

The Lakhandei River has been chosen as a priority river. Some of the sedimentation coming from the Siwalik hills is a result of human activity in these catchment areas. Therefore, as part of the overall flood mitigation plan, a watershed study has been proposed to evaluate various intervention measures, including bank protection and land use measures. This study will help with the formulation of a watershed management plan. At that stage, an Initial Environmental Evaluation (IEE) is required in accordance with the Environmental Conservation Rules (ECR) issued in June 1997.

To assist the watershed study, two sub-watersheds were chosen to undertake a detailed examination of existing land-use patterns and to determine a possible plan of action for decreasing erosion in this catchment area. A summary of the principal findings of this study is now given.

In 1998, an estimated 3,226 people lived in 539 houses in the sub-catchment areas of the Chapani and Kothi rivers. The existing land use pattern is shown in below.

Lakhandei Watershed: Land Use Pattern in the Study Area.

	Chapani khola		Kothi khola		Total	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Forest land	410	54	350	53	760	54
Agricultural land	310	40	280	43	590	41
River bed	40	5	20	3	60	4
Infrastructure	5	1	5	1	10	1
Total	**765**	**100**	**655**	**100**	**1,420**	**100**
Length of stream (m)	4,600 m		4,200 m		8,800 m	

While over 50% of the land is still forest, about 40% of the land is farmed. None of the farmers in the area have title to the forest land they cleared, although some of them

have been farming in the area for more than 30 years. In consequence, less than 5% of the farmland is terraced. This results in excessive erosion from the arable farmland.

Contrary to expectations, the forestland is well stocked with more than 40 species of trees. On average, the forests have a stocking density of 4,700 trees per hectare, of which 900 are greater than 20 cm. in diameter. The estimated standing stock of these large trees is nearly 500 m^3 (stem volume) per hectare. Thus, there is more than sufficient wood to meet the needs of the people on a sustainable basis. However, the trees in these watershed areas are not supposed to be cut. It could be argued that there is too much competition in these forests. If they were thinned, the remaining trees would be able to grow more vigorously and form a deep root system, thus helping to bind the soil. Several natural landslides were recorded in the forests of the study area and this could be because of too much competition between the trees.

In order to conserve the agricultural and forest lands and improve environmental conditions, it is proposed to:

1) Give security of tenure to farmers, provided they undertake appropriate land use measures in these watershed areas. Such measures include
   - Contour planting with trees and grass and/or terracing the fields.
   - Planting perennial crops in a belt of at least 20-m. along streams etc.
   - Banning arable farming on steep slopes, replanting these areas with trees.
   - Introducing or extending agro-forestry practices and other farm tree planting initiatives.
   - Limiting the livestock numbers to the available sustainable fodder supply and encouraging stall-feeding.
2) Providing advice and training to farmers on crops, methods and marketing.
3) Establishing community forests for the sustainable management of the natural forests. Provide management and marketing advice so that the people have a vested interest in maintaining the forests, rather than clearing them for agriculture.
4) Encourage the planting of "commercial" perennial crops and provide advice on management and markets for these species.
5) Train the people in erosion control techniques and encourage them to undertake bank and erosion control interventions, including annual maintenance.
6) Only permit properly approved roads and footpaths and undertake erosion

prevention measures along these routes.

7) Above all, treat the existing population as agents to preserve and enhance their environment, rather than as a principal cause of erosion and environmental deterioration.

(5) Environmental Inventory along Lakhandei River in Terai.

The detailed results of the environmental inventory along the Lakhandei river are given in the "Environmental Inventory Report" (GEOCE 1998). A summary of the principal findings is given here.

Over 3,500 hectares of land in a strip of about 350 meters on either side of the Lakhandei river was surveyed. The following table gives a breakdown of the land use in this strip and in 1998.

Lakhandei River Belt: Land Use and Land Ownership.

Land Use	Land Ownership (ha)				
	Private	Public-state	Public-community	Total	%
Cultivated land	2,955	70	0	3,025	85.9
Barren land	0	154	0	154	4.4
Forest land	0	253	1	254	7.2
Building area	78	1	0	79	2.2
Road/canal area	0	11	0	11	0.3
Total area	**3,033**	**489**	**1**	**3,523**	**100.0**
Percentage	86.1	13.9	0.0	100.0	

An estimated 86 percent of the land is farmed in this narrow, erosion prone belt along the Lakhandei river. A similar percentage is privately owned. This means that negotiations will have to take place with private individuals about the fixing of a River Boundary Line (RBL) and the proposed planting of a 50-m. wide grass/tree belt along the river. Without permanent vegetation, the banks are more prone to erosion. The following table gives population, housing numbers and conditions of bank erosion:

Population, Buildings and Flood Damage in the Riverside Strips.

Lakhandei left and right river strips	
Length of river in the Terai (m)	50,960
Average width of strip (m)	346.5
Number of houses in the area	7,748
Houses destroyed or moved in 1998	75
Houses in danger from flood damage	65
Number of other building in the area	188
Number of people living along the river bank strips	39,960
Population density: people per hectare (ha/person)	11.3 (0.09)
Length of river bank erosion (m)	11,500
Length of road damage (m)	1,800

There are over 7,900 buildings in this belt, practically all houses. In 1998, seventy-five houses were destroyed or had to be moved because of flood damage and erosion. A further 65 houses are in danger of being destroyed. From an environmental perspective, if and when a flood mitigation project is proposed for this river, an Initial Environmental Evaluation (IEE) will be requires to determine the fate of these buildings.

The population density is extremely high along the Lakhandei and so is the incidence of bank erosion. An estimated 11,500 meters of riverbank were eroded in 1998, (11.3% of the bank length). At least 12 ha. of land was washed away, but the erosion could be as much as 60 ha.

Thus, it is very important to have bank protection measures along this river. These should not only be engineering interventions such as spurs and revetment work, but bio-engineering initiatives with belts of grass and trees planted along the river bank. It is no coincidence that the other priority river, - the Babai – with nearly 50% of its river bank covered with trees, had only 5% or 5,300 m. of its banks eroded in 1998. This is less than half that of the Lakhandei.

But bank protection alone will not prevent flooding. Bank protection is an integral part of flood mitigation of which dykes are an essential component. This is because in 1998, an estimated 165 ha. of land was inundated with coarse sand and 1,200 ha. were damaged by flood water, mainly in the lower reaches of the river. In the previous year, - a bad flood year – over 9,000 hectares were flooded and/or inundated with sand.

(6) General Environmental Evaluation.

The flood mitigation Master Plan proposed new boundary lines in the Terai. Along these boundary lines, bioengineering measures will be undertaken. The fixing of the boundary lines is critical to meaningful and lasting flood mitigation measures. The agreement of the people living along the river is not only necessary, but also important to the success of the plan.

This is why it is vital to explain the proposals to all the concerned individuals and local authorities so that a consensus can be arrived at. Without agreement and support of the local people some of the proposed flood mitigation measures, particularly local dike work and bioengineering measures, may not be implemented.

Many bank protection sites are proposed along the river. For the sites over 1 km. in length, IEEs are necessary at the project preparation stage. A retarding basin is proposed, but this does not require an environmental study.

According to the Inventory of Wetlands in the Terai, (IUCN 1996), there are no registered wetlands along the Lakhandei river. Thus no EIA's are required.

6.8.3 Technical Evaluation

The flood mitigation activities must be undertaken in a sustainable way. Therefore, the plan must fit well with the local situation, the technical capability and financial solvency of the central and local government agencies, non-governmental organizations and local communities concerned.

In planning the flood mitigation plan of the rivers in the Terai plain, efforts were made for the plan to meet these requirements as presented below.

1) **Consideration on Local Situation:**
   - Bottom-up procedures by community development activities are proposed for planning and implementation of the project.
   - Maximum use of local materials is proposed, and the works proposed are labor intensive.
   - Considering the potential disastrous situation of the Study Area, stage-wise approaches are proposed so that the residents could enjoy the benefits soon after they have been finished the component works

invested.

- The proposed works are selective for their sizes and able to enhance their function depending on the requirements and solvency of the local communities.

2) **Consideration on Technical Capability:**
   - The proposed works are mostly simple for their construction and maintenance as far as the appropriate instructions are given timely by the DOI/DIO engineer.
   - Participation of local communities in flood mitigation work is proposed. Through the experience of participation, local community will also learn the technique for flood mitigation and improve their awareness. This would contribute much to the sustainability of the project operation.
   - The proposed river control measures will be improved through on-site experience so that the measures will be more effective, practical and economic.

3) **Consideration on Financial Solvency:**
   - Taking into consideration the financial strictures of the country, low cost and labor intensive project is proposed with full use of local materials.
   - In addition to the procurement of fund from central and local government, in-come generation measures are proposed as a part of community development activities.

6.8.4 Summary and Conclusion

1) **Economic Viability:** Implementation of the Master Plan will bring about various tangible and intangible benefits, to the communities in the Study Area. Though the economic viability is not high under the existing basin conditions, it shows higher viability in future basin. The proposed works can be started from any place and at any size. Project works can be implemented from those of higher cost-performance, keeping pace with basin's development.
2) **Environmental Impacts:** From environmental conservation viewpoint, the proposed project will exert favorable effects on social and natural environment and no pollution problems are envisaged. Only problems found so far are conservation of wetlands most of which have already been developed as farmlands or are in protected areas of national parks and wildlife reserves.

3) **Technical Aspect:** The technology proposed for the Master Plan is appropriate, since the plan took due consideration of the local situation, the technical capability of the people and financial solvency of the country, etc.
4) **Conclusion:** In conclusion, the proposed master plan is economically and technically feasible and exerts little adverse effect to the environment. The implementation of plan is recommended in order to promote and support people's livelihood and the sound development of the Terai plain.

PROFILE OF DOI'S NATIONAL-LEVEL RIVER TRAINING PROJECTS

Project Name	Fiscal Year	Description	Total Budget (Rs.)	Source of Funding
Rajapur Irrigation	1991/92 - 97/98	A irrigation project (15,800 ha. of land in 11 VDCs), with a component for flood control works	204,502,000*	HMG, & Asian Development Bank
East Rapti Irrigation	1992/93 -	A irrigation project (5,200 ha. of land), which includes 18 km long embankment, with some additional river control works	291,888,000*	HMG, & Asian Development Bank
Bagmati River Training	1994/95 - 99/00	Construction of 10 km embankment as well as spurs (also when require, emergency protection works)	79,765,000	HMG
Banganga River Training	1996/97 - 98/99	Construction of 1.5 km length of boulder/earthen bund, with river diversion and channelization work.	28,5000,000	HMG
Extension of Right Embankment along Lalbankeya	1996/97 - 97/98	Extension of embankment (by 9.5 km) along Lanlbankeya river	52,146,000	HMG, & Govt. of India
Bakra River Flood Protection	1997/98 - 99/00	River control covering from foothill to Indian border, with main construction works of 66.5km embankment, 104 spurs, and 14.6 km revetments.	370,000,000	HMG, & OPEC Fund

source: Dept. of Irrigation

* only budget for river training component

ROUTE OF LAKHANDEI BETWEEN LAKSMIPUR AND BELHI VILLAGES

Descriptions	Alternative-1 (Existing route)	Alternative-2 (Eastern route)	Alternative-3 (Western route)
SCHEME DESCRIPTION	Improvement of existing channel with intensive revetment works	Bypassing Sundarpur and Laksmipur villages on the east side by new channel of about 2.3km long.	Bypassing Sundarpur and Laksmipur villages on the west side by new channel of about 2.1km long.
TECHNICAL ASPECT			
- Major quantity of work	- New channel: None Excavation: None - Spur: 97 pcs. - Revetment: 450 m - Closing dike: 7,730 m^3	-New channel: 2.3 km Excavation: 97,750 m^3 - Spur: 67 pcs. - Revetment: None - Closing dike: 7,730 m^3	- New channel: 2.1 km Excavation: 89,250 m^3 - Spur: 83 pcs. - Revetment: None - Closing dike: 7,730 m^3
- Difficulty in work	Not difficult	New channel	New channel
- Ranking (Wt=0.15)	1	2	2
FINANCIAL ASPECT			
- Project cost	Rs 27.9 million	Rs 23.6 million	Rs 27.6 million
- Maintenance cost	High	Medium	Medium
- Ranking (Wt=0.40)	2	1	3
ECONOMIC ASPECT			
- Project effects	- Same as other scheme	- Same as other scheme	- Same as other scheme
- Other positive/negative effects	- Though the bank protection will be achieved, villages still suffer from direct attack from flood flows.	- Route is most smooth among the three, and no village suffers from direct flood attack.	- Route is more smooth than the existing route, but Sundarpur still suffers from direct flood attack.
- Ranking (Wt=0.15)	3	1	2
SOCIAL ASPECT			
- Relocation of houses	9 houses	None	None
- Land acquisition	None	12 ha	11 ha
	Easy to get consent	Beneficiaries live near the new channel	Beneficiaries live near the new channel
- Ranking (Wt=0.15)	3	1	1
ENVIRONMENTAL ASPECT			
- Negative impact	Not identified	Not identified	Not identified
- Positive impact	Not identified	Not identified	Not identified
- Ranking (Wt=0.15)	1	1	1
OVERALL EVALUATION			
- Summary of ranking	**1.97**	**1.14**	**2.08**
- Special remarks	None	None	None
- Evaluation	Not selected	SELECTED	Not selected

(REMARKS) Wt: Weight for overall evaluation

COSTS ESTIMATED FOR ALTERNATIVE SCHEMES

ALTERNATIVE ROUTES OF LAKHANDEI RIVER BETWEEN LAKSMIPUR AND BELLI VILLAGES

(unit: NRs1,000)

Item	Unit	Alt.1 (Existing Route)			Alt.2 (East Route)			Alt.3 (West Route)		
		Quantity	Unit Price	Amount	Quantity	Unit Price	Amount	Quantity	Unit Price	Amount
Spur	pc	97	211.20	20,539	67	211.20	14,150	83	211.20	17,503
Revetment	m	450	9.85	4,431	0	9.85	0	0	9.85	0
Closing Dike	m3	10,000	0.11	1,100	10,000	0.11	1,100	10,000	0.11	1,100
Excavation	m3	0	0.09	0	97,750	0.09	8,798	89,250	0.09	8,033
Land Acquisition	ha	0	0	0	12	270	3,105	11	270	3,005
House Evacuation	pc	9	200	1,800	0	0	0	0	0	0
Land Development	ha	0	0	0	18	203	-3,544	10	203	-2,025
Total				27,870			23,609			27,616

Table A6.4

NATIONAL HOLIDAYS

NO.	DATE	NAME OF HOLIDAY
1	11-Jan	Birthday of Prithvi Narayan Sha & Unity Day
2	29-Jan	Shahid Divas
3	1-Feb	Basanta Panchami
4	19-Feb	National Democracy Day
5	25-Feb	Mahashivaratri
6	8-Mar	Women's Day (Only for Women)
7	12-Mar	Fagu Purnima
8	13-Mar	Fagu Purnima (Only in Terai)
9	27-Mar	Ghode Jatra Kathmandu Vally Only)
10	5-Apr	Shree Ram Nawami
11	14-Apr	New Year's Day
12	9-May	Law Day (Courts Only)
13	11-May	Buddha Jayanti
14	8-Aug	Janai Purnima
15	9-Aug	Gai Jatra (Kathmandu Vally Only)
16	14-Aug	Krishnasthami
17	22-Aug	Solar Eclipse
18	25-Aug	Tij (Women Only)
19	27-Aug	Rishi Panchami (Women Only)
20	30-Aug	Gaura Parva (in far-westren development region where the festival is obesrved)
21	5-Sep	Indra Jatra (Kathmandu Only)
22	21-Sep	Ghatasthapana
23	28-Sep to 5-Oct	Dashain*
24	19-Oct	Laxmi Puja
25	20-Oct	Gai Puja
26	21-Oct	Govardhan Puja
27	22-Oct	Tihar (Bhai -Tika)
28	26-Oct	Chhat (in districts where the festival is obse-rved
29	9-Nov	Constitution Day
30	25-Dec	Christmas Day (Christian employees only)
31	29-Dec	His Majesty's Birthday

(As of 1998)

Table A6.5

MONTHLY RAINY DAY IN LAKHANDEI RIVER (STATION No.1111)

Unit : day

Year	Rainfall	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
	0-4 mm	30	26	31	26	29	24	12	23	16	25	30	30	302
	5-9 mm	1	1	0	0	1	1	4	3	6	2	0	1	20
1987	10-14 mm	0	0	0	2	1	1	3	1	0	2	0	0	10
	15-29 mm	0	1	0	2	0	2	6	1	1	1	0	0	14
	>30 mm	0	0	0	0	0	2	6	3	7	1	0	0	19
	0-4 mm	31	27	29	24	27	21	15	14	24	28	30	30	300
	5-9 mm	0	1	0	1	2	3	2	3	2	1	0	0	15
1988	10-14 mm	0	0	1	1	1	0	2	2	1	0	0	0	8
	15-29 mm	0	0	1	3	1	1	2	2	1	1	0	1	13
	>30 mm	0	1	0	1	0	5	10	10	2	1	0	0	30
	0-4 mm	30	26	29	30	27	24	16	22	19	30	30	30	313
	5-9 mm	0	2	1	0	2	2	3	3	4	1	0	1	19
1989	10-14 mm	1	0	1	0	1	1	2	1	1	0	0	0	8
	15-29 mm	0	0	0	0	1	2	2	1	2	0	0	0	8
	>30 mm	0	0	0	0	0	1	8	4	4	0	0	0	17
	0-4 mm	31	27	28	27	23	25	14	24	19	30	30	30	308
	5-9 mm	0	0	3	1	1	4	2	2	2	1	0	0	16
1990	10-14 mm	0	0	0	1	1	0	3	1	1	0	0	0	7
	15-29 mm	0	1	0	1	2	0	5	2	2	0	0	1	14
	>30 mm	0	0	0	0	4	1	7	2	6	0	0	0	20
	0-4 mm	29	27	30	28	29	22	24	20	21	29	30	30	319
	5-9 mm	1	1	0	0	1	1	3	5	3	1	0	1	17
1991	10-14 mm	0	0	0	1	0	2	0	2	1	0	0	0	6
	15-29 mm	0	0	1	1	1	2	0	2	2	1	0	0	10
	>30 mm	1	0	0	0	0	3	4	2	3	0	0	0	13
	0-4 mm	31	28	31	29	24	26	22	25	25	27	29	31	328
	5-9 mm	0	1	0	1	2	1	3	3	2	0	1	0	14
1992	10-14 mm	0	0	0	0	1	0	1	0	0	0	0	0	2
	15-29 mm	0	0	0	0	1	1	1	0	1	1	0	0	5
	>30 mm	0	0	0	0	3	2	4	3	2	3	0	0	17
	0-4 mm	30	27	29	24	26	23	22	15	21	31	30	31	309
	5-9 mm	1	1	1	1	1	2	2	3	5	0	0	0	17
1993	10-14 mm	0	0	0	1	2	1	0	3	1	0	0	0	8
	15-29 mm	0	0	1	1	2	1	1	3	1	0	0	0	10
	>30 mm	0	0	0	3	0	3	6	7	2	0	0	0	21
	0-4 mm	29	25	30	28	28	27	23	20	21	31	30	31	323
	5-9 mm	1	1	1	1	0	1	3	2	2	0	0	0	12
1994	10-14 mm	0	1	0	0	0	0	1	1	0	0	0	0	3
	15-29 mm	0	1	0	1	1	1	1	4	0	0	0	0	9
	>30 mm	1	0	0	0	2	1	3	4	7	0	0	0	18
	0-4 mm	30	27	30	27	27	24	19	20	21	29	30	30	313
	5-9 mm	1	1	1	1	1	2	3	3	3	1	0	0	17
Ave	10-14 mm	0	0	0	1	1	1	2	1	1	0	0	0	7
	15-29 mm	0	0	0	1	1	1	2	2	1	1	0	0	9
	>30 mm	0	0	0	1	1	2	6	4	4	1	0	0	19

MONTHLY WORKABLE DAY FOR CONCRETE WORKS IN LAKHANDEI RIVER (STATION No. 1111)

Unit : day

Item	Month												Total
	Jan	Feb	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
(1) Rainy Day & Suspended Day													
Calendar Day	31	28	31	30	31	30	31	31	30	31	30	31	365
5-9 mm : Rainy day	1.0	1.0	1.0	1.0	1.0	2.0	3.0	3.0	3.0	1.0	0.0	0.0	17.0
: Suspended Day (Rainy Day x 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
10-14 mm : Rainy Day	0.0	0.0	0.0	1.0	1.0	1.0	2.0	1.0	1.0	0.0	0.0	0.0	7.0
: Suspended Day (Rainy Day x 1.0)	0.0	0.0	0.0	1.0	1.0	1.0	2.0	1.0	1.0	0.0	0.0	0.0	7.0
15-29 mm : Rainy Day	0.0	0.0	0.0	1.0	1.0	1.0	2.0	2.0	1.0	1.0	0.0	0.0	9.0
: Suspended Day (Rainy Day x 1.0)	0.0	0.0	0.0	1.0	1.0	1.0	2.0	2.0	1.0	1.0	0.0	0.0	9.0
>30 mm : Rainy Day	0.0	0.0	0.0	1.0	1.0	2.0	6.0	4.0	4.0	1.0	0.0	0.0	19.0
: Suspended Day (Rainy Day x 2.0)	0.0	0.0	0.0	2.0	2.0	4.0	12.0	8.0	8.0	2.0	0.0	0.0	38.0
(2) Total of Rainy Day	1.0	1.0	1.0	4.0	4.0	6.0	13.0	10.0	9.0	3.0	0.0	0.0	52.0
(3) Total of Suspended Day	0.0	0.0	0.0	4.0	4.0	6.0	16.0	11.0	10.0	3.0	0.0	0.0	54.0
(4) Suspended Rate :(3)/(1)%	0.0	0.0	0.0	13.3	12.9	20.0	51.6	35.5	33.3	9.7	0.0	0.0	14.8
(5) Sunday and National Holiday	6.0	7.0	9.0	6.0	7.0	4.0	4.0	12.0	9.0	14.0	6.0	6.0	90.0
(6) Rainy Day in Sunday & National Holiday (5)x(4)	0.0	0.0	0.0	0.8	0.9	0.8	2.1	4.3	3.0	1.4	0.0	0.0	13.2
(7) Non Workable Day : (3)+(5) (6)	6.0	7.0	9.0	9.2	10.1	9.2	17.9	18.7	16.0	15.6	6.0	6.0	130.8
(8) Workable Day : (1) (7)	25.0	21.0	22.0	20.8	20.9	20.8	13.1	12.3	14.0	15.4	24.0	25.0	234.2
(9) Workable Rate : (8)/(1)%	80.6	75.0	71.0	69.3	67.4	69.3	42.1	39.5	46.7	49.5	80.0	80.6	64.2
(10) Applied Workable Day	25	21	22	21	21	21	13	12	14	15	24	25	234

Note : Data of average rainy day is given from 1987 to 1994 at station No. 1111

Table A6.7

MONTHLY WORKABLE DAY FOR EARTHWORKS IN LAKHANDEI RIVER (STATION No. 1111)

Unit : day

Item	Month												Total
	Jan	Feb	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
(1) Rainy Day & Suspended Day													
Calendar Day	31	28	31	30	31	30	31	31	30	31	30	31	365
5-9 mm : Rainy day	1.0	1.0	1.0	1.0	1.0	2.0	3.0	3.0	3.0	1.0	0.0	0.0	17.0
: Suspended Day (Rainy Day x 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
10-14 mm : Rainy Day	0.0	0.0	0.0	1.0	1.0	1.0	2.0	1.0	1.0	0.0	0.0	0.0	7.0
: Suspended Day (Rainy Day x 1.0)	0.0	0.0	0.0	1.0	1.0	1.0	2.0	1.0	1.0	0.0	0.0	0.0	7.0
15-29 mm : Rainy Day	0.0	0.0	0.0	1.0	1.0	1.0	2.0	2.0	1.0	1.0	0.0	0.0	9.0
: Suspended Day (Rainy Day x 2.0)	0.0	0.0	0.0	2.0	2.0	2.0	4.0	4.0	2.0	2.0	0.0	0.0	18.0
>30 mm : Rainy Day	0.0	0.0	0.0	1.0	1.0	2.0	6.0	4.0	4.0	1.0	0.0	0.0	19.0
: Suspended Day (Rainy Day x 3.0)	0.0	0.0	0.0	3.0	3.0	6.0	18.0	12.0	12.0	3.0	0.0	0.0	57.0
(2) Total of Rainy Day	1.0	1.0	1.0	4.0	4.0	6.0	13.0	10.0	9.0	3.0	0.0	0.0	52.0
(3) Total of Suspended Day	0.0	0.0	0.0	6.0	6.0	9.0	24.0	17.0	15.0	5.0	0.0	0.0	82.0
(4) Suspended Rate :(3)/(1)%	0.0	0.0	0.0	20.0	19.4	30.0	77.4	54.8	50.0	16.1	0.0	0.0	22.5
(5) Sunday and National Holiday	6.0	7.0	9.0	6.0	7.0	4.0	4.0	12.0	9.0	14.0	6.0	6.0	90.0
(6) Rainy Day in Sunday & National Holiday (5)x(4)	0.0	0.0	0.0	1.2	1.4	1.2	3.1	6.6	4.5	2.3	0.0	0.0	20.2
(7) Non Workable Day : (3)+(5)-(6)	6.0	7.0	9.0	10.8	11.6	11.8	24.9	22.4	19.5	16.7	6.0	6.0	151.8
(8) Workable Day : (1)-(7)	25.0	21.0	22.0	19.2	19.4	18.2	6.1	8.6	10.5	14.3	24.0	25.0	213.2
(9) Workable Rate : (8)/(1)%	80.6	75.0	71.0	64.0	62.4	60.7	19.7	27.7	35.0	46.0	80.0	80.6	58.4
(10) Applied Workable Day	25	21	22	19	19	18	6	9	11	14	24	25	213

Note : Data of average rainy day is given from 1987 to 1994 at station No. 1111

COMMUNITY DEVELOPMENT COMPONENT

MAIN FEATUTRES OF "COMMUNITY MOBILIZATION" ALONG LAKHANDEI

(1) Workshops for Local Government Institutions (LGIs)
- Technicalities of Flood Control Measures
- Local Initiative for Flood Mitigation
- **Cost Benefit of Master Plan** (special subject for Lakhandei)
- Community Mobilization Processes
- Facilitative Roles by LGIs

(2) Creation of Organizational Bases

① **Formation of Community Organizations**
- Learning from a few cases of outstanding community mobilization

② **Promotion of Public Awareness, Knowledge, & Skills**
- Understanding why continuous dikes are not desirable
- Learning what measures are taken to contain run-off and erosion from upper watersheds
- Skills training on gabion netting and masonry
- Learning the basics of "participatory development"

③ **Generation of Financial Resources**
- Emphasis on mobilizing women engaged in vegetable farming and livestock raising.

MAIN FEATURES OF "LOCAL COPING MEASURES" ALONG LAKHANDEI

(1) Flood Proofing
- Agricultural adjustments (esp. through adoption of "catch crop", and production of extra paddy seedlings)
- Housing structure (through plantation of tree species that produce durable timber)
- Improvement in grain storage

(2) Forecasting, Warning, & Evacuation
- Forecasting & warning utilizing existing facilities (e.g., mosque speakers)
- Organized strategy for river watching
- Accessibility enhancement for evacuation

(3) Flood Fighting
- Supply of materials not available locally (e.g., boulders, gabion)
- Local production & procurement of flood fighting materials (e.g., tree, shrubs)
- Dissemination of flood fighting activities to wider areas

MAIN FEATURES OF "COMMUNITY-BASED SUSTAINABLE STRATEGIES" ALONG LAKHANDEI

(1) Forest/Grass Belts
- Utilization of forest/grass products for livelihood improvements
- Linkage with flood proofing, evacuation etc.
- Plantation of mulberries that can be linked promotion of sericulture

(2) Preventive Bank Protection Works
- Combine bio-engineering with other simple protection works using local materials (e.g., sandbags, bamboo, shrubs)
- Introduction of higher-value shrubs/grass
- Planting shrubs/grass to augment engineering measures for flood control

(3) Access Improvements
- Development of gravel/earthen roads where dike works are envisaged
- Support in developing road linking the programme sites & other road networks

(4) Bed Material Collection
- Dialogue between DDC &VDC to clarify responsibilities for bed material collection
- Development of roads linking extraction sites & outside road networks
- Guidelines for LGIs to monitor and regulate bed material collection

(5) O&M of Flood Control Structures
- Regular maintenance and minor repair of spurs & dikes

(6) Land Use Management
- Stop over cultivation along the river, while pursuing other income opportunities
- Make sure land newly available through river training not over cultivated

Table A6.9

LIST OF LOCAL ORGANIZATIONS IN FLOOD-AFFECTED VDCs ALONG LAKHANDEI RIVER

VDCs	Local/Indigenous Groups	Externally Induced Organizations
Patharkot VDC	Irrigation Group (only in Ward 1 & 3) Forestry Group (only in Ward 1,2 &9) Youth Sports Club	Women's Group (Supported by District Woman Development Office)
Netragunj VDC	-	Women's Group (Supported by Rural Woman Development Organization)
Gurkauli VDC	Tamang Gheding Committees Langhali Sang (Magar Community Group)	Women's Group (Supported by District Woman Development Office) Farmers' Groups (Supported by Agriculture Development Bank)
Haripur VDC	Manab Chhahari Sangh (Livestock Groups) Tharu Welfare Committee Group	-
Pidari VDC	Tharu Welfare Committee Group	Women's Group (Supported by SFDP - Small Farmer Development Program)
Pipariya VDC	-	Women's Group (Supported by Agricultural Development Bank)
Janaki Nagar VDC	Irrigation Group (Only in Ward 6 &7)	-
Shripur VDC	-	-
Bheli VDC	Shree Jan Kalyan Youth Club. Belhi Market Committee	Goat Farming. Group (Support By Social Welfare Council)
Padariya VDC	-	-
Sunderpur VDC	Muslim Language School Committee	-
Laksmipur VDC	-	-
Phul Parasi VDC	-	-
Sakrual VDC	-	-
Bhadsar VDC	Gan Joyti Youth Club Dairy Cooperative	-
Simara VDC	Mahadev Temple Committee Purnima (Religious Group) Shree Panchimi. (Religious Group)	-

RESULTS OF COMMUNITY INTERVIEWS ON CAUSES OF FLOODS & PROPOSED MEASURES

	What the people perceive to be the main causes of the flooding ?	What measures the people consider should be taken ?
Patharkot VDC	• Deforestation in upper watersheds • Settlements in upper watersheds	• Aforestation in ward 1&2 • Resettlement of ward 1&2 • Channelization for diversion.
Netragunj VDC	• Deforestation from Churiya range to plain area • Population growth lead to more land use for farming and soil become loose.	• Embankment both sides • Shift cultivated land away from river
Gurkauli VDC	• High rainfall • Deforestation in Churiya range. • Thrash & burn agriculture in Churia range. • After construction of bridge in east – west highway – river start changing courses.	• Embankment construction from Outlet to Chhapani. • Embankment construction both sides.
Haripur VDC	• Settlement at churia range (from BS 2023 there were new VDCs) • After eradicate malaria people are migrate from Churia range.	• Shifted 2 VDC at other parts in Terai and reforest those areas and make a green belt at Churia range. • Both-side embankment at plain area and at backside of embankment, green belt
Pidari VDC	• Width of bridge is very narrow. • Deforestation in Churia range that causes speed of water	• Shift of settlements in Churia range. • Embankment construction at both sides of river.
Pipariya VDC	• Deforestation in Churia range. • Level of river beds rising every year by small flood	• Channelization at center of river. • Revetment at both sides about 15 ft.
Janaki Nagar VDC	• Deforestation in Churia range • Soil erosion from Churia range, and deposit of soil/sand at river: • Because bridge is narrow and also due to drained water from Bagmati irrigation, river change courses. • In 1993 flood due to collapse of gate of Bagmati Irrigation Project at Bagmati bridge. • Deforestation in Churia range.	• Embankment both side and plantation at both side. • Embankment with sufficient spur.
Shripur VDC	• High rainfall in mountain range. • About 40 – 50 streams in catchment area and aggregate in one river at foot of hill.	• Embankment both sides

Table A6.10(2/2)

	What the people perceive to be the main causes of the flooding ?	What measures the people consider should be taken ?
Belhi VDC	• Level of river rise due to deposit of soil in old course, thus spreading water every where	• Channalization to old course. • Embankment from Patherkot.
Padariya VDC	• Deforestation • Naked land • Drainage problem	• Embankment both sides. • Aforestation (eucalyptus, sisau, mango, jackfruit, jamun) at embankment (back side of embankment)
Padariya VDC	• High rainfall • Mansura Irrigation Project constructed embankment at only western side of river, and this changes course and affects this village.	• Change old course from east of the Naya of Shreepur VDC. • Do not want to make embankment at bothside (in this village mitigation activities by engineering work is difficult)
Sunderpur VDC	• Level of riverbed increases every year. • Carry soil from each VDC to next VDC. • Bagmati Irrigation water (over flood) flown from the Dhangra river.	• Change river course away from Padariya VDC • But to change course Padariya and Bhali VDC opposed wants embankment both sides.
Laksmipur VDC	• Change of the river course from west to east of village. • Additional water coming from Bagmati Irrigation cannel and Dhangra river.	• To make the embankment both side of river
Phul Parasi VDC	• High rainfall in churiya range • Bagmati irrigation drainage waters in Lakhandehi.	• To make river 300 – 400 ft. wide and bridge also.
Sakraul VDC	• Continuous rainfall. High rainfall with in 2 – 3 days.	• Irrigation facilities from Lakhandehi river
Bhadsar VDC	• New course is formed after 1993 flood. This year Phulparasi making dyke and change course.	• South from Sakrual people plantation paddy, sugarcane at old course. So change river course from north side of Sakrual to Bhadsar VDC.
Simara VDC	• Near the village about 12 – 13 years change the course near to village so problem.	• Fix river in original course. Which is still shown in map also till date (which are unregistered land or GO's land.)

source: JICA Study Team

Table A6.11

AVAILABILITY OF SKILLED LABOURERS (GABION NETTING & MASONRY) IN FLOOD-PRONE AREAS

VDCs/Municipality Wards	Availability	Whether People Would be Interested in Taking Masonry & Gabion-netting Training
Patharkot VDC	O	About 15 skilled people inside the village, but still hope to receive training.
Netragunj VDC	X	Yes probable to get opportunity in canal construction.
Gurkauli VDC	O	Gabion netting skill man are here (12–15 people) in Ward 1 Chhedatole, but others are also interested.
Haripur VDC	X	Some people are interested in learning from Bagmati Irrigation Project and very interested to take training. There is more opportunity to obtain employment from Dept of Roads and Irrigation,etc.
Pidari VDC	X	Yes if get skill training people from community go outside to work.
Pipariya VDC	X	Yes, many people are interested in training.
Janaki Nagar VDC	O	Two people getting training from Government. Other people also hope to go for training
Shripur VDC	X	They are interested if the people go outside.
Belhi VDC	X	Interest to get training for gabion netting. But must be provide lodging, food during training period.
Paderiya VDC	X	Some are interest and some are not interest.
Sundaarpur VDC	X	Yes.
Laksmipur	O	3- 5 skilled people are already inside village.
Phul Parasi VDC	X	People are interest but so far no opportunity for skills training.
Sakrual VDC	O	Some people have bit of skills already, those people are interest to take training.
Bhadsar VDC	X	Yes, interest to take training.
Simara VDC	X	More are hope to work as skilled laborers, so interested to get skill work.

source: JICA Study Team

Table A6.12

POSSIBLE CATCH CROPS AT FLOOD AFFECTED AREA (LAKHANDEI R.)

NAME OF THE VDC	WARD NO. - VILLAGE		CROPS/VEGETABLES/ OTHERS
Netragunj	4.	Magar Tole	Sugarcane, Lentil Pigionpea & Groundnut
Gurkauli	1.	Chheda Tole	Groundnuts, Pointed Gourd & Cuccurbits,
	7.	Kingring Tole	-
Haripur	1.	Jagatpur, Jutpani	
	7.	Kacchadiya Tole, Pulchoke, Sano Jagatpur & Sakuwa	
	8.	Haripur	Sugarcane & Pigionpea
	9.	Baltampur	Sugarcane & Pigionpea
Pidari	1-9	Dhapa Tole	Sugarcane
Pipariya VDC	3,4 & 5	Pipariya	Sugarcane & Banana
Janaki Nagar	1. & 2.	Khaira Tole, Nakha Tole, Janakinagar	Sugarcane, Lentil & Groundnut
	6. & 7.	Gangapur	Sugarcane, Pointed Gourd, Sweet Potato, Groundnut & Banana
Shripur	7,8 & 9.	Shreepur	Sugarcane, Banana, Groundnut
Belhi	5,7,8 & 9	Belhi	Sugarcane
Padariya VDC	1-5	Pakriya	Sarpat (very good for river training also) Sugarcane
	6,7,8, & 9	Shivnagar	Sugarcane, Groundnut
Sundarpur	1.	Sundarpur	Sugarcane
Laksmipur	2-4	Laxmipur	-
	5-9	Sukhchaina	Sugarcane & Banana
Phul Parasi	1-9	Phool Parasi/Inruwa	Pigionpea, Sugarcane, Groundnut & Banana
Sakraul	1 & 7	Sakraul	Sugarcane, Banana, Groundnut & Pointed Gourd.
Bhadsar	2,3,4 & 5	Malaha Tole	-
Simara	2-3	Simara	Sugarcane

EXISTING FACILITIES AND OFFICES ALONG LAKHANDEI RIVER

	School/ Campus	Temple	Church	Mosque	Health Post	Post Office	Telephone	Police	Agriculture	Livestock Center	Forest Office	Irrigation	Milk Center
Patharkot	7	2	-	-	-	1		1-	-	-	1	-	-
Netragunj	4	9	1	1	1	1	1	2	-	-	1	1	3
Ghurkauli	7	7	-	1	1	1	-	-	-	1	1	-	5
Haripur	4	2	1	-	1	1	1	--	1	1	-	1	2
Pidari	2	1	-	-	1	1	-	-	-	-	1	-	1
Pipariya	1	3	-	2	1	1	-	-	-	1	-	-	1
Janaki Nagar	4	14	-	-	1	1	-	1	-	-	2	-	1
Shripur	2	4	-	-	1	-	-	-	-	-	-	-	2
Belhi	1	9	-	-	1	-	-	1	-	-	-		-
Padariya	2	9	-	-	1	-	-	-	-	-	-	-	1
Sundarpur	1	5	-	4	1	-	1	-	-	-	-	-	1
Laksmipur	2	8	-	-	1		-	-					
Phul Parasi	1	7	-	1	1	1	-	-	-	-	-	-	2
Sakraul	2	11	-	2	1	-	-	-	-	-	-	-	-
Bhadsar	1	6	-	2	1	2	-	1	-	-	-	-	1
Simara	3	7	-	2	1	-	-	-	-	-	-	-	-

source: JICA Study Team

TREES/SHRUBS/GRASS ALONG LAKHANDEI RIVER

	Name of Plants	Uses
1.	Sisso (tree)	Fuel , Furniture , Timber
2.	Khayer (tree)	Fuel , Katha , Piller
3.	Simal (tree)	Timber for House Construction , Fuel
4.	Sal (tree)	Timber
5.	Babul (tree)	Fuel, Make for cart , Live Fence
6.	Teak (tree)	Furniture
7.	Behiya (shrub)	Live Fence , River Training (Bio-Engineering)
8.	Bamboo	Local Furniture, House Construction
9.	Kusum (tree)	Fodder, Furniture, Fruit, Fuel
10.	Jamun (tree)	Timber, Fuel
11.	Karma (tree)	Timber, Furniture
12.	Bhady (tree)	Timber, Furniture
13.	Barro (tree)	Fuel, Furniture
14.	Eucalyltus (tree)	Fuel Timber
15.	Badahar (tree)	Fodder
16.	Paddy	Fuel, Green Compost
17.	Jackfruit (tree)	-
18.	Litchi (tree)	-
19.	Coconut (tree)	-
20.	Pepal (tree)	-
21.	Salpat (grass)	Sal Leaf(Long Grass Use For House Fence, Roof And Very Good For River Training)
22.	Mango (tree)	Best Timber Fuel And Fruit)
23.	Guwava (tree)	-
24.	Banana (tree)	-
25.	Tilka (shrub)	-
26.	Hatle (tree)	-
27.	Karam (tree)	-
28.	Dadape (tree)	-

TREES/SHRUBS/GRASS
AVAILABI/ NEEDS IN VARIOUS LOCALITEIS (LAKHANDEI)

	What Trees/Shrubs/Grass Are Available Locallly ?	What Trees/Shrubs/Grass Are Needed Most by People ?
Patharkot VDC Ward 7 & 9	Sal, Sissoo, Euclyptus, Mango, Jackfruit, Sal, Hatle, Khayer, Karam And Dadape	
Netragunj VDC 4	Sisau, Tik, Ecupltus).	
Gurkauli VDC 1	Sasau, Babul, Bamboo.	
Gurkauli VDC 7	Ecupltus, Sisau	Sissoo, Mango, Jack Fruits
Haripur VDC 7, 8& 9	Sal, Karma, Jamun, Bhady, Kusum.	Sissoo, Mango, Jack Fruits, Euclyptus, And Khayer
Janaki Nagar VDC 1 & 2	Sisau Ecuplentus Badahar Bamboo, Sal, Simal, Paddy Kusum And Jamun	Sissoo, Mango, Jack Fruits And Leechi
Pidari VDC 1- 9	Sisau, Mango Bamboo Ecupltus	Sissoo, Mango, Euclyptus
Pipariya VDC 3, 4 & 5	Sisau, Ecupltus, Sal, Tik, Mango, Simal, Jackfruit, Leechi And Coconut.	Mango
Janaki Nagar VDC 7& 6	Sisau, Ecupltus, Bamboo, Mango.	
Shripur VDC 7, 8,& 9	Sisau, Simal, Mango, Bamboo, Euclyptus.	Sisso, Mango, Bamboo, Tik, Euclyptus
Belhi VDC 5, 7 & 8	Sisau, Mango, Bamboo Jackfruit, Simal, Jamun And Ecupltus	Sisau
PadariyaVDC – 6, 7, 8 & 9	Sisau, Mango, Simal	Sisau, Mango
PadariyaVDC 1-5	Sisau, Mango, Salpat	
Sundarpur VDC 1	Sisau, Mango, Bamboo, Jamun And Pepal.	Sissoo, Khayer, Simal
Laksmipur VDC 5	Mango, Sisau, Guava, Jackfruit, Bamboo, Badahar Simal.	Mango
Phul Parasi VDC 1-9	Sisau, Bamboo, Mango.	Sal
Sakraul VDC 1 & 7	Sisau, Mango, Simal, Bamboo, Jackfruit, Tilka (Local Name), Banana.	
Bhadsar VDC 2, 3, 4 & 5	Sisau, Mango, Banana.	
Simara VDC 2, 3 & 7	Sisau, Mango, Bamboo, Jackfruit.	Sisau, Mango

OVERALL FRAMEWORK OF COMMUNITY DEVELOPMENT

Lakahndei River

Community Mobilization

1) Formation of Community Groups
- Learning from a limited # of outstanding cases of community mobilization

2) Creation of Awareness, Knowledge & Skills
- Education on technical measures for flood control (spurs, dikes etc.)
- Skills training on gabion netting and masonry
- Promotion of proper land use practices

3) Groups Savings for Disaster Management
- Resource mobilization for regular maintenance of river training facilities
- Local contributions for community-based actions
- More emphasis on women's participation

Local Coping Strategy

1) Flood Proofing
- Agricultural adjustments (esp. through flood-proof varieties, & storage of rice saplings)
- Housing structure through plantation of trees for durable construction materials

2) Forecasting, Warning, & Evacuation
- Warning utilizing existing facilities (e.g., PCO, & mosques)
- Accessibility enhancement for evacuation

3) Flood Fighting
- Supply of materials not available locally (e.g., boulders, gabion)
- Dissemination of flood fighting activities

Multi-purpose Facility

1) Collection of Bed Materials
- Clear-cut rules for sand/gravel extraction
- Enforcement of guidelines for proper extractions

2) Forest/Grass Belts
- Use of trees/grass for livelihood improvements (fuel, fruits etc.)
- Plantation of trees for evacuation & housing

3) Preventive Bank Protection
- Introduction of high-value grass /shrubs
- Simple protection works using local materials
- Dissemination of bio-engineering

4) Road Network Development
- Access improvement using river control facilities (esp. dikes)
- Road improvements for flood mitigation & to meet other local needs

Babai River

Community Mobilization

1) Formation of Community Groups
- Working through, or building upon, traditional irrigation groups

2) Creation of Awareness, Knowledge & Skills
- Education on technical measures for flood control (spurs, revetments etc.)
- Skills training on gabion netting and masonry
- Promotion of proper land use practices

3) Groups Savings for Disaster Management
- Resource mobilization for regular maintenance of river training facilities
- Local contributions to undertake community-based disaster management actions

Local Coping Strategy

1) Flood Proofing
- Agricultural adjustments (esp. through irrigation, & flood-proof varieties)
- Reforestation/aforestation
- Installation of drainage

2) Forecasting, Warning, & Evacuation
- Forecasting & warning utilizing existing facilities (e.g., irrigation barrage)
- Organized strategy for river watching

3) Flood Fighting
- Local production and procurement of flood fighting materials (e.g., bamboo, sandbags)
- Dissemination of flood fighting activities

Multi-purpose Facility

1) Collection of Bed Materials
- Exemption of prohibitive rules
- Enforcement of guidelines for proper extractions

2) Forest/Grass Belts
- Use of trees/grass for livelihood improvements (fuel, fodder, roofing, etc.)
- Plantation of trees for flood fighting

3) Preventive Bank Protection
- Introduction of high-value grass /shrubs
- Simple protection works using local materials
- Dissemination of bio-engineering

4) Road Network Development
- Access improvement using river control facilities (esp. bank protection)

LABOR WAGE & CONSTRUCTION EQUIPMENT COST

BASIC LABOUR WEGES (NRs)

Item	Unit	F.C.	L.C.	Total
Foreman	md	0	150	150
Welder	md	0	140	140
Operator	md	0	120	120
Electrician	md	0	140	140
Mechanic	md	0	120	120
Mason	md	0	140	140
Painter	md	0	140	140
Driver	md	0	100	100
Concrete Worker	md	0	140	140
Steel Worker	md	0	140	140
Carpenter	md	0	140	140
Skilled Labour	md	0	100	100
As.Operator	md	0	100	100
As.Driver	md	0	80	80
Common Labour	md	0	60	60

(REMARKS) F.C:Foreign currency portion, L.C:Local currency portion

UNIT OPERATION COST OF MAJOR CONSTRUCTION EQUIPMENT (NRs)

Item	Capacity	Unit	F.C.	L.C.	Total
Backhoe	0.7 m^3	hour	1,440	360	1,800
Backhoe	1.2 m^3	hour	2,560	640	3,200
Bulldozer	21 ton	hour	3,200	800	4,000
Bulldozer	11 ton	hour	1,440	360	1,800
Tractor Shavel	2 m^3	hour	1,440	360	1,800
Dump Truck	8 ton	hour	640	160	800
Air Compressor	11 m^3/min	day	3,360	840	4,200
Leg Hammer		day	800	200	1,000
Tire Roller	8 ton	hour	960	240	1,200
Vibratory Roller	3 ton	hour	560	140	700
Vibratory Roller	8 ton	hour	1,120	280	1,400
Truck Crane		hour	2,080	520	2,600
Aggregate Plant		hour	7,200	1,800	9,000
Batcher Plant	25 m^3/h	hour	4,320	1,080	5,400
Concrete Mixer		day	240	60	300
Crawle Crane	30 t	hour	3,200	800	4,000
Concrete Vibrator		day	400	100	500

Table A6.18

MATERIAL PRICE AND WORK COST IN LAKHANDEI RIVER FOR FEASIBILITY STUDY

UNIT PRICES OF CONSTRUCTION MATERIALS (NRs)

Item	Unit	F.C.	L.C.	Total
Portland Cement	ton	3,100	3,100	6,200
Concrete Aggregate; Coarse	m^3	324	216	540
Concrete Aggregate; Fine	m^3	240	160	400
Boulder Stone	m^3	276	184	460
Crushed Stone	m^3	324	216	540
Formwork Timber	m^3	2,000	18,000	20,000
Plywood (t=1.2 cm)	m^2	168	112	280
Bamboo; (L=5m)	pc	10	90	100
Deformed Bar	t	25,520	6,380	31,900
Gabion Wire	kg	36	9	45
Asphalt	kg	13	13	25
Gasoline	ltr	15	15	30
Light Oil	ltr	5	5	10
Hydraulic Oil	ltr	40	40	80
Grease	kg	35	35	70
Drain Pipe; PVC(D=40mm)	m	36	144	180
Hume Pipe (D=0.9m)	m	700	2,800	3,500
Hume Pipe (D=1.2m)	m	1,080	4,320	5,400
Water Stop; t=250mm	m	200	200	400
Log Pile (ϕ 0.15m)	m	35	318	353
RC Pile (□ 0.2m x 0.2m)	m	180	180	360

(REMARKS) F.C:Foreign currency portion, L.C:Local currency portion

UNIT COSTS OF CONSTRUCTION WORKS (NRs)

Work Item	Unit	F.C.	L.C.	Total
Stripping of Top Soil	m^2	0	5	5
Excavation(soft soil)	m^3	0	45	45
Excavation(boulder mixed soil)	m^3	0	90	90
Excavation(weathered rock)	m^3	252	28	280
Excavation(rock)	m^3	324	36	360
Embankment	m^3	51	34	85
Back Filling	m^3	24	16	40
Plain Concrete(1:3), inc.formwork	m^3	1,920	2,880	4,800
Reinforced Con.(1:3.), inc.form&steel	m^3	4,500	4,500	9,000
Wet Masonry	m^3	800	1,200	2,000
Rubble Concrete	m^3	1,200	1,800	3,000
Boulder Pitching	m^3	480	720	1,200
Gabion	m^3	680	1,020	1,700
Boulder Riprap	m^3	240	360	600
Gravel Work	m^3	340	510	850
Turfing	m^2	3	12	15
Log Pile Piling (ϕ 0.15m)	m	42	398	440
RC Pile Piling (□ 0.2m x 0.2m)	m	218	282	500
Tree Planting	ha	17,420	50,700	68,120
Grass Planting	ha	24,900	101,000	125,900

SUMMARY OF PROJECT COST FOR LAKHANDEI RIVER (FINANCIAL) FEASIBILITY STUDY

(NRs1,000)

Item	Unit	Quantity	Amount		
			F.C.	L.C.	Total
I . Construction Base Cost			108,045	172,411	280,456
1. Preparatory Works	L.S.	1.00	9,822	15,674	25,496
2. Bank Protection			32,806	48,522	81,328
2-1 Pile Spur	km	4.10	10,497	13,165	23,662
2-2 Gabion Spur	km	11.46	22,309	35,357	57,666
2-3 Revetment	km	0.00	0	0	0
3. Dike Embankment			38,947	68,578	107,525
3-1 Forest and Grass Belt	ha	377.50	9,471	40,059	49,530
3-2 Dike Road	km	6.55	10,247	7,849	18,096
3-3 Ring Dike	km	5.30	10,623	9,980	20,603
3-4 Closing Dike	place	8.00	8,607	10,690	19,297
4. Channel Excavation	km	9.88	17,540	25,387	42,928
5. Miscellaneous Works	L.S.	1.00	8,929	14,249	23,178
II . Compensation Cost	L.S.	1.00	0	45,384	45,384
III. Addministration Cost	L.S.	1.00	0	16,292	16,292
IV. Engineering Cost	L.S.	1.00	33,655	22,436	56,091
V . Physical Contingency	L.S.	1.00	14,170	25,652	39,822
VI. Total			155,870	282,176	438,046
VII. Value Added Tax	L.S.	1.00	0	43,805	43,805
VIII. Grand Total			155,870	325,980	481,850

Note: 1: Price Level in October 1998
2: Convertion Rate US$ 1.00 = NRs 67.93, 1.00 Yen = NRs 0.59
3: Cost does not include price contingency
4: Figures may not add up to totals due to rounding
F.C:Foreign currency portion
L.C:Local currency portion

SUMMARY OF PROJECT COST FOR EROSION CONTROL TEST WORKS (FINANCIAL)

(NRs1,000)

Item	Unit	Quantity	Amount		
			F.C.	L.C.	Total
I . Construction Base Cost			16,123	18,610	34,733
1. Preparatory Works	L.S.	1.00	1,347	1,504	2,851
2. Groundsill Work	place	4.00	2,650	4,432	7,082
3. Slope Protection Work	km	1.00	5,304	8,388	13,692
4. Check-dam Work	place	2.00	1,302	2,070	3,372
5. Gauging Instrument Work	set	8.00	4,177	661	4,838
6. Miscellaneous Works	L.S.	1.00	1,343	1,555	2,898
II . Compensation Cost	L.S.	1.00	0	0	0
III. Addministration Cost	L.S.	1.00	0	1,737	1,737
IV. Engineering Cost	L.S.	1.00	4,168	2,779	6,947
V . Physical Contingency	L.S.	1.00	2,029	2,139	4,168
VI. Total			22,320	25,264	47,584
VII. Value Added Tax	L.S.	1.00	0	4,758	4,758
VIII. Grand Total			22,320	30,022	52,343

Note: 1: Price Level in October 1998
2: Convertion Rate US$ 1.00 = NRs 67.93, 1.00 Yen = NRs 0.59
3: Cost does not include price contingency
4: Figures may not add up to totals due to rounding
F.C:Foreign currency portion
L.C:Local currency portion

ANNUAL DISBURSEMENT SCHEDULE OF LAKHANDEI RIVER PROJECT (FINANCIAL)

(NRs1,000)

Discription	Amount			1999/2000		2000/2001		2001/2002		2002/2003		2003/2004		2004/2005		2005/2006		2006/2007	
	F.C.	L.C.	Total	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.
I . Construction Base Cost	108,045	172,411	280,456	0	0	0	0	0	0	42,563	67,919	32,741	52,246	32,741	52,246	0	0	0	0
1. Preparatory Works	9,822	15,674	25,496	0	0	0	0	0	0	9,822	15,674	0	0	0	0	0	0	0	0
2. Bank Protection	32,806	48,522	81,328	0	0	0	0	0	0	10,935	16,174	10,935	16,174	10,935	16,174				
3. Dike Embankment	38,947	68,578	107,525	0	0	0	0	0	0	12,982	22,859	12,982	22,859	12,982	22,859				
4. Channel Excavation	17,540	25,387	42,928	0	0	0	0	0	0	5,847	8,462	5,847	8,462	5,847	8,462				
5. Miscellaneous Works	8,929	14,249	23,178	0	0	0	0	0	0	2,976	4,750	2,976	4,750	2,976	4,750	0	0	0	0
Sub-total	108,045	172,411	280,456	0	0	0	0	0	0	42,563	67,919	32,741	52,246	32,741	52,246	0	0	0	0
II . Compensation Cost	0	45,384	45,384	0	0	0	0	0	15,128	0	15,128	0	15,128	0	0	0	0	0	0
1. Compensation	0	45,384	45,384		0	0	0	0	15,128	0	15,128	0	15,128	0	0	0	0	0	0
III. Addministration Cost	0	16,292	16,292	0	0	0	0	0	756	0	6,281	0	5,006	0	4,249	0	0	0	0
1. Administration	0	16,292	16,292	0	0	0	0	0	756	0	6,281	0	5,006	0	4,249	0	0	0	0
IV. Engineering Cost	33,655	22,436	56,091	0	0	0	0	16,827	11,218	6,629	4,419	5,099	3,399	5,099	3,399	0	0	0	0
1. Detail Design	16,827	11,218	28,046	0	0	0	0	16,827	11,218										
2. Construction Supervision	16,827	11,218	28,046	0	0	0	0	0	0	6,629	4,419	5,099	3,399	5,099	3,399				
V. Physical Contingency	14,170	25,652	39,822	0	0	0	0	1,683	2,710	4,919	9,375	3,784	7,578	3,784	5,989	0	0	0	0
VI. Value Added Tax	0	43,805	43,805	0	0	0	0	0	4,832	0	15,723	0	12,498	0	10,751	0	0	0	0
VII. Total	155,870	325,980	481,850	0	0	0	0	18,510	34,645	54,111	118,845	41,624	95,855	41,624	76,635	0	0	0	0
VIII. Price Contingency	23,215	184,272	207,487	0	0	0	0	1,716	11,468	6,791	55,156	6,630	58,520	8,077	59,128	0	0	0	0
IX. Grand Total	179,085	510,253	689,337	0	0	0	0	20,226	46,113	60,903	174,001	48,254	154,375	49,701	135,763	0	0	0	0

Note: *1 Price Level in October 1998
*2 Convertion Rate US$ 1.00 = NRs 67.93, 1.00 Yen = NRs 0.59
*3 Figures may not add up to totals due to rounding

COST BENEFIT FLOW (F/S)

(Existing Basin)

River: Lakhandei (Unit: NRs. 1,000)

Year	Economic cost/benefit				Discounted (10%)	
	Project cost	Maintenance cost	Total cost	Benefit	(C) Cost	(B) Benefit
1 1999	0	0	0	0	0	0
2 2000	0	0	0	0	0	0
3 2001	43,491	0	43,491	0	35,943	0
4 2002	141,510	0	141,510	0	106,319	0
5 2003	112,483	795	113,278	16,400	77,371	11,202
6 2004	96,757	1,427	98,184	29,436	60,965	18,278
7 2005	0	1,971	1,971	40,650	1,113	22,946
8 2006	0	1,971	1,971	40,650	1,012	20,860
9 2007		1,971	1,971	40,650	920	18,964
10 2008		1,971	1,971	40,650	836	17,240
11 2009		1,971	1,971	40,650	760	15,672
12 2010		1,971	1,971	40,650	691	14,248
13 2011		1,971	1,971	40,650	628	12,952
14 2012		1,971	1,971	40,650	571	11,775
15 2013		1,971	1,971	40,650	519	10,704
16 2014		1,971	1,971	40,650	472	9,731
17 2015		1,971	1,971	40,650	429	8,847
18 2016		1,971	1,971	40,650	390	8,042
19 2017		1,971	1,971	40,650	355	7,311
20 2018		1,971	1,971	40,650	322	6,647
21 2019		1,971	1,971	40,650	293	6,042
22 2020		1,971	1,971	40,650	266	5,493
23 2021		1,971	1,971	40,650	242	4,994
24 2022		1,971	1,971	40,650	220	4,540
25 2023		1,971	1,971	40,650	200	4,127
26 2024		1,971	1,971	40,650	182	3,752
27 2025		1,971	1,971	40,650	165	3,411
28 2026		1,971	1,971	40,650	150	3,101
29 2027		1,971	1,971	40,650	137	2,819
30 2028		1,971	1,971	40,650	124	2,563
31 2029		1,971	1,971	40,650	113	2,330
32 2030		1,971	1,971	40,650	103	2,118
33 2031		1,971	1,971	40,650	93	1,925
34 2032		1,971	1,971	40,650	85	1,750
35 2033		1,971	1,971	40,650	77	1,591
36 2034		1,971	1,971	40,650	70	1,446
37 2035		1,971	1,971	40,650	64	1,315
38 2036		1,971	1,971	40,650	58	1,195
39 2037		1,971	1,971	40,650	53	1,087
40 2038		1,971	1,971	40,650	48	988
41 2039		1,971	1,971	40,650	44	898
42 2040		1,971	1,971	40,650	40	817
43 2041		1,971	1,971	40,650	36	742
44 2042		1,971	1,971	40,650	33	675
45 2043		1,971	1,971	40,650	30	613
46 2044		1,971	1,971	40,650	27	558
47 2045		1,971	1,971	40,650	25	507
48 2046		1,971	1,971	40,650	22	461
49 2047		1,971	1,971	40,650	20	419
50 2048		1,971	1,971	40,650	18	381
Total	394,241	88,956	483,197	1,834,437	292,652	278,075

EIRR: 9.5%
B/C: 0.95
NPV(B-C): -14,577 (NRs.1,000)

COST BENEFIT FLOW (F/S)

(Future Basin)

River: Lakhandei (Unit: NRs. 1,000)

Year	Economic cost/benefit				Discounted (10%)	
	Project cost	Maintenance cost	Total cost	Benefit	(C) Cost	(B) Benefit
1 1999	0	0	0	0	0	0
2 2000	0	0	0	0	0	0
3 2001	43,491	0	43,491	0	35,943	0
4 2002	141,510	0	141,510	0	106,319	0
5 2003	112,483	795	113,278	35,424	77,371	24,195
6 2004	96,757	1,427	98,184	63,583	60,965	39,480
7 2005	0	1,971	1,971	87,804	1,113	49,563
8 2006	0	1,971	1,971	87,804	1,012	45,057
9 2007		1,971	1,971	87,804	920	40,961
10 2008		1,971	1,971	87,804	836	37,237
11 2009		1,971	1,971	87,804	760	33,852
12 2010		1,971	1,971	87,804	691	30,775
13 2011		1,971	1,971	87,804	628	27,977
14 2012		1,971	1,971	87,804	571	25,434
15 2013		1,971	1,971	87,804	519	23,122
16 2014		1,971	1,971	87,804	472	21,020
17 2015		1,971	1,971	87,804	429	19,109
18 2016		1,971	1,971	87,804	390	17,372
19 2017		1,971	1,971	87,804	355	15,792
20 2018		1,971	1,971	87,804	322	14,357
21 2019		1,971	1,971	87,804	293	13,052
22 2020		1,971	1,971	87,804	266	11,865
23 2021		1,971	1,971	87,804	242	10,786
24 2022		1,971	1,971	87,804	220	9,806
25 2023		1,971	1,971	87,804	200	8,914
26 2024		1,971	1,971	87,804	182	8,104
27 2025		1,971	1,971	87,804	165	7,367
28 2026		1,971	1,971	87,804	150	6,697
29 2027		1,971	1,971	87,804	137	6,089
30 2028		1,971	1,971	87,804	124	5,535
31 2029		1,971	1,971	87,804	113	5,032
32 2030		1,971	1,971	87,804	103	4,574
33 2031		1,971	1,971	87,804	93	4,159
34 2032		1,971	1,971	87,804	85	3,781
35 2033		1,971	1,971	87,804	77	3,437
36 2034		1,971	1,971	87,804	70	3,124
37 2035		1,971	1,971	87,804	64	2,840
38 2036		1,971	1,971	87,804	58	2,582
39 2037		1,971	1,971	87,804	53	2,347
40 2038		1,971	1,971	87,804	48	2,134
41 2039		1,971	1,971	87,804	44	1,940
42 2040		1,971	1,971	87,804	40	1,764
43 2041		1,971	1,971	87,804	36	1,603
44 2042		1,971	1,971	87,804	33	1,458
45 2043		1,971	1,971	87,804	30	1,325
46 2044		1,971	1,971	87,804	27	1,205
47 2045		1,971	1,971	87,804	25	1,095
48 2046		1,971	1,971	87,804	22	996
49 2047		1,971	1,971	87,804	20	905
50 2048		1,971	1,971	87,804	18	823
Total	394,241	88,956	483,197	3,962,383	292,652	600,641

EIRR: 20.8%
B/C: 2.05
NPV(B-C): 307,989 (NRs.1,000)

SOCIAL ENVIRONMENT ASSESSMENT: LAKHANDEI RIVER.

No.	Environmental Item	Type of Impact	Evaluation	Remarks
a	Resettlement	Resettlement by land occupation (Transfer of residence/land ownership rights)	B	Some people along the river will have to be resettled
b	Economic Activities	GAIN in production base (land etc.) and change of economic structure.	A	Stabilization of river banks and prevention of erosion and land degradation should lead to increase of productive land base.
c	Traffic and Public Facilities	Positive impact on existing traffic, schools, hospital etc. (e.g., Traffic congestion, accident rate)	A	New roads should improve access to facilities and markets
d	Split of Communities	Separation of communities by interference of regional traffic.	D	No regional traffic
e	Cultural Property	Loss or deterioration of cultural properties such as temples, shrines, historic assets.	D	No loss envisaged. List to be made of historic assets, if any.
f	Water Rights and Rights of Common	IMPROVED access to water, irrigation or fishing rights.	B	By stabilizing river, there should be improved access to irrigation water and well water will have less chance of contamination.
g	Public Health Condition	IMPROVEMENT of health or sanitary conditions due to more secure latrines. There may be increased risk of pollution due additional use of agricultural chemicals.	B	Improved sanitary conditions may reduce the risk of water born diseases such as cholera. Over time farmers will use more fertilizers; these may contaminate the water supply
h	Waste	Eroded gravel, sand and soil trapped by the vegetation planted along the river banks. Domestic waste secured from polluting the river.	A	Vegetation used to build up river banks. Houses moved to prevent subsidence and thus effluent pollution
i	Hazards (Risks)	DECREASED risk of subsidence, building collapse and accidents.	A	By stabilizing the river banks, it will reduce risk of subsidence to buildings near the river.
j	Other (specify)			

Note. The column entitle "Type of Impact" describes the possible outcomes as a result of the project.
The marking system under "Evaluation" refers to the degree of environmental impact.
It is as follows: **A**, Important; **B**, Some; **C**, Unknown; **D**, No.
The "Remarks" column lists major environmental costs and benefits.

NATURAL ENVIRONMENT ASSESSMENT: LAKHANDEI RIVER.

No.	Environmental Item	Type of Impact	Evaluation	Remarks
a	Topography And Geology	Change of important topography and geology DECREASED due to REDUCTION of natural excavation and earth-fill.	B	Flood mitigation measures help prevent natural excavation and earth-fill.
b	Soil And Land	DECREASE of topsoil erosion by flood mitigation initiatives including reforestation. IMPROVEMENT to soil fertility, through decrease deposition of coarse gravel etc.	A	Flood mitigation measures will decrease topsoil erosion and the deposition of coarse sand and gravel onto fields close to the river.
c	Groundwater	Lowering of groundwater table due to overdraft and turbid water caused by construction work.	D	Flood mitigation measures will not affect water table during construction work.
d	Hydrological Situation	Change of discharge and water quality due to reclamation and/or drainage.	B	Successful flood mitigation interventions will lead to land reclamation of land previously degraded by past flooding.
e	River Basin	River basin erosion DECREASED and POSITIVE vegetation changes due to land reclamation and river training.	A	As a result of flood mitigation measures, soil erosion should decrease in the river basin, and land reclamation will increase due to river training. These measures should have a positive impact on the flora and fauna.
f	Fauna And Flora	Interruption of reproduction or extinction of species due to habitat changes.	D	There should be no effect on species due to habitat changes.
g	Meteorology	Changes in microclimate, such as temperature, wind etc. due to large-scale reclamation and construction.	D	No large-scale construction or reclamation considered. However, the proposed planting of a belt of trees along both river banks may improve the local microclimate.
h	Landscape	IMPROVEMENT of aesthetic beauty by structural and topographical changes due to reclamation.	B	Flood mitigation measures, especially the planting of trees and grasses should improve the habitat and encourage an increased fauna.
i	Other (specify)			

Note. The column entitle "Type of Impact" describes the possible outcomes as a result of the project.
The marking system under "Evaluation" refers to the degree of environmental impact.
It is as follows: **A**, Important; **B**, Some; **C**, Unknown; **D**, No.
The "Remarks" column lists major environmental costs and benefits.

POLLUTION ASSESSMENT: LAKHANDEI RIVER.

No.	Environmental Item	Type of Impact	Evaluation	Remarks
a	Air Pollution	Change in air quality caused by exhaust gases or toxic gases from vehicles and/or factories.	D	Not applicable
b	Water Pollution	Water pollution of rivers and groundwater caused by drilling mud and oil.	D	Not applicable
c	Soil Contamination	Contamination caused by discharge or diffusion of sewage or toxic substances.	D	Sewage from houses contaminating the soil should be negligible.
d	Noise and Vibration	Generation of noise and vibrations due to drilling and operation of pumping machines.	D	Not applicable
e	Land Subsidence	Deformation of the land and land subsidence due to lowering of groundwater table.	D	Increased population may use more groundwater, but the flood mitigation project should have no negative effect on the groundwater table.
f	Offensive Odour	Generation of offensive odours and exhaust gases.	D	These will be negligible or non-existant.
g	Other (specify)			

Note. The column entitle "Type of Impact" describes the possible outcomes as a result of the project.
The marking system under "Evaluation" refers to the degree of environmental impact.
It is as follows: **A**, Important; **B**, Some; **C**, Unknown; **D**, No.
The "Remarks" column lists major environmental costs and benefits