CANDIDATE SPECIES FOR BIOENGINEERING WORKS IN TERAI

	Naturally Grown Species	Nursery Species
Grasses	- Arundo clonax (Narkato) - Cymbopogon microtheca (Khar) - Cymbopogon pendulus (Dangre Khar) - Cynodon dactylon (Dhubo) - Eulaliopsis ninanta (Babiyo, Sabai Grass) - Neyraudia arundinacea (Sito) - Neyraudia reynaudiana (Dhonde) - Pennisetum clandestinum (Kikuyu, Thulo Dhubo) - Pogonatherum paniceum (Musekharuki) - Saccharum spontaneus (Kans)	- Desmodium intortum - Pennisetum purpureum (Napier) - Setaria anceps - Thysanolaena maxima (Amliso) - also in forests - - Stylo - Molasess grass
Shrubs & Non-Plantation Trees	- Adhatoda vasica (Assuro) - Butea minor (Bhujetro) - Calatorpha giganteum (Aak) - Colebrookea oppositifolia (Chusun) - Ipomoea fistulata (Saruwa --- Beheu) - Lantana camara (Phul Kanda) - Phoenix humilis (Thakal) - Trema orientalis (Kunyelo) - Vitex negundo (Simali) - Wedlandia species (Tilka) - Woodfordia fruticosa (Dhanyero)	
Trees	- Acacia catechu (Khayer) --- also in nursery - Acacia auriculiformis - Albizia julibrissin - Ficus semicordata (Khasre Khayu, Khanayo) - Shorea robusta (Sal) -- also in nursery	- Bauhinia purpurea (Tanki) - Delonix regia (Gulmohar) - Leucaena species (Ipil Ipil) - Bamboo species

source: "Vegetation Structures for Stabilizing Highway Slopes", Dept. of Roads, 1991

INCOME GENERATION OPPORTUNITIES THROUGH BIOENGINEERING

From:	Species Used	Income-generating Products
Nursery	Trees	
	- Acacia catechu (Khayer)	- saplings
	- Shorea robusta (Sal)	- saplings
	- Bauhinia purpurea (Tanki)	- saplings
	- Delonix regia (Gulmohar)	- seeds/saplings
	- Leucaena species (Ipil Ipil)	- seeds/saplings
	- Bamboo species	- roots
	Grasses	
	- Desmodium intortu	
	- Pennisetum purpureum (Napier)	- seeds
	- Thysanolaena maxima (Amliso)	- cutting
	- Stylo	- seeds/cutting
	- Molasess grass	- seeds
		- seeds
Bio-Engineering Facility	Grasses	
	- Desmodium intortum	- fuel wood
	- Pennisetum purpureum (Napier)	- fodder/mulching
	- Thysanolaena maxima (Amliso)	- fodder/broom
	- Stylo	- fodder/seed
	- Molasess grass	- fodder/seed
	- Arundo clonax (Narkato)	- fencing
	- Cymbopogon microtheca (Khar)	- roof thatch
	- Cymbopogon pendulus (Dangre Khar)	- roof thatch
	- Cynodon dactylon (Dhubo)	- fodder
	- Eulaliopsis ninanta (Babiyo)	- rope
	- Saccharum spontaneus (Kans)	- roof thatch/rope
	Shrubs	
	- Adhatoda vasica (Assuro)	- green manure/medicine
	Trees	
	- Bamboo species	- furniture/timber
	- Bauhinia purpurea (Tanki)	- fodder/fuel wood
	- Delonix regia (Gulmohar)	- fuel wood
	- Leucaena species (Ipil Ipil)	- fodder/fuel wood
	- Acacia catechu (Khayer)	- timber/fuel wood/medicine
	- Shorea robusta (Sal)	- leaf plate

source: "Vegetation Structures for Stabilizing Highway Slopes", Dept. of Roads, 1991

PROJECT COST FOR MASTER PLAN

LOHANDRA RIVER (unit: NRs1000)

Item	Unit	Quantity	Unit Cost	Amount
I . Construction Base Cost				376,545
1. Preparatory Works	L.S.	1.00		34,231
2. Bank Protection Works				39,878
2-1 Pile Spur (Type-A)	km	4.10	5,301	21,734
2-2 Gabion Spur (Type-A)	km	2.20	8,247	18,143
3. Cannel Works				95,644
3-1 River Boundary Line	km	105.00	27	2,835
3-2 Tree Belt	ha	55.50	68	3,774
3-3 Grass Belt	ha	436.50	126	54,999
3-4 Cut-off Cannel	$1000m^3$	272.00	93	25,296
3-5 Closing Dike/structure	place	4.00	2,185	8,740
4. Ring Dike Works				175,672
4-1 Dike Embankment	km	31.30	2,596	81,255
4-2 Drainage Sluice	place	47.00	1,275	59,925
4-3 Gravel Metaling	km	31.30	1,102	34,493
5. Miscellaneous Works	L.S.	1.00		31,119
II . Compensation Cost	L.S.	1.00		135,792
III. Administration Cost	L.S.	1.00		25,617
IV. Engineering Service	L.S.	1.00		56,482
V . Physical Contingency	L.S.	1.00		56,882
Poject Cost				651,317

Note: *1 Price Level in October 1998
*2 Convertion Rate US$ 1.00 = NRs 67.93, 1.00 Yen = NRs 0.59
*3 Cost do not include Price Contingency and Value Added Tax
*4 Figures may not add up to totals due to rounding

ANNUAL DISBURSEMENT SCHEDULE OF LOHANDRA RIVER PROJECT FOR MASTER PLAN

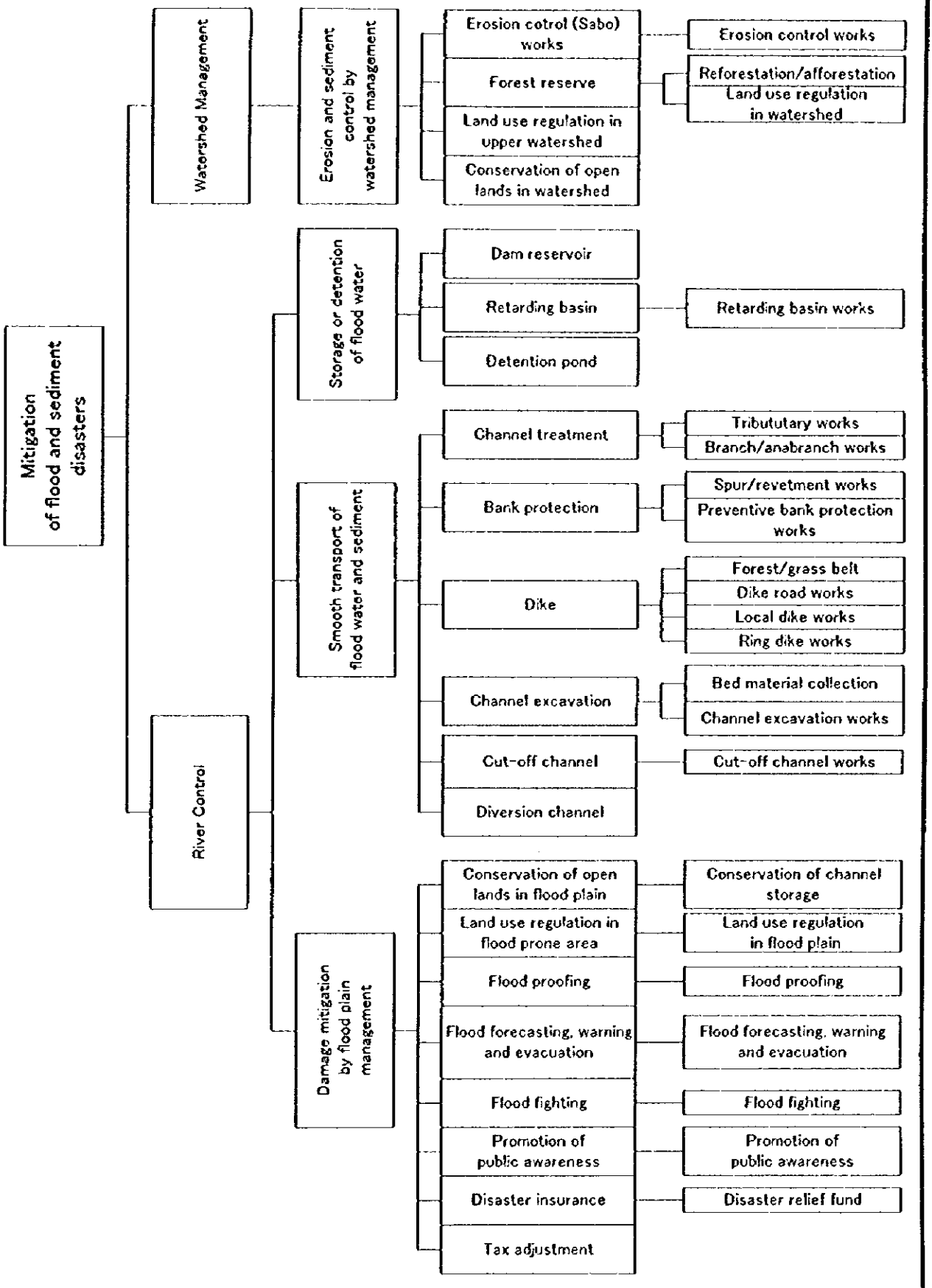
(Financial Cost) (1,000NRs)

Discription	Total	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
I . Construction Base Cost	376,545	0	0	0	32,805	32,805	32,805	21,395	21,395	21,395	21,395	21,395	21,395	21,395	21,395	21,395	21,395	21,395	21,395	21,395
1. Preparatory Works	34,231	0	0	0	11,410	11,410	11,410	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Bank Protection Works	39,878	0	0	0	2,492	2,492	2,492	2,492	2,492	2,492	2,492	2,492	2,492	2,492	2,492	2,492	2,492	2,492	2,492	2,492
3. Channel Woks	95,644	0	0	0	5,978	5,978	5,978	5,978	5,978	5,978	5,978	5,978	5,978	5,978	5,978	5,978	5,978	5,978	5,978	5,978
4. Ring Dike Works	175,672	0	0	0	10,980	10,980	10,980	10,980	10,980	10,980	10,980	10,980	10,980	10,980	10,980	10,980	10,980	10,980	10,980	10,980
5. Miscellaneous Works	31,119	0	0	0	1,945	1,945	1,945	1,945	1,945	1,945	1,945	1,945	1,945	1,945	1,945	1,945	1,945	1,945	1,945	1,945
II . Compensation Cost	135,792	0	0	8,487	8,487	8,487	8,487	8,487	8,487	8,487	8,487	8,487	8,487	8,487	8,487	8,487	8,487	8,487	8,487	0
III. Addministration Cost	25,617	0	0	424	2,065	2,065	2,065	1,494	1,494	1,494	1,494	1,494	1,494	1,494	1,494	1,494	1,494	1,494	1,494	1,070
IV. Engineering Cost	56,482	9,414	9,414	9,414	2,460	2,460	2,460	1,605	1,605	1,605	1,605	1,605	1,605	1,605	1,605	1,605	1,605	1,605	1,605	1,605
1. F/S, D/D etc.	28,241	9,414	9,414	9,414	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Construction Supervision	28,241	0	0	0	2,460	2,460	2,460	1,605	1,605	1,605	1,605	1,605	1,605	1,605	1,605	1,605	1,605	1,605	1,605	1,605
V. Physical Contingency (10% of Items I , II &IV)	56,882	941	941	1,790	4,375	4,375	4,375	3,149	3,149	3,149	3,149	3,149	3,149	3,149	3,149	3,149	3,149	3,149	3,149	2,300
VI. Total	651,317	10,355	10,355	20,115	50,192	50,192	50,192	36,129	36,129	36,129	36,129	36,129	36,129	36,129	36,129	36,129	36,129	36,129	36,129	26,369

Note: *1 Price Level in October 1998
*2 Convertion Rate US$ 1.00 = NRs 67.93, 1.00 Yen = NRs 0.59
*3 Cost do not include Price Contingency and Value Added Tax
*4 Figures may not add up to totals due to rounding

(Economic Cost) (1,000NRs)

Discription	Total	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
I . Construction Base Cost	338,890	0	0	0	29,525	29,525	29,525	19,255	19,255	19,255	19,255	19,255	19,255	19,255	19,255	19,255	19,255	19,255	19,255	19,255
1. Preparatory Works	30,808	0	0	0	10,269	10,269	10,269	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Bank Protection Works	35,890	0	0	0	2,243	2,243	2,243	2,243	2,243	2,243	2,243	2,243	2,243	2,243	2,243	2,243	2,243	2,243	2,243	2,243
3. Channel Woks	86,080	0	0	0	5,380	5,380	5,380	5,380	5,380	5,380	5,380	5,380	5,380	5,380	5,380	5,380	5,380	5,380	5,380	5,380
4. Ring Dike Works	158,105	0	0	0	9,882	9,882	9,882	9,882	9,882	9,882	9,882	9,882	9,882	9,882	9,882	9,882	9,882	9,882	9,882	9,882
5. Miscellaneous Works	28,007	0	0	0	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750
II . Compensation Cost	122,213	0	0	7,638	7,638	7,638	7,638	7,638	7,638	7,638	7,638	7,638	7,638	7,638	7,638	7,638	7,638	7,638	7,638	0
III. Administration Cost	23,055	0	0	382	1,858	1,858	1,858	1,345	1,345	1,345	1,345	1,345	1,345	1,345	1,345	1,345	1,345	1,345	1,345	963
IV. Engineering Cost	50,834	8,472	8,472	8,472	2,214	2,214	2,214	1,444	1,444	1,444	1,444	1,444	1,444	1,444	1,444	1,444	1,444	1,444	1,444	1,444
1. F/S, D/D etc.	25,417	8,472	8,472	8,472	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Construction Supervision	25,417	0	0	0	2,214	2,214	2,214	1,444	1,444	1,444	1,444	1,444	1,444	1,444	1,444	1,444	1,444	1,444	1,444	1,444
V. Physical Contingency (10% of Items I , II &IV)	51,194	847	847	1,611	3,938	3,938	3,938	2,834	2,834	2,834	2,834	2,834	2,834	2,834	2,834	2,834	2,834	2,834	2,834	2,070
VI. Total	586,185	9,319	9,319	18,104	45,173	45,173	45,173	32,516	32,516	32,516	32,516	32,516	32,516	32,516	32,516	32,516	32,516	32,516	32,516	23,732



FLOOD MITIGATION MEASURES

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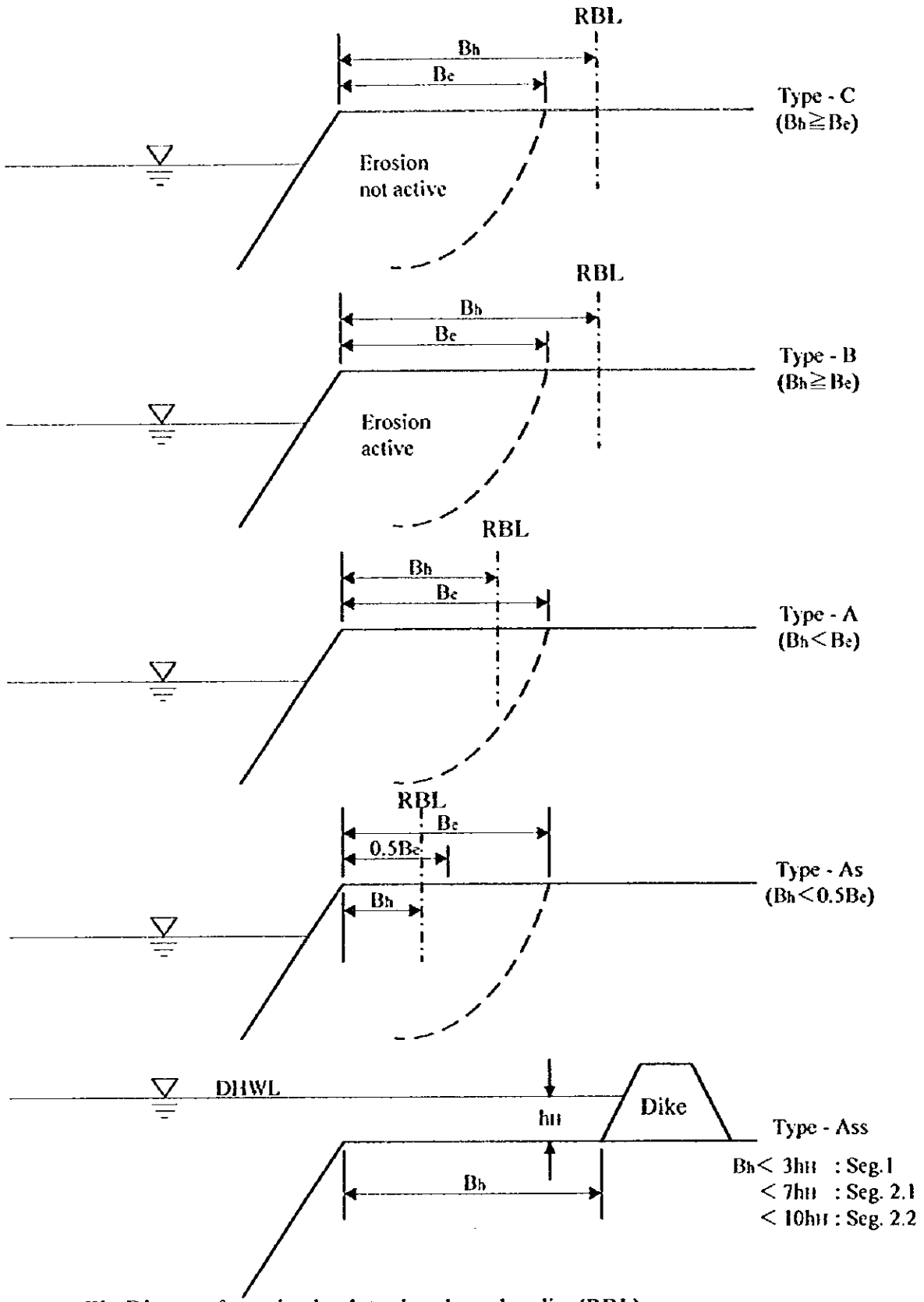
JAPAN INTERNATIONAL COOPERATION AGENCY



Bh: Distance from riverbank to river boundary line(RBL)

Be: Design erosion width (Assumed maximum annual erosion width)

CLASSIFICATION OF TYPES OF RIVER BANK

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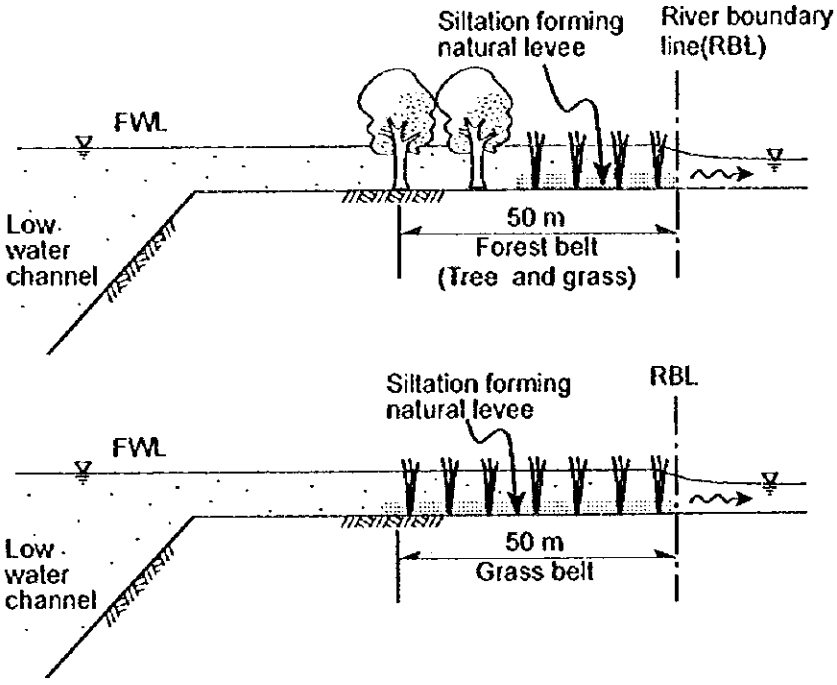
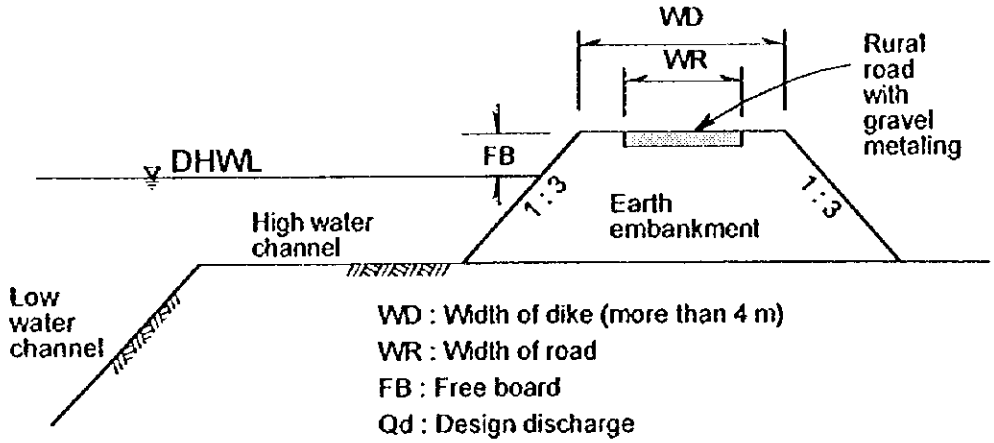
Forest and Grass Belt



Earth Dike / Road



WD : Width of dike (more than 4 m)
WR : Width of road
FB : Free board
Qd : Design discharge

Qd (m^3/s)	FB (m) (Not less than)	WD (m, Not less than)	
		Dike only	Dike road
Less than 200	0.6	3	5
200 to 500	0.8	3	5
500 to 2,000	1.0	4	5
2,000 to 5,000	1.2	5	5
5,000 to 10,000	1.5	6	6
More than 10,000	2.0	7	7

DIKE WORKS

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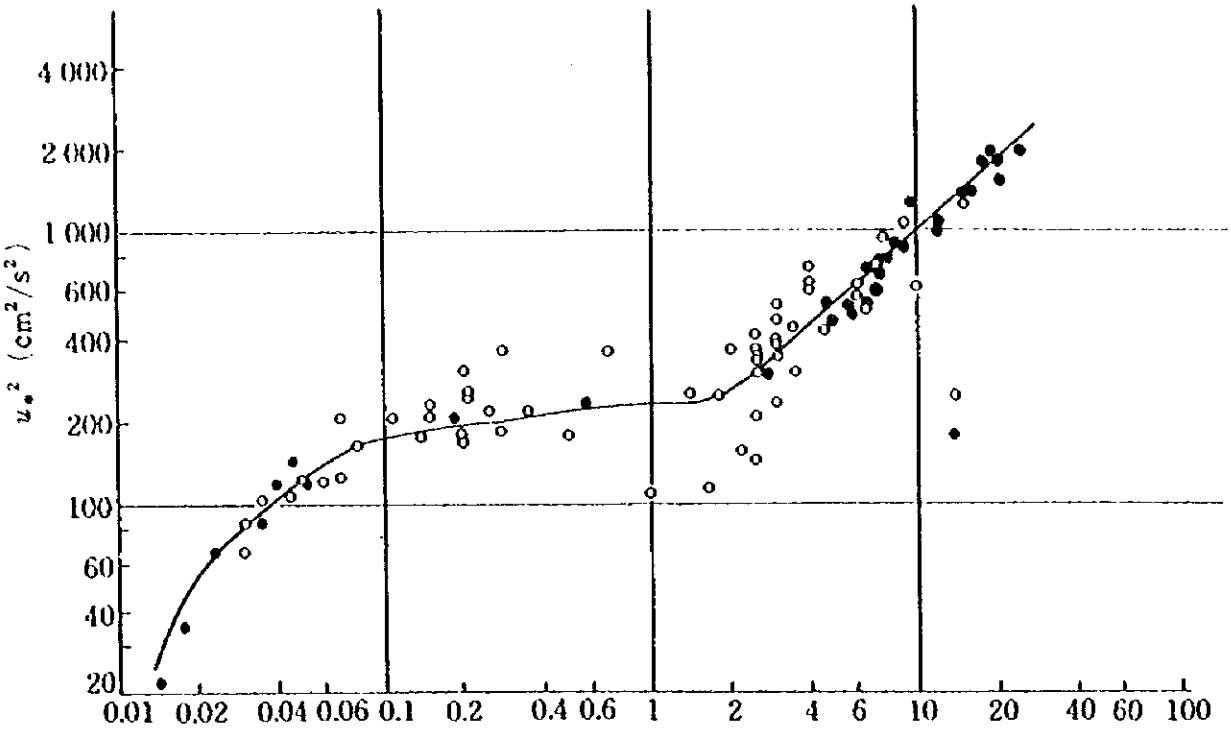

$$Q_2 = A \cdot V = \frac{B \cdot h_L^{5/3} \cdot I^{1/2}}{n} \quad \Rightarrow \quad h_L = \left\{ \frac{Q_2 \cdot n}{B \cdot I^{1/2}} \right\}^{3/5}$$

$$u_*^2 = g \cdot h_L \cdot I \quad \Rightarrow \quad I = \frac{u_*^2}{g \cdot h_L}$$

$$B = \frac{n \cdot Q_2}{h_L^{5/3} \cdot I^{1/2}} = \frac{n \cdot g^{1/2} \cdot Q_2}{u_* \cdot h_L^{7/6}} \qquad (m, \text{sec})$$

n : Manning's coefficient of roughness

g : Accceleration of gravity (m/sec^2)

Q_2 : Two-year probable discharge (m3/s)

u_* : u_*-value obtained from d_R-u_* diagram for a given representative grain size (d_R) (m/s)

h_L : Mean depth of low water channel (m)

B : Low water channel width

RELATIONSHIP BETWEEN BED MATERIAL SIZE AND FRICTION VELOCITY

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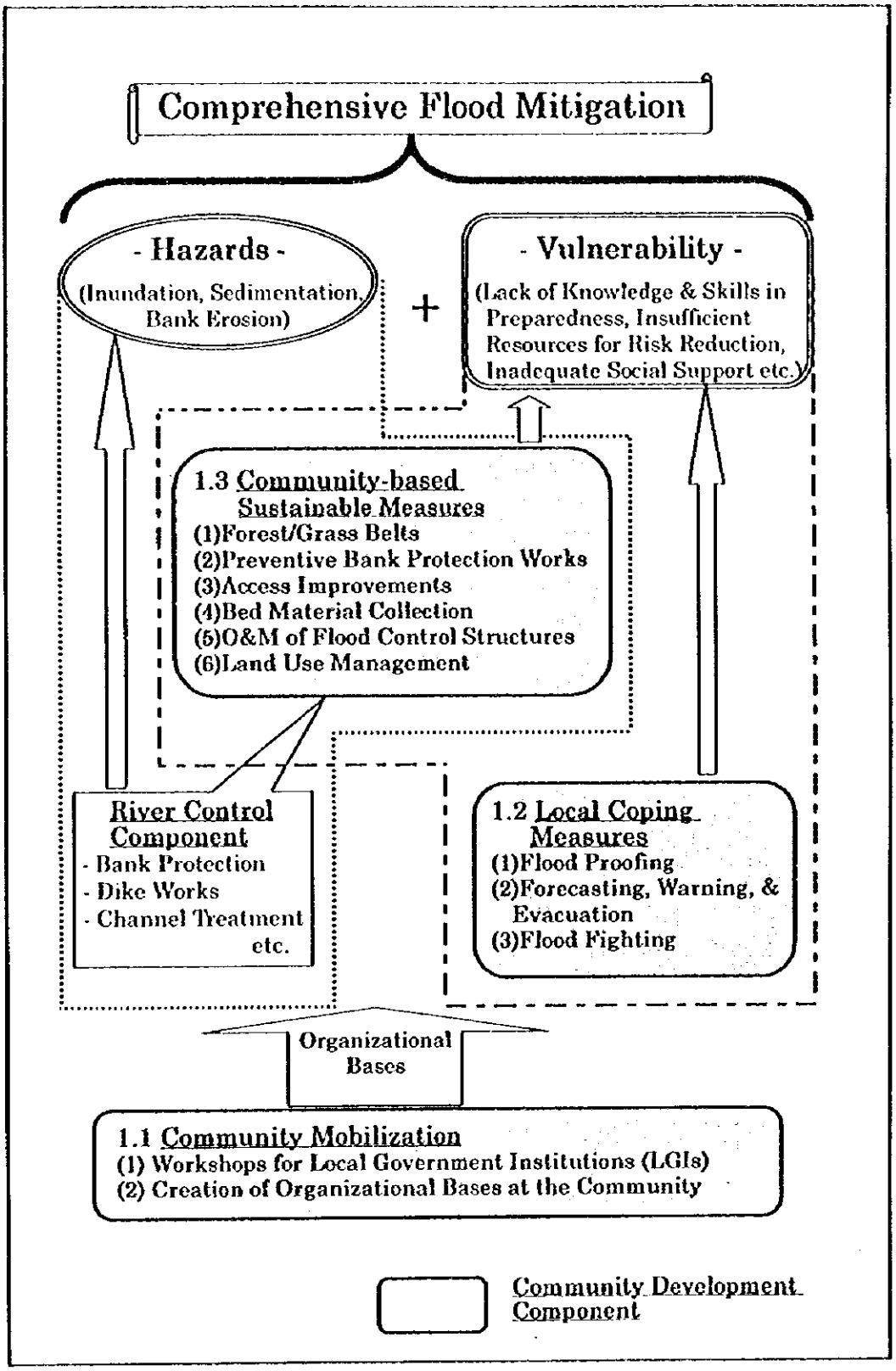

COMPREHENSIVE FLOOD MITIGATION

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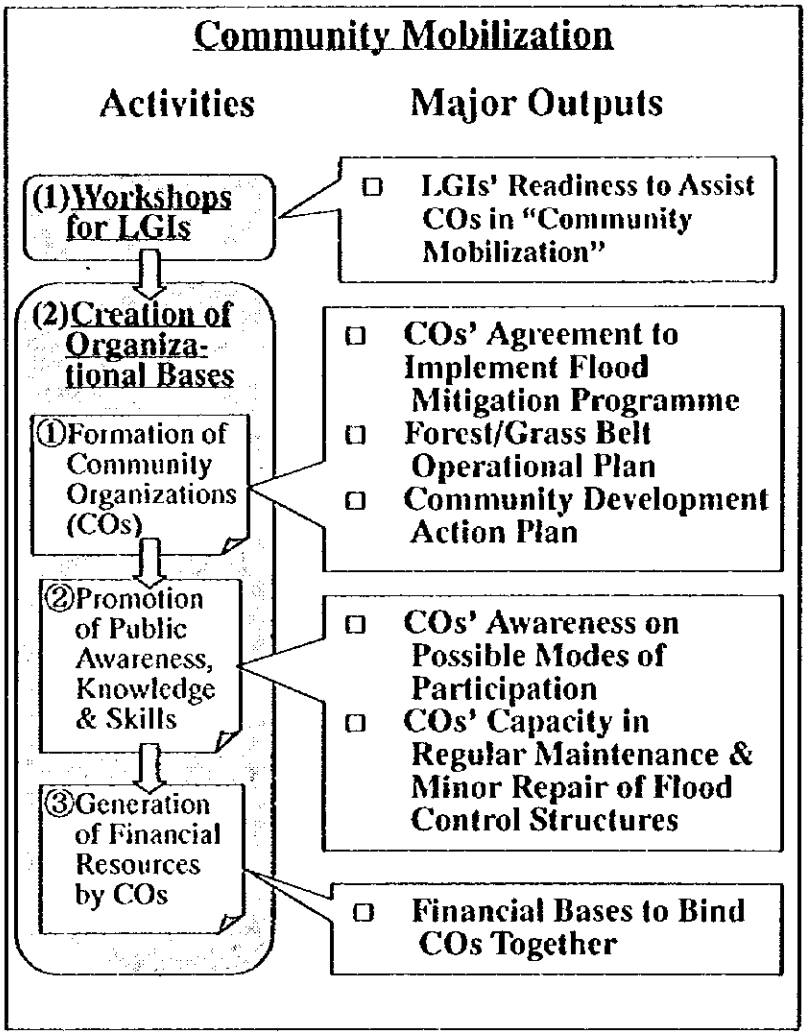

COMMUNITY MOBILIZATION

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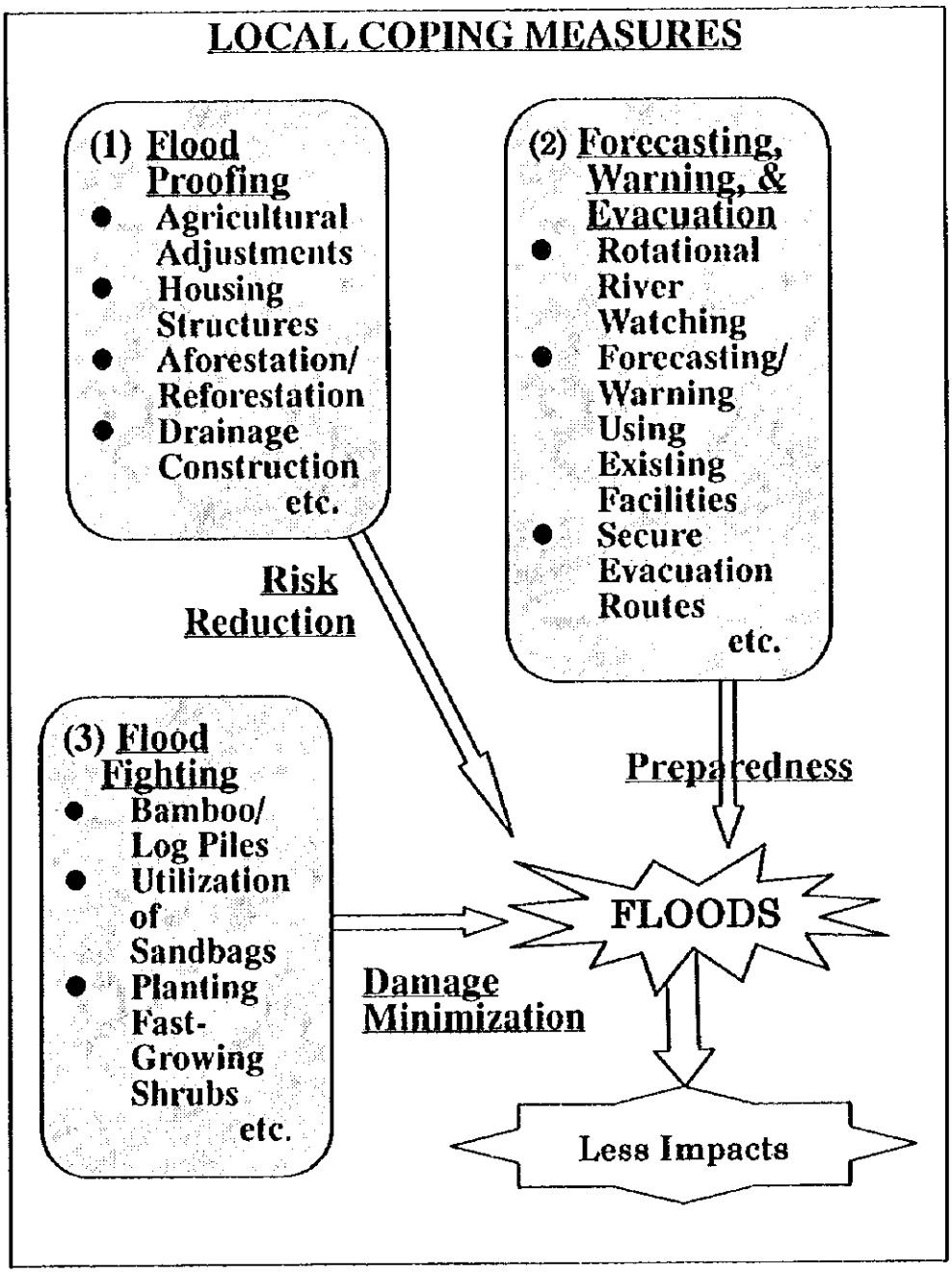

LOCAL COPING MEASURES

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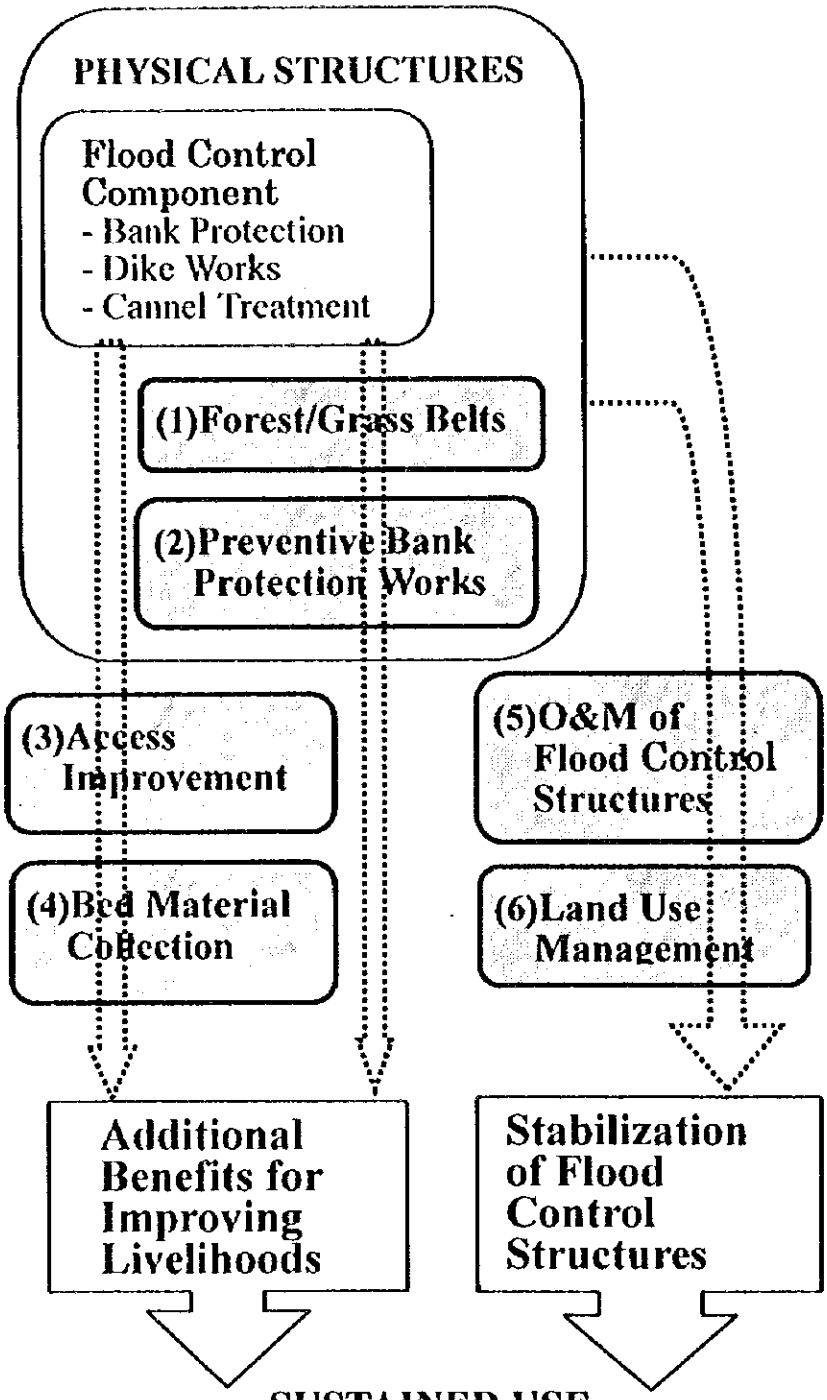
Community-based Sustainable Measures



COMMUNITY-BASED SUSTAINABLE MEASURES

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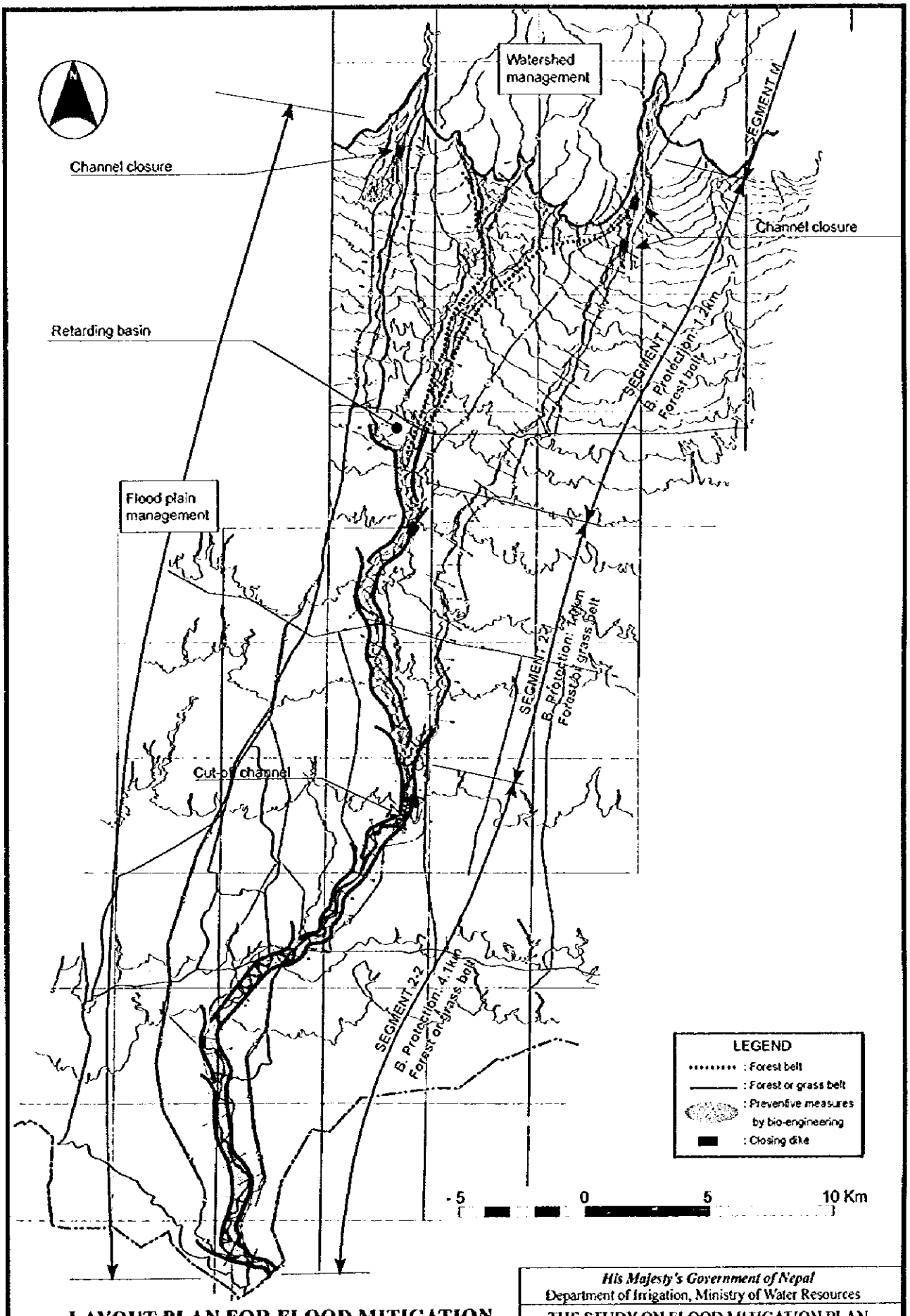
Fig. A2.9



LAYOUT PLAN FOR FLOOD MITIGATION (LOHANDRA RIVER)

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Department of Irrigation, Ministry of Water Resources

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JAPAN INTERNATIONAL COOPERATION AGENCY

3. ACTION PROGRAM TOWARD TARGET YEAR

3.1 Sequence of Works

The Master Plan is proposed for the implementation by the target year of 2017. The project works must be carried out effectively in orderly manner toward the target year. It is also important to realize the flood mitigation effects, in the course of implementation, corresponding to the progress of work. In view of the above, consideration was given to the sequence of work as presented below.

(1) Preparatory Works

1) **Feasibility Study:** A Feasibility Study will be conducted immediately, mainly covering the following:
   (a) **River Survey:** To obtain topographic maps along the river with smaller contour intervals, longitudinal river profiles and cross sections.
   (b) **Restudy of Master Plan:** Based on the river survey result, the Master Plan proposed at the present stage should be subject to in-depth study.
   (c) **Feasibility Study:** The study will cover discrete environmental studies as well, in order to obtain approval for project implementation from MOPE.
2) **Fund Arrangement:** The project cost estimated in the Feasibility Study is allocated between the central and local governments, and local communities, taking into consideration the nature of work and the capability of funding.
3) **Definite Plan/Detail Design:** A definite plan of the flood mitigation works, including the river boundary line (RBL), will be drawn up after getting consent of the central and local government agencies and local communities concerned. A detailed design will be prepared of the project facilities.
4) **Preservation of Lands:** Population in the Terai is growing rapidly. Because of this, more and more people live in the flood prone areas close to the rivers. Therefore, it is essential to preserve the lands for flood mitigation facilities, and 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) **Research and Investigation:** In parallel with implementation of the specific flood mitigation projects, research and investigation activities are needed to support the projects. Among these following are included, but not limited to:
   (a) **Hydrological Study for Class-III Rivers:** Flood runoff and sediment

yield to be studied and analyzed especially for class III rivers originating at Siwalik hills. Observations on a designated model basin would serve this purpose.

(b) **Investigation of Bank Erosion Characteristics:** Characteristics of bank erosion in the Terai have yet to be investigated. Mechanisms of bank erosion, erosion speed/width, etc. should be investigated in relation with the river segment, riverbed and bank materials, river flow condition, etc.

(c) **Development of Bank Protection Works:** Various types of bank protection works should be introduced in each of the river segment, hared on effectiveness, materials available and cost-performance. Recommended bank protection work for rivers in the Terai should be made through hydraulic model tests in the laboratory and prototype models in field.

(d) **Research on Application of Bio-engineering Technology:** In order to introduce bio-engineering technology as a component of flood mitigation, research works and accumulation of experience are necessary, mainly for the selection of plant species, type and function of work applicable, cultivation techniques, and contribution to income generation.

(2) Coordination For Flood Mitigation

Coordination to mobilize watershed management and flood plain management should be taken as soon as possible in combination with the community development activities.

(3) River Works

1) **Channel Treatment Works:**

(a) **Tributary Works:** Tributary work to stop inflow/outflow from/to adjacent river basins will be implemented soon after the preparation of the definite plan.

(b) **Branch/Anabranch Work:** Closing works of branches and anabranches, with diversion structure if necessary, will be carried out soon after the preparation of definite plan.

(c) **Channel Connection Works:** Unification and normalization by connecting tributaries and drainage can be executed at any time before dike work commences.

2) **Bank Protection Works:**

(a) **Spur/Revetment Work:** Riverbank classified as Type-As bank needs protection works immediately and works are desirable for Type-A bank as well. The bank protection works will be executed continuously, primarily for Type-As banks identified by the periodic monitoring after every flood seasons.

(b) **Preventive Bank Protection Measures:** Preventive bank erosion measures by bioengineering is required immediately for Type-A bank and are desirable for all the river bank between river course and boundary line of river zone.

3) **Dike Works:**

(a) **Forest and Grass Belts:** Forest belt will be formed inside of the river boundary line (RBL) in Segment 1 (alluvial fan) and grass belt in Segments 2-1 and 2-2 (natural levee zone). The work can be carried out at any time and any place, but for the purpose of marking the RBL it is best to do it quickly.

(b) **Local Dike and Dike Road:** The local dike and the dike road will be constructed inside along the RBL to protect the land locally and serves as rural road as well. These works should be started soon from the places where possible so as to realize the flood mitigation.

(c) **Ring Dike:** Ring dike work will be executed at the critical site.

(d) **Retarding Basin:** It is important to preserve the lands for the retarding basin, confining by forest belt, grass belt or earth dike.

4) **Channel Excavation and COC Works:**

(a) **Channel Excavation:** Channel excavation will be executed for channel normalization in extremely narrow sections.

(b) **Bed Material Collection:** Bed materials can be collected for construction materials soon after the preparation of definite plan according to a regulation to be prepared for bed material exploitation.

3.2 Action Plan

Implementation of the Master Plan project is programmed, in principle, by the phases of the national development plan from the ninth through twelfth plans as follows:

1) **1st Phase (Ninth plan: 1997-2002):**
   (a) Preparatory works such as feasibility study, fund arrangement, definite plan/detail design, preservation of lands will be performed.
   (b) Research and investigation, and coordination for watershed management and flood plain management will be started in combination with community development activities.
   (c) Bank protection and ring dike works will be executed at the critical sites.
   (d) Preventive bank protection works by bioengineering, and bed material collection are also started in this phase.

2) **2nd Phase (Tenth plan: 2002-2007):**
   (a) Channel treatment works which are the key to stabilize the river system will be executed.
   (b) Forest belt will start for its work in field. Grass belt will be completed for Segment 2-1 and 2-2.
   (c) Local dikes and dike roads will be constructed where they are required.

3) **3rd Phase (Eleventh and twelfth plan: 2007-2017):**
   (a) All the works and activities targeted for the Master Plan will be completed.

General Action plan for the implementation of the Master Plan project is shown in Fig. A3.1.

3.3 Implementation Arrangements

(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.A3.2, 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:

1) **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).

2) 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.

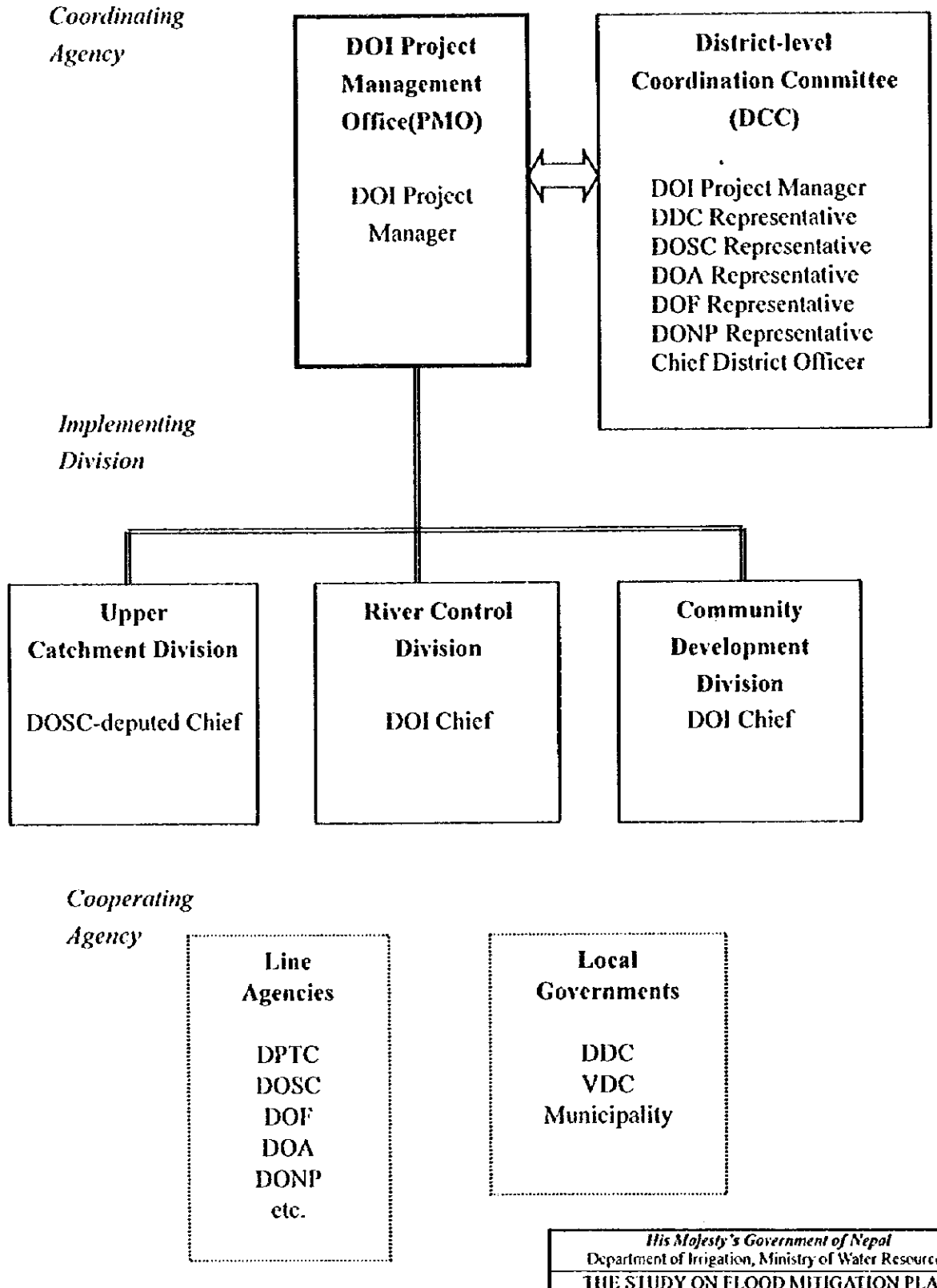
In view of upgrading the LGIs' capabilities to undertake these crucial roles for "community development", a series of training workshops will be undertaken at the inception of "community development" activities, as mentioned in the section on "Community Development" component/

ACTION PROGRAM TOWARD TARGET YEAR

River: LOHANDRA RIVER

Activities	Phasing			
Master Plan	1st.	2nd.	3rd.	
National Plan (year)	9th (1997-2002)	10th (2002-2007)	11th (2007-2012)	12th (2012-2017)
(1) Preparatory Works				
1) Feasibility study:				
·River survey				
·Restudy of master plan				
·Feasibility study				
·Environmental study				
2) Fund arrangement				
3) Definite plan/ detail design				
4) Preservation of lands				
5) Rsearch/ investigation				
(2) Coordination for Flood Mitigation				
1) Community development				
2) Watershed management				
3) Flood Plain Management				
(3) River Works in Segment-1				
Channel treatment works:				
·Tributary works				
·Branch/ anabranch works				
Bank protection works:				
· Spur/ revetment				
· Preventive bank protection measurs (by bio-engineering)				
Dike works:				
· Forest belt				
· Ring dike				
Channel excavation works:				
· Bed material exploitation				
Retarding basin				
(4) River Works in Segment-2				
Channel treatment works:				
·Tributary works				
·Branch/ anabranch works				
Bank protection works:				
· Spur/ revetment				
· Preventive bank protection measurs (by bio-engineering)				
Dike works:				
· Grass belt				
· Low dike road w/ drainage sluice				
· Continuous dike w/ drainage sluice				
· Ring dike				
Channel excavation works:				
· Bed material exploitation				
· Widening channel				
Cut-off channel works				
Retarding basin				

IMPLEMENTATION ARRANGEMENT FOR FLOOD MITIGATION IN TERAI



His Majesty's Government of Nepal Department of Irrigation, Ministry of Water Resources
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL
JAPAN INTERNATIONAL COOPERATION AGENCY

4. EVALUATION

4.1 Economic Evaluation

(1) Basin Overview

The Lohandra river flows through rural areas of Morang district. Of the eight rivers in the plan, the Lohandra river basin contains the most industrial establishments. Although about 80% of lands 27,900 ha are in agriculture, the large number (19) of manufacturing establishments exist in flood-prone villages along the Lohandra river (11-rice mill, 2-oil/flour mill, 2-carpert/cloth, 1-biscuit, 1-timber, 1-leather, 1-plastic). There also exist numerous agro-based micro-industries which serves the demands of the surrounding towns. The Master Plan implementation will lessen the impacts of floods on these outlying areas of this industrial district.

Just like the Ratuwa basin, paddy production occupies the largest area of agricultural land (with the estimated 1996/97 production of 46,900 metric tons in the whole plain areas), followed by maize (5,100 metric tons) and wheat (6,100 metric tons). Based on the retail value of 96/97 in Morang district, paddy production amounted to Rs.681 million, and maize production was worth about Rs.48 million.

(2) Effects of Flood Mitigation

Implementation of the flood mitigation Master Plan will primarily safeguard the land and properties in the flood prone areas and also bring about other favorable effects to the Study Area. The potential benefits and effects expected to accrue from the Master Plan, including tangible and intangible ones, are listed below.

1) **Reduction of damage due to flood and sediment:** Inundation and sedimentation will be alleviated and reduce damages of village houses, crop production, public facilities, etc.
2) **Protection of riverbank from erosion:** Loss of lands due to riverbank erosion are averted, and villages and farmlands will be protected.
3) **Indirect effects:** Owing to the reduction in damages in flood prone area, social and economic activities in the surrounding areas will not be interfered.
4) **Land enhancement:** Flood mitigation project ensures the social and economic activities in the flood prone area which enable further investments for the development of the flood prone area and the surrounding areas.

5) **Land reclamation:** Existing low-lying barren lands along the river turn to arable ones. Channel excavation and normalization at severely meandering section may create lands for agriculture and settlement.
6) **Flood-free embankment:** The earth embankment constructed as local dike and ring dike can be used as rural roads and flood-free areas in the flood prone area. The area will also serve for evacuation and flood fighting activities.
7) **Income generation:** The forest belt and grass belt for flood mitigation will generate community's income. The trees from the forest belt could be used for flood mitigation as well.
8) **Stabilization of residents' livelihood:** Flood free land is the basis of the residents' livelihood in the flood prone areas. Only under such conditions, residents are encouraged to accumulate their immovable and other properties, and accordingly can stabilize their livelihood.
9) **Community development:** The Master Plan places emphasis on flood mitigation through community development. The community-based approaches will forge links among the resident people and may enable other community development activities.

(3) Preliminary Economic Evaluation for Master Plan Projects

Economic viability of the flood mitigation Master Plan was examined preliminarily. Out of the various effects listed in the previous section, (a) flood damage reduction benefit, (b) bank protection benefit, and (c) indirect benefit were considered as tangible benefit for the evaluation.

Flood Damage Reduction Benefit: Flood damage study by hydraulic analysis is difficult at this stage, since the river section data are not available and available topographic and hydrological data are limited. The flood damage reduction benefit was estimated preliminarily based on the damage data of recent large flood.

Bank Protection Benefit: Benefit accruing from bank protection works was estimated as a product of the land area to be protected from erosion and the amount of property on the unit land area to be protected.

Conditions for Economic Evaluation: Evaluation was made for the existing basin conditions and future basin conditions in target year (2017). The benefit in the target year was assumed in proportional to the population projected. Cash flows of the project

cost, maintenance cost and benefit are shown in Table A4.1. With these cash flows, the economic internal rate of return (EIRR), cost-benefit ratio (B/C) and net present value (NPV, or B-C) were worked out. The results are summarized below, though these should be restudied in future based river survey data.

River	Existing basin			Future basin		
	EIRR (%)	B/C	NPV (10^6Rs)	EIRR (%)	B/C	NPV (10^6Rs)
Lohandra	0.0	0.22	-189.9	2.8	0.35	-158.5

Note *: B/C and NPV were calculated under the discount rate of 12%.

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

4.2 Environmental Screening

(1) Environmental Screening at Master Plan Study Stage

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 Lohandra 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 belts). Occasionally, riverbanks will be banks 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 are shown in Tables A4.2 through A4.4 for social environment assessment, natural environment assessment and pollution assessment, respectively.

(3) Overall Evaluation

The flood mitigation interventions on the Lohandra 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.

(4) Environmental Study in Future

According to the new Environmental Conservation Rules (ECR) issued in June 1997, if

a watershed management plan for the upland areas (Segment M) is included as part of the flood prevention measures, then an Initial Environmental Evaluation (IEE) is required at the planning stage. If any of the planned interventions, such as riverbank protection, are more than 1 km. in length, then an IEE is needed at the project proposal stage. Similarly, if tree planting is planned then an IEE or an Environmental Impact Assessment (EIA) may be necessary at the project proposal stage. The determining factor is whether the proposed planting is in a continuous block of a single indigenous species of more than 25 hectares, or for a single exotic species, is in a continuous block of more than 5 ha.

There are many houses and some fields within the proposed RBL. A survey should be undertaken along the whole stretch of the river system, within the Terai, to determine the number of houses falling between the proposed new RBL and the ownership and land use of the land between the boundaries. Some of these houses may have to be relocated and others protected by a ring dyke. Depending upon the number of houses to be relocated, either an IEE or an EIA will have to be undertaken at the project proposal stage. This survey should record possible relocation sites by location and area as well as degraded land that could be rehabilitated. At the same time, a note could be made of any religious, historic or archeological sites or building along or near the river. If there are any, then measures must be taken to protect them.

The agreement on the interventions of the people living along the river is not only necessary, but also critical to the success of the plan. This is why it is important 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 dike work and bioengineering measures, may not be implemented. If so, lasting flood prevention will be impossible to achieve.

Several bank protection measures are proposed along the river. If these are over 1 km. in length, an IEE will be necessary along these river stretches at the project proposal stage. Similarly, there may be ring dike protection work, of more than 1 km. in circumference, round some groups of houses. If so, an IEE is necessary.

According to the Inventory of Wetlands in the Terai, (IUCN 1996), there are no registered wetland along the Lohandra river. Thus no EIA's are necessary in this area.

4.3 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.

4.4 Conclusion and Recommendation

1) Implementation of the Master Plan will bring about various tangible and intangible benefits, to the communities in the Study Area. The project works can be implemented from those of higher cost-performance, keeping pace with basin's development.
2) 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) 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) The proposed Master Plan is economically and technically sound and exerts little adverse effect to the environment. Immediate implementation of the Feasibility Study is recommended in order to promote and support people's livelihood and the sound development of the Terai plain.

COST BENEFIT FLOW FOR MASTER PLAN

(Existing Basin)

River: Lohadra

(Unit: NRs. 1,000)

Year	Economic cost/benefit				Discounted (10%)	
	Project cost	Maintenance cost	Total cost	Benefit	(C) Cost	(B) Benefit
1 1999	9,319	0	9,319	0	9,319	0
2 2000	9,319	0	9,319	0	8,472	0
3 2001	18,101	0	18,104	0	14,962	0
4 2002	45,173	0	45,173	0	33,939	0
5 2003	45,173	241	45,414	1,478	31,018	1,010
6 2004	45,173	482	45,655	2,957	28,348	1,836
7 2005	32,516	723	33,239	4,435	18,762	2,503
8 2006	32,516	896	33,412	5,499	17,146	2,822
9 2007	32,516	1,070	33,586	6,563	15,668	3,062
10 2008	32,516	1,243	33,759	7,627	14,317	3,235
11 2009	32,516	1,417	33,933	8,691	13,083	3,351
12 2010	32,516	1,590	34,106	9,756	11,954	3,419
13 2011	32,516	1,764	34,280	10,820	10,923	3,447
14 2012	32,516	1,937	34,453	11,884	9,980	3,442
15 2013	32,516	2,111	34,627	12,948	9,118	3,410
16 2014	32,516	2,284	34,800	14,012	8,331	3,354
17 2015	32,516	2,457	34,973	15,076	7,611	3,281
18 2016	32,516	2,631	35,147	16,140	6,954	3,193
19 2017	23,732	2,804	26,536	17,204	4,773	3,094
20 2018		2,931	2,931	17,981	479	2,940
21 2019		2,931	2,931	17,981	436	2,673
22 2020		2,931	2,931	17,981	396	2,430
23 2021		2,931	2,931	17,981	360	2,209
24 2022		2,931	2,931	17,981	327	2,008
25 2023		2,931	2,931	17,981	298	1,826
26 2024		2,931	2,931	17,981	271	1,660
27 2025		2,931	2,931	17,981	246	1,509
28 2026		2,931	2,931	17,981	224	1,372
29 2027		2,931	2,931	17,981	203	1,247
30 2028		2,931	2,931	17,981	185	1,134
31 2029		2,931	2,931	17,981	168	1,030
32 2030		2,931	2,931	17,981	153	937
33 2031		2,931	2,931	17,981	139	852
34 2032		2,931	2,931	17,981	126	774
35 2033		2,931	2,931	17,981	115	704
36 2034		2,931	2,931	17,981	104	640
37 2035		2,931	2,931	17,981	95	582
38 2036		2,931	2,931	17,981	86	529
39 2037		2,931	2,931	17,981	78	481
40 2038		2,931	2,931	17,981	71	437
41 2039		2,931	2,931	17,981	65	397
42 2040		2,931	2,931	17,981	59	361
43 2041		2,931	2,931	17,981	54	328
44 2042		2,931	2,931	17,981	49	298
45 2043		2,931	2,931	17,981	44	271
46 2044		2,931	2,931	17,981	40	247
47 2045		2,931	2,931	17,981	37	224
48 2046		2,931	2,931	17,981	33	204
49 2047		2,931	2,931	17,981	30	185
50 2048		2,931	2,931	17,981	27	168
Total	586,185	114,509	700,694	702,502	279,675	75,115

EIRR: 0.0%

B/C: 0.27

NPV(B-C): -204,559 (NRs.1,000)

COST BENEFIT FLOW FOR MASTER PLAN

(Future Basin)

River: Lohadra

(Unit: NRs. 1,000)

Year	Economic cost/benefit				Discounted (10%)	
	Project cost	Maintenance cost	Total cost	Benefit	(C) Cost	(B) Benefit
1 1999	9,319	0	9,319	0	9,319	0
2 2000	9,319	0	9,319	0	8,472	0
3 2001	18,101	0	18,101	0	14,962	0
4 2002	45,173	0	45,173	0	33,939	0
5 2003	45,173	241	45,414	2,321	31,018	1,585
6 2004	45,173	482	45,655	4,642	28,348	2,882
7 2005	32,516	723	33,239	6,963	18,762	3,930
8 2006	32,516	896	33,412	8,634	17,146	4,430
9 2007	32,516	1,070	33,586	10,301	15,668	4,807
10 2008	32,516	1,243	33,759	11,975	14,317	5,079
11 2009	32,516	1,417	33,933	13,646	13,083	5,261
12 2010	32,516	1,590	34,106	15,316	11,954	5,368
13 2011	32,516	1,764	34,280	16,987	10,923	5,413
14 2012	32,516	1,937	34,453	18,658	9,980	5,404
15 2013	32,516	2,111	34,627	20,328	9,118	5,353
16 2014	32,516	2,284	34,800	21,999	8,331	5,266
17 2015	32,516	2,457	34,973	23,670	7,611	5,151
18 2016	32,516	2,631	35,147	25,340	6,954	5,013
19 2017	23,732	2,804	26,536	27,011	4,773	4,858
20 2018		2,931	2,931	28,230	479	4,616
21 2019		2,931	2,931	28,230	436	4,196
22 2020		2,931	2,931	28,230	396	3,815
23 2021		2,931	2,931	28,230	360	3,468
24 2022		2,931	2,931	28,230	327	3,153
25 2023		2,931	2,931	28,230	298	2,866
26 2024		2,931	2,931	28,230	271	2,606
27 2025		2,931	2,931	28,230	246	2,369
28 2026		2,931	2,931	28,230	224	2,153
29 2027		2,931	2,931	28,230	203	1,958
30 2028		2,931	2,931	28,230	185	1,780
31 2029		2,931	2,931	28,230	168	1,618
32 2030		2,931	2,931	28,230	153	1,471
33 2031		2,931	2,931	28,230	139	1,337
34 2032		2,931	2,931	28,230	126	1,215
35 2033		2,931	2,931	28,230	115	1,105
36 2034		2,931	2,931	28,230	104	1,005
37 2035		2,931	2,931	28,230	95	913
38 2036		2,931	2,931	28,230	86	830
39 2037		2,931	2,931	28,230	78	755
40 2038		2,931	2,931	28,230	71	686
41 2039		2,931	2,931	28,230	65	624
42 2040		2,931	2,931	28,230	59	567
43 2041		2,931	2,931	28,230	54	515
44 2042		2,931	2,931	28,230	49	469
45 2043		2,931	2,931	28,230	44	426
46 2044		2,931	2,931	28,230	40	387
47 2045		2,931	2,931	28,230	37	352
48 2046		2,931	2,931	28,230	33	320
49 2047		2,931	2,931	28,230	30	291
50 2048		2,931	2,931	28,230	27	265
Total	586,185	114,509	700,691	1,102,928	279,675	117,931

EIRR: 2.8%

B/C: 0.42

NPV(B-C): -161,743 (NRs.1,000)

SOCIAL ENVIRONMENT ASSESSMENT: LOHANDRA 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: LOHANDRA 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: LOHANDRA 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