Japan International Cooperation Agency (JICA)
His Majesty's Government of Nepal

No. 2

The Development Study on Integrated Watershed Management in the Western Hills of Nepal

GUIDELINES FOR FORMULATION OF INTEGRATED WATERSHED MANAGEMENT PLAN

January, 1998

Japan Forest Technical Association (JAFTA)
Kokusai Kogyo Co., Ltd.

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Introduction

(1) Concept of the Guidelines

The slopes of the western hills of Nepal have been almost fully developed to obtain food, firewood and fodder trees to meet the increasing demand, reflecting the population increase in the area. Forests are mainly observed on north-facing slopes. The difficulty of earning enough cash locally has compelled young people to seek employment outside the area, resulting in the inadequate maintenance of farmland. The poorly maintained farmland faces erosion during the monsoon season with heavy rainfall over a short period of time, further degrading the watersheds.

In order to combat the situation, His Majesty's Government of Nepal has prepared and is implementing the Soil Conservation and Watershed Management Programmes as part of the Master Plan for the Forestry Sector (MPFS). In the western hills, HMG and JICA have been implementing the Development Study on Integrated Watershed Management since November, 1995 and the Management Plan has been prepared for the five Model Areas established in the Study Area. The present Guidelines outline the formulation processes and contents of integrated watershed management planning for the Study Area located in the Western hills of Nepal based on the actual processes used to formulate the above-mentioned Integrated Watershed Management Plan for the Model Areas.

(2) Notes for Using the Guidelines

① The Study Area is some 120,000 ha established by HMG and JICA in the western hills of Nepal.

② Prior to application of the Guidelines to other areas, the numerical values, etc. used in the Guidelines must be reviewed (for example, the rating values used for hazard prediction).

③ As the Guidelines are designed to assist the formulation of an integrated watershed management plan as a master plan, it will be necessary to prepare an implementation plan based on the findings of detailed field surveys prior to the implementation of an actual project.

④ It is assumed that the Guidelines will be used by staff members of the Department of Soil Conservation. .

⑤ The Guidelines must be used in conjunction with the various guidelines and manuals, etc. prepared by the Department of Soil Conservation.

⑥ The scope of a plan or project is assumed to be within the jurisdiction of the Department of Soil Conservation and to be implemented with the participation of local people. A different set of guidelines will be required to deal with much larger plans or projects at the national level.

⑦ Careful examination is particularly required in regard to the size and number of samples, etc. of socioeconomic baseline surveys.

⑧ As plan implementation with the participation of local people is intended, proper liaison and coordination among the related administrative organizations as well as related people is essential.

⑨ These Guidelines have been formulated based on the reports for the Development Study on Integrated Watershed Management in the Western Hills of Nepal. Refer to the development study reports for details of the questionnaire and planning contents for the Model Areas, etc. referred to in various parts of the Guidelines.

(3) Main References Used in Preparing the Guidelines

1) Basic Guidelines for Semi Detailed Watershed Planning, Planning Section, Watershed Management Project, 1987

2) Basic Guidelines for Sub Watershed Management Planning, B.D.Shrestha, 1994

3) Forest Act 2049 (1993) and Forest Regulation 2051 (1995), HMGN/USAID

4) Guidelines for Phewa Lake Conservation: National Conservation Strategy Implementation Project, 1995 HMG/IUCN

5) Guidelines and Methodology for Sub-Watershed Prioritization in Watershed Management Planning, DOSC, 1997

6) Guidelines for People's Participation in Soil Conservation, DOSC, 1993

7) Manual on Watershed Management, Project Planning, Monitoring and Evaluation, ASEAN-SU Watershed Project, 1990

8) Master Plan for the Forestry Sector Nepal (MPFS) MPFSP of HMGN / ADB / FINNIDA, 1988

① Main report
② Forestry Sector Policy
③ Forest Resources Information Status and Development Plan
④ Soil Conservation and Watershed Management Plan
⑤ Revised Executive Summary, 1989

9) Operational Guideline for Community Forestry Development Programme (2051), Department of Forests, Community and Private Forestry Division, 1995

10) Report on Geological Survey, JICA Study Team / Mountain Risk Engineering Unit, Tribhuvan University, 1996

11) Sub Watershed Management Planning Manual, Watershed Planning Section, 1995

12) Soil Survey Report of Kaski and Parbat District, Forestry and Consercvation Technology Services (P.) Ltd./JICA Study Team, 1996

13) Watershed Planning Manual No. 4 (Land Capability Classification) Keshar Man Sthapit, 1987

Flow of Integrated Watershed Management Plan

The preparation of an integrated watershed management plan should follow the flow described below.

① Preparation Stage

Selection of the subject area of the plan, obtaining of topographical maps, etc. and selection of the survey items

② Inspection Stage

Understanding of the current conditions and problems in accordance with the survey items

③ Planning Stage

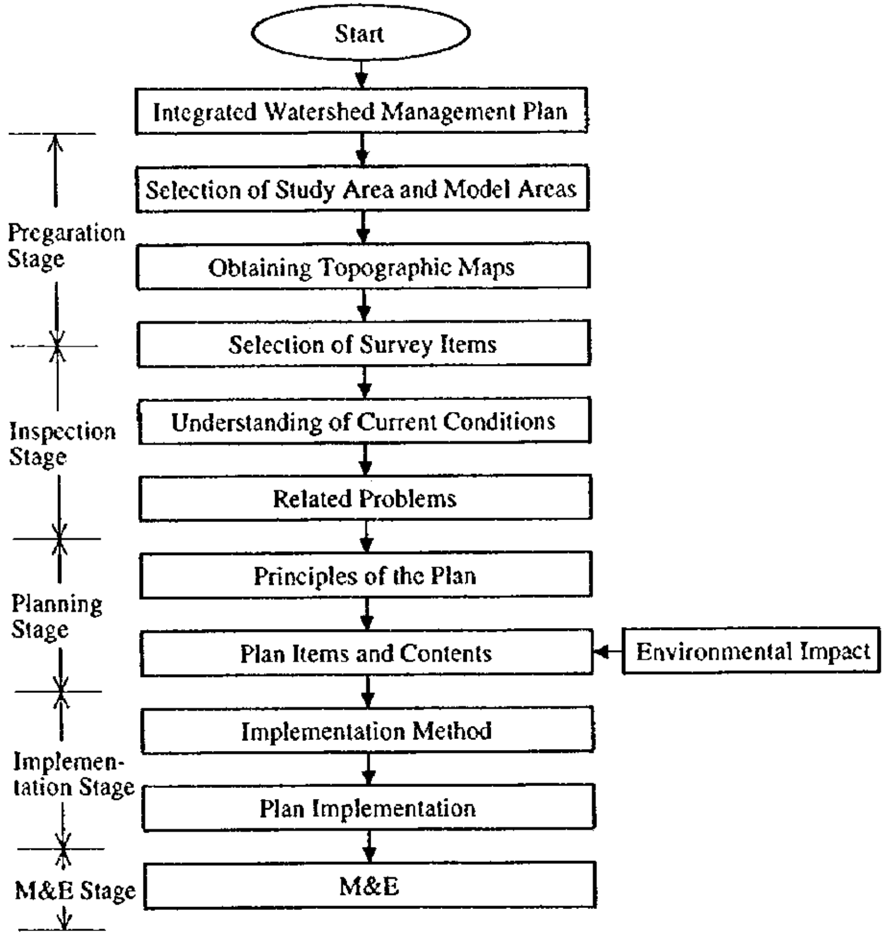
Planning principles, plan contents and implementation method

④ Implementation Stage

Implementation of the plan in accordance with the plan implementation method

⑤ Monitoring and Evaluation Stage

Monitoring and evaluation of the implementation results of the plan



Flow of Integrated Watershed Management Plan Preparation

Integrated Watershed Management Plan

Here, the background and significance of watershed management are clarified to facilitate a general understanding of integrated watershed management.

(1) Background

The national land and natural resources of Nepal play an important role in preserving the ecological balance, natural environment and genetic resources. However, severe devastation of the national land and environmental impoverishment have been continuing for some time due to the following reasons.

① Large-scale felling of forests, shifting cultivation, excessive grazing and concentrated farming on slopes, etc.
② Poverty resulting from the combination of a lack of environmental awareness due to a lack of education, a lack of knowledge of how to proceed with soil conservation and other factors
③ Insufficient environmental care, including the lack of implementation of effective measures to alleviate environmental deterioration, lack of infrastructure and uneven distribution of the population and resources, in the planning and plan implementation processes

The Department of Soil Conservation has been implementing wide ranging measures, including those designed to promote soil conservation and to control erosion as a part of watershed management, extension education for local people and measures to improve the earnings of local people, in order to alleviate land degradation, to maintain land productivity and to improve the environment.

These activities have been run with the participation of local people from the planning stage to the implementation stage as soil conservation projects with the coordination of the Department of Soil Conservation.

(2) Integrated Watershed Management Plan

An integrated watershed management plan is formulated to prepare integrated measures and programmes in order to identify the problems in a watershed, set targets to be achieved, meet the needs of local people and create a bright future.

Selection of Plan Area

The selection of the plan area is a fundamental item in the process of preparing an integrated watershed management plan. Firstly, the location of the target area should be determined, followed by a decision on the location of the site(s) for which the plan is to be prepared within the study area through consultations with DDC and related organizations using topographical maps and other reference materials. It is desirable that a plan area consist of an administrative unit from the viewpoint of ensuring smooth plan implementation.

(1) Main Watersheds in Nepal

Main watersheds of Nepal are as shown in Fig. 1.

(a) Kosi Watershed

(b) Narayani Watershed

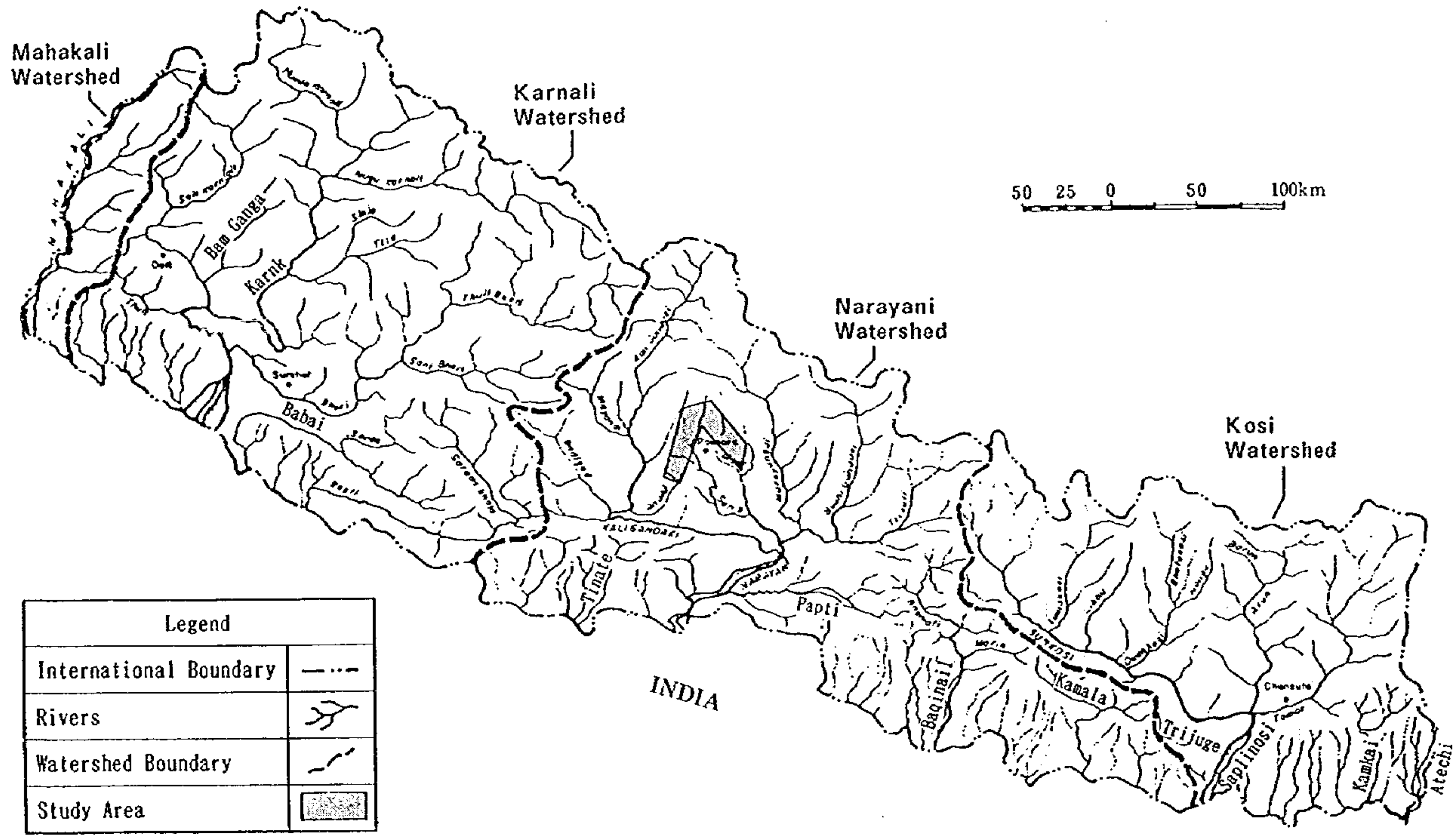
(c) Karnali Watershed

(d) Mahakali Watershed

a. An Example of Some Watersheds in Nepal

	NAME OF THE WATERSHED	AREA IN SQ KM
(a)	1. Saptakoshi	56,732
	2. Sapta Gandaki Watershed	33,381
	3. Karnali Watershed	42,708
	4. Mahakali Watershed	5,086
	5. Mechi Watershed	585
(b)	6. Kankai Watershed	1,256
	7. Trijaga Watershed	670
	8. Kamala Watershed	2,091
	9. Bagmati Watershed	3,744
	10. Tinau Watershed	491
	11. Ban Ganga Watershed	422
	12. Rapti Watershed	6,827
	13. Babai Watershed	2,569
(c)	14. Various Small Siwalik River Watersheds	20,829
Total		147,181

Source: Malla, unpablished report



Source: Modified from Forest Plants of Nepal by B.P. Shrestha

Fig. 1 Main Watersheds in Nepal

(2) Study Area

The Study Area of some 120,000 ha consists of the southern parts of Kaski District and Parbat District as shown in Fig. 2. Five Model Areas for which an integrated watershed management plan has been prepared are located inside the Study Area.

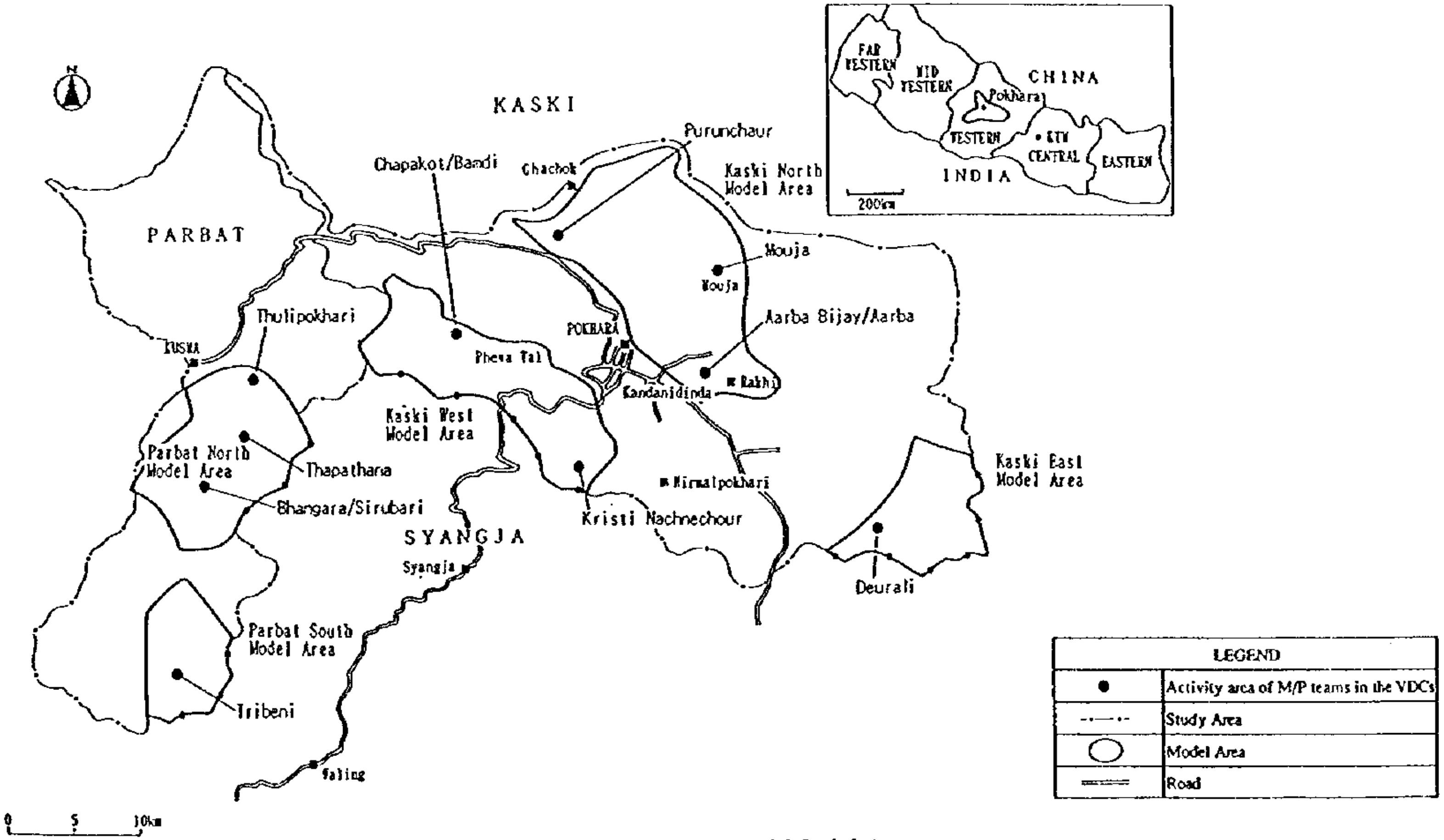


Fig. 2 Study Area and Model Areas

(3) Watershed Management PlanningUnit

① Watershed

A watershed is a topographically delineated area that is drained by a stream system, i.e. the total land area that is drained to some point on a stream or river (FAO Conservation Guide 13/6).

② Study area and watershed

The boundaries of the Study Area do not necessarily correspond to the natural watershed boundaries. From the view point of plan execution, Model Areas and the Study Area are established in administrative zones and follow VDC, etc. boundary lines.

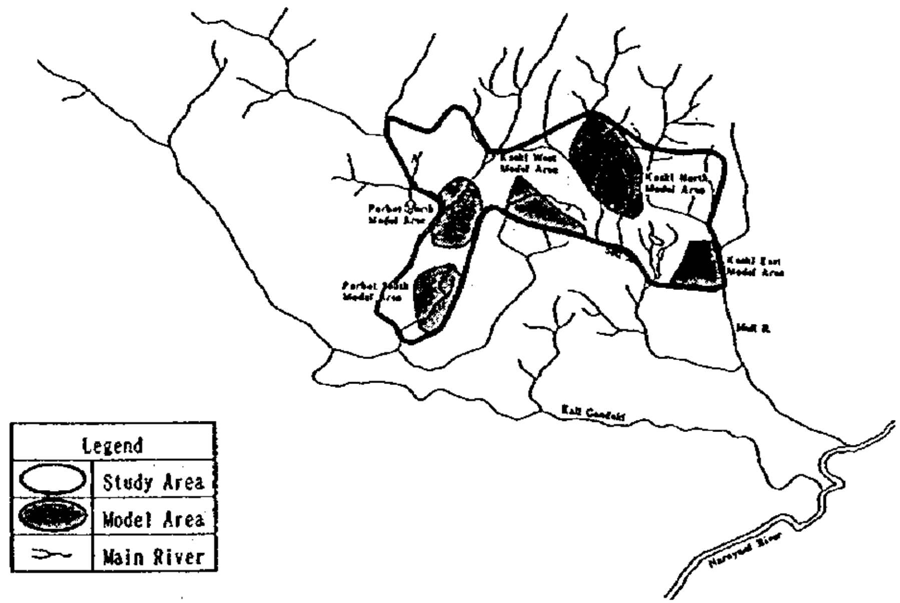


Fig. 3 Drainage Map of Study Area

Obtaining Topographic Maps, etc.

Preparations are made and necessary documents and topographical maps are collected for conducting field surveys. Some of the main documents are as follows.

① Topographic Maps
② Aerial photographs
③ Statistical Data

(1) Topographic Maps

The latest available topographic maps are obtained.

a. Topographical maps prepared by India (Scale 1/63,360) and enlarged to the Scale 1/50,000.

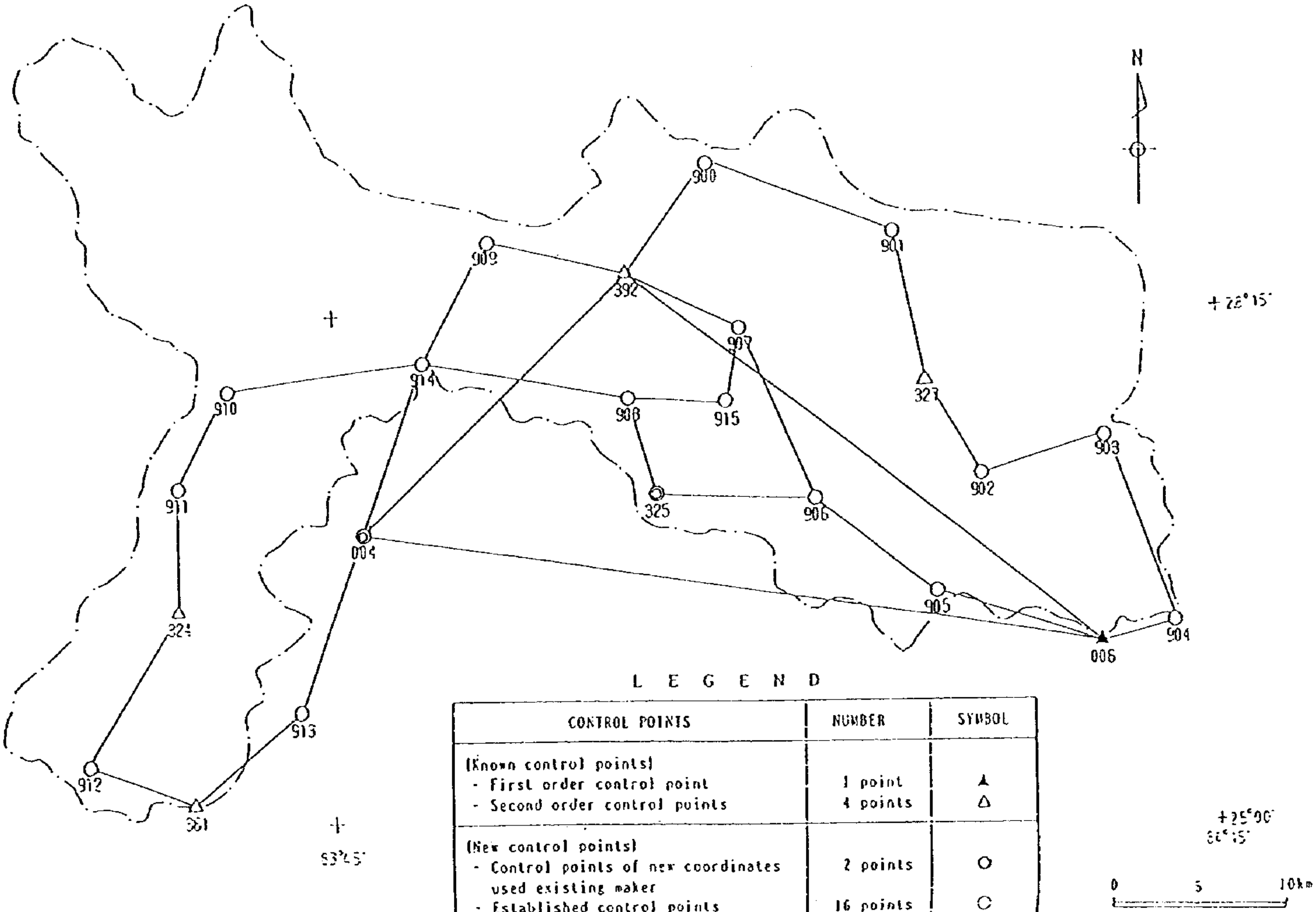
b. Maps prepared by LRMP.

c. Maps prepared by JICA at the Scale 1/25,000, using aerial photographs taken in 1996.

d. Others

Other latest available information and data.

Control points established for mapping in Model Areas are shown below. However, north-west Parbat is not covered, which necessitates supplementary surveys.



L E G E N D

CONTROL POINTS	NUMBER	SYMBOL
(Known control points)		
- First order control point	1 point	▲
- Second order control points	4 points	△
(New control points)		
- Control points of new coordinates used existing maker	2 points	◎
- Established control points	16 points	○

Fig. 4 Location Map of the Control Points

Table 1 Coordinate Result of the Control Points

Point	Latitude			Longitude			Northing (m)	Easting (m)	Ele. (m)
004**	28°	08'	41.13"	83°	45'	59.32"	3113,931.39	477,066.47	2,266.63
006**	28	05	01.41	84	11	14.01	3107,160.84	518,397.01	1,281.60
324*	28	06	30.87	83	39	25.44	3109,947.78	466,310.30	2,263.02
325**	28	09	38.26	83	56	01.03	3115,669.46	493,481.93	1,535.75
327*	28	12	46.66	84	05	18.70	3121,469.17	508,688.44	1,418.84
361*	28	00	50.76	83	39	56.81	3099,477.41	467,137.60	1,819.51
392*	28	16	14.38	83	55	04.31	3127,862.01	491,943.22	1,790.42
900	28	19	34.91	83	57	51.20	3134,031.91	496,492.28	1,201.10
901	28	17	20.37	84	04	17.04	3129,892.38	507,002.63	1,737.49
902	28	09	59.35	84	07	08.56	3116,322.37	511,688.59	756.16
903	28	11	06.50	84	11	30.22	3118,398.41	518,821.87	1,135.40
904	28	05	35.60	84	13	53.36	3108,220.73	522,744.57	385.73
905	28	06	34.32	84	05	32.87	3110,009.67	509,083.41	592.01
906	28	09	24.73	84	01	26.19	3115,251.37	502,351.05	719.82
907	28	14	32.89	83	58	57.89	3124,735.72	498,307.29	1,058.57
908	28	12	29.41	83	55	03.65	3120,937.92	491,920.48	1,364.72
909	28	17	19.82	83	50	09.78	3129,884.52	283,920.68	1,722.04
910	28	13	02.11	83	41	11.87	3121,981.55	469,245.76	847.09
911	28	10	11.74	83	39	23.77	3116,745.75	466,283.89	889.09
912	28	02	04.40	83	36	14.00	3101,762.09	461,059.50	1,004.08
913	28	03	28.19	83	43	49.90	3104,307.10	473,514.62	1,582.43
914	28	13	43.79	83	48	03.30	3123,240.67	480,464.02	2,490.57
915	28	12	17.05	83	58	28.42	3120,555.13	497,503.10	816.70

Note: * Known points to fixed coordinates of the existing control points.
** Control points of new coordinates due to the GPS observation on the existing maker.

(2) Aerial Photographs

The latest available aerial photographs are used.

a. Existing Photographs (those taken by India and others)

b. Aerial Photographs Taken by LRMP

   All Nepal (Northern and western regions at Scale 1/50,000)

c. Aerial Photographs Taken by JICA

   Index map is shown in Fig. 5. The total number of aerial photographs is 230.

   Ordinarily contact prints of the Scale 1/25,000 are used but the photographs could be enlarged 2.5 times to the Scale 1/10,000 for use in photo interpretation.

(3) Statistical Information

Data and information necessary for the study are collected.

a. Statistical Year Book of Nepal 1995: CBS HML

b. Population Monograph of Nepal 1995: CBS HML

c. Agricultural Statistics (Latest edition)

d. Data; Development Office in Parbat District

e. Data; Development Office in Kaski District

f. Other related documents

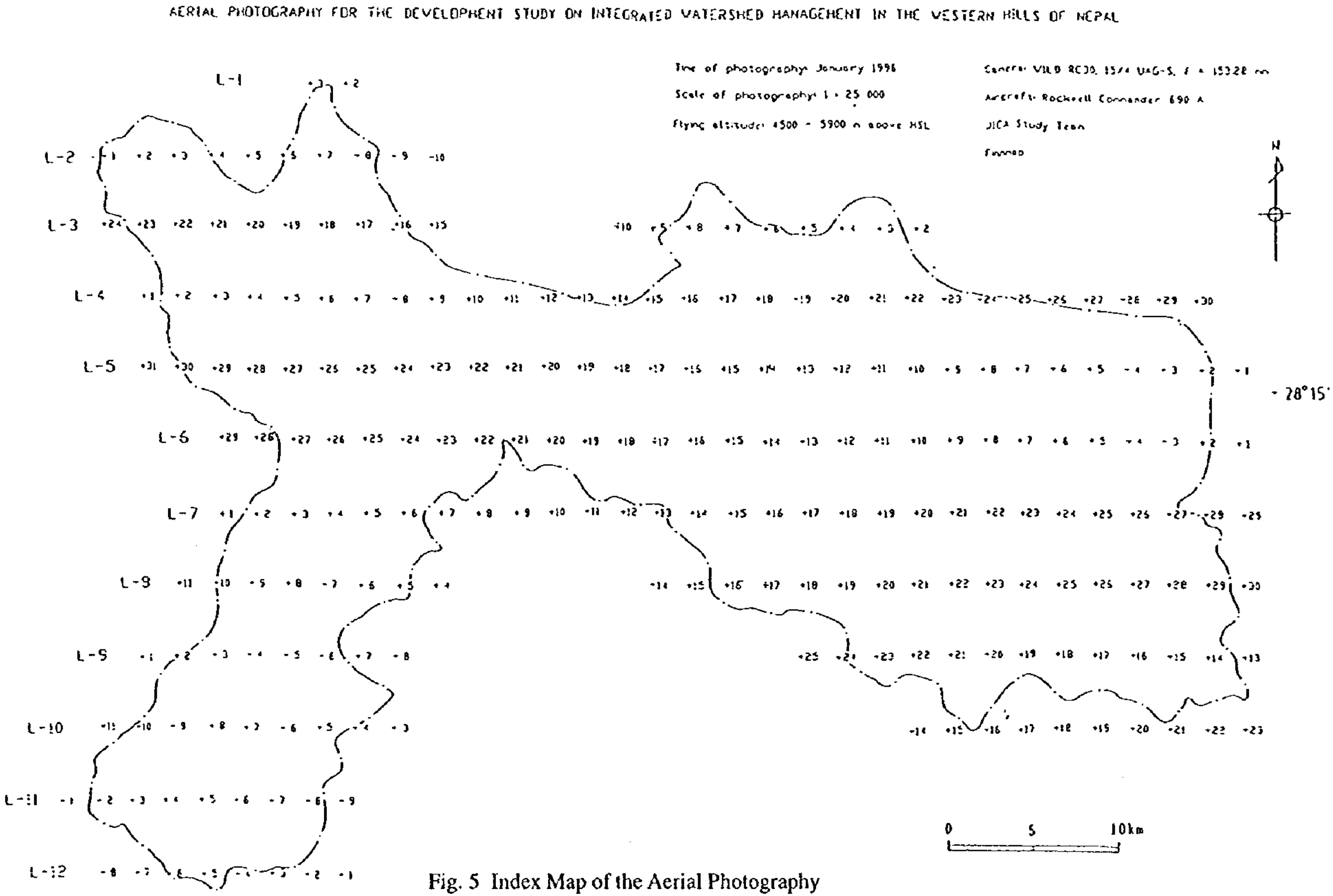


Fig. 5 Index Map of the Aerial Photography

Selection of Survey Items

The survey items required for plan formulation are listed on the right. Existing data and information on these items should be used as much as possible. See the next section "Understanding of Current Conditions" for the field surveys designed to obtain vital data and information on these items if previous data, etc. is unavailable.

Main items	Sub items	Detailed items
Natural conditions	Climate	Precipitation, temperature, etc.
	Hydrology	Drainage, river discharge, surface run-off, ground water
	Geology/ Topography	Geology, topography, soil
	Soil	Soil profile, soil sample analysis
	Land use/ vegetation	Preparation of legend and photo interpretation standards, photo interpretation and transfer of results, forest inventory (when necessary)
	Erosion	Landslide, gully erosion, bank erosion, flooding, surface erosion, past disasters
Socio-economic conditions	Social conditions	Households and population, structure of cast, out-migrants and long term absentees, education status, occupation, participation in community organizations, cash income source
	Living condition	Drinking water supply, fuelwood source, food, health and sanitation, family planning
	Agriculture	Farmland area, farmlands affected by natural disaster, cropping pattern, cropping area & yield, crop damage
	Livestock	Livestock population, livestock feed & its sufficiency
	Forests	Community forest and private forest, privately owned trees
	Cottage industry & local skills	Bamboo works
	Infrastructure	Foot trail, road, water source
	Role of men & women	Home activity, farming, livestock feeding, forest product related activity, domestic business, communication, religious/cultural activities
	Perception on importance of forest	Importance of forest, measures to improve forest condition
	Measures to prevent natural disasters	Measures to control landslides and damage to terraces

Moreover, thematic maps necessary for plan formulation are as follows.

Planning zone	Administrative boundary maps (Ward, VDC)
Climate	Map showing isohyet
Hydrology	Drainage pattern maps, hydrographs
Geology/Topography	Geological maps, landform maps, slope classification maps
Soil	Soil maps, land suitability classification maps
Land use/vegetation	Land use/vegetation maps
Erosion	Landslide distribution maps, gully erosion distribution maps, bank erosion distribution maps, hazard prediction maps
Infrastructure	Foot trail & road distribution maps

Understanding of Current Conditions

The following surveys are conducted to clarify the current conditions of the Study Area. The data obtained through the surveys are used as basic material for the Study.

① Current conditions are investigated by:

a. Using aerial photographs, existing data and literature, etc.
b. Confirming field condition through actual field surveys, interviews, etc.
c. Field verification of draft thematic maps

② Use of Aerial photographs

a. Aerial photographs of the Scale 1/25,000 taken by JICA
b. Ordinarily contact prints of photographs are used.
   When necessary the photographs could be enlarged to the Scale 1/10,000
c. To improve the accuracy of photo interpretation it is necessary to verify its results in the field, specially regarding such interpretation items as species classification, etc.

(1) Climatic Survey

(Objectives)

Precipitation, temperature, etc. are investigated to provide basic data for land use improvement and erosion control plans.

Precipitation, temperature, stream discharge, etc. are investigated through collection of existing data.

(2) Land Use/Vegetation Survey

(Objectives)

- Clarification of the current conditions of land use and vegetation (including forest type classification)
- Preparation of land use and vegetation maps

① Land use/vegetation are classified as mentioned in Table 2 by using the following method

② Aerial photo interpretation

a. Land use/vegetation are interpreted and classified using aerial photographs
b. Taking into consideration the scale of aerial photographs (1/25,000), the minimum unit area for interpretation is set at 1 cm × 1 cm (6.25 ha).
c. In regard to hillside farmlands, for example, those with bunds are classified as level terraces (Khet land) and those containing sporadic trees are classified as sloping terraces (Bari land).
d. In view of the existence of some farmland mixed with forest or grassland of a smaller area than the minimum unit area for interpretation, the ratio of farmland in one unit area is established as the farmland ratio.
e. Forest site with a crown density of 10% or less is classified as grassland.

③ Transfer of mapping units

Mapping units interpreted on aerial photographs are transferred onto topographic maps of the Scale 1/25,000.

④ Field verification

Using the draft land use/vegetation maps, the field verification of the interpretation results is conducted. In addition, those sites which are not clearly identified on the photographs are checked in the field.

⑤ Preparation of land use/vegetation maps

Land use/vegetation maps (Scale 1/25,000) are prepared through aerial photo interpretation and field verification.

Land use and vegetation categories in the Model Areas are as shown in Table 2. The categories are established based on the standards of LRMP.

Table 2 Land Use and Vegetation Categories
(Example of Model Areas)

1. Farmland
   - (1) Hillside Farmland
     - T: Level Terrace
     - C: Sloping Terrace
   - (2) Cultivation Ratio
     - 3: Intense (75 - 100%)
     - 2: Medium (50 - 75%)
     - 1: Light (25 - 50%)
   - (3) Abandoned Farmland
     - A: Abandoned Farmland
   - (4) Valley Cultivation
     - V: Valley Floor
     - F: Old River Terrace, Alluvial Fan or Mountain Foot Slope
2. Grassland
   - G: Grassland
3. Non-Farmland
   - R: Rocky Site
   - Ls: Landslide/Collapse Site
   - B: Sand/Gravel/Boulder Site
   - W: Water Body
   - Ri: River/Flood Plain
   - U: Settlement
4. Forest
   - (1) Forest Cover
     - C: Coniferous Forest: coniferous species accounting for 75% or more
     - H: Hardwood Forest: hardwood species accounting for 75% or more
     - M: Mixed Forest: mixture of coniferous and hardwood species
     - S: Shrub: shrub with a tree height of upto 3 m
   - (2) Species
     - Sal: Shorea spp.
     - Pn: Pine spp.
     - Tmh: Tropical Mixed Hardwood
     - Dmb: Deciduous Mixed Broad-Leaved
     - Q: Oak spp.
     - An: Alnus spp.
   - (3) Purpose of Use
     - Pl: Afforestation Site
     - Pf: Protection Forest
   - (4) Crown Density
     - Ratio of area covered by crown
     - 1: <10% (non forest)
     - 2: 10 - 40%
     - 3: 40- 70%
     - 4: >70%
   - (5) Maturity class
     - Mx: Mature trees reaching rotation age or usable size for timber
     - Ix: Immature or small diameter trees for timber use
     - Rx: Regeneration trees (reaching pole size)

Legend Example

- T2: Level Terrace; Cultivation Ratio (50 - 75%)
- H Tmh: Forest Hardwood; Tropical Mixed Hardwood
- 4 Mx: Crown Density (>70%); Mature Trees

(3) Soil Survey

(Objectives)

To prepare soil maps to clarify the distribution of soils in the Study Area as well as to investigate soil properties to obtain basic information for plan preparation.

① Method

To investigate the conditions of soils, standard soil profile survey and simple pit profile survey are conducted.

a. Size of a standard soil profile could be width, length and depth of 1.0 m, 1.5 m and 1.5 m respectively. For supplementary investigations, simple pit (size for example: width 50 cm, depth 70 cm) survey is also conducted.

b. Number of soil profiles to be dug for investigation depends on the distribution condition of soil types. In Model Area, some 5 profiles per 600 ha were established.

② Soil Profile Survey

A soil profile survey is conducted based on the FAO-Unesco's Guideline for Soil Profile Description; Second Edition 1977.

③ Soil Classification

Soils are classified according to the FAO-Unesco's Soil Map of the World, Revised Legend 1990. As the result of the soil survey conducted, the following soil units, for example, were found to exist in the Model Areas.

Table 3 Soil Classification (Example of Model Areas)

Mapping Symbol	Main Soil Units	Soil Units
Fle/c/d	Fluvisols	Eutric/Calcaric/Dystric Fluvisols
Flc		Calcaric Fluvisols (Cement Pan)
Rgc	Regosols	Calcaric Regosols
Rgd		Dystric Regosols
Lpd	Leptosols	Dystric Leptosols
Lpk		Rendzic Leptosols
Cme	Cambisols	Eutric Cambisols
Cmd		Dystric Cambisols
Cmu		Humic Cambisols
Lvh	Luvisols	Haplic Luvisols
Lvh/Alh	Luvisols/Alisols	Haplic Luvisols/Haplic Alisols
Ach	Acrisols	Haplic Acrisols

Others: S - Sand Outcrop (River), C - Cliff Outcrop (Lithic Leptosols)

④ Analysis of soil samples

a. A soil sample of approximately 1 kg is collected from each horizon.
b. Physiochemical analysis is conducted featuring the following items.
   (a) pH (H_2O, $KC\ell$)
   (b) Soil texture (sand, silt, clay)
   (c) Exchangeable cation (Na, K, Mg, Ca) (me/100 g)
   (d) Cation exchange capacity (me/100 g)
   (e) Base saturation (%)
   (f) Total nitrogen (me/100 g)
   (g) Organic carbon (mg/100 g)
   (h) Phosphoric acid concentration (ppm)

Simple soil analysis can be conducted at the Soil Laboratory of the DOSC while more detailed analysis can be conducted at the Soil Laboratory of the Ministry of Forests and Soil Conservation.

⑤ Preparation of soil maps

Using the aerial photographs and field survey books describing the confirmed findings of the field investigations on the local topography and land use, etc., the state of soil distribution is established and this soil distribution based on the FAO-UNESCO soil classification method is transcribed on the topographical map (scale: 1/25,000) to produce the soil map.

An example of soil suitability in Model Areas based on soil properties and land use is mentioned in the table below.

Table 4 Suitability of Soil Seen in Terms of Soil Character and Land Use by Soil Unit (1) (Example of Model Areas)

Soil Unit	Soil Characteristics							Land use and Vegetation	Soil suitability
	Key Horizon	pH (H2o) value	CECA Layer	B-S (%)	Texture	Landform	Parent material		
Eutric/ Calcaric/ Dystric Fluvisols	Alluvial soils Shallow A layer	>5.5	<5	>50 Flc/e <50 Fld	SL SiL L	Riverside lowland River terraces	Various. Sedimentary rock is broken by Ca.	Cultivated land	The riverside lowland containing fluvisols is extremely important for agriculture in the mountain areas. Owing to a low CEC value, the soil is basically lacking in water-retaining capacity and fertility, so productivity is not high. However, the soil responds well to fertilizer use (mainly nitrogen and phosphorous) and provision of irrigation is essential for obtaining very high crop yields. The most suitable land for cultivation is that containing no stony deposits to a depth of 1 m, but such land only occupies a meager portion of the overall Model Area.
Calcaric/ Fluvisiols (Cement Pan)	Surface cement C horizon at and below 30 cm	7.0	<5	>100	SiL	Riverside lowland	Limestone	Cultivated land (irrigated areas) and grassland (not irrigated)	There is a thick, cement-like, depositional limestone horizon at around 30 cm below the surface, and the soil is alkaline. For this reason, the cement horizon blocks root growth, and the A horizon with a pH value of more than 7.0 slows the inorganic conversion of nitrogen and makes other elements insoluble, thus making the soil devoid of nutrients for growing crops. Unless agriculture is practiced intensively, there is little likelihood that this soil will generate high yields.
Calcaric/ Regosols	A-C horizon, Calcic layer	>6.8	<10	>100	SiL L	Steep slope with surface erosion and slope collapse	Dolomite Limestone	Grazing land, shrub forest, agricultural land (where irrigation is possible)	This soil type is widespread in the Parbat South Model Area. As the Regosols layer is stony and shallow, the soil has limited suitability for cultivation purposes. Because the dolomite and other basic rock which forms the parent material of this soil contains much magnesium, the soil quickly dries out if it is shallow, and this creates problems for cultivation. If this soil is to be used, it is probably most appropriate to use it for grazing. In the case of reforesting, a careful choice of species would be necessary (species that can adapt to the base rock and dry conditions).
Dystric Regosols	A-C horizon	<5.5	5-13	<50	L SL	Residual ridges Surface erosion Collapsed slopes Mountains	Schist Quartzite Slate	Grassland for grazing Forest Shrub forest Abandoned cultivated land	The residual soil of ridges and collapsed slopes are very stony, making cultivation difficult. The soil texture is also coarse and surface erosion and slope collapse is apt to occur in exposed areas. It is best to maintain forest on the land, and the abandoned cultivated land and collapsed slopes should also be planted with trees. Because the abandoned cultivated land on ridges has poor permeability, it is necessary to take preservation measures (erection of rock fences, etc.) to ensure that surface water does not affect other cultivated land, etc.
Dystric Leptosols	A-R horizon Bed rock within 30 cm	<5.5	<10	<50	L	Steep slopes Rocky land	Schist Quartzite Slate Not yet eroded	Abandoned cultivated land Shrub forest and forest Grazing land	Because there is only a 30 cm layer of soil, this land is basically moorland unable to support cultivation. However, there are cases of burning the base vegetation and cultivating the land in the few areas where the soil is fertile. As the land is not suited to cultivation, the preservation of forest is desirable.
Rendzic Leptosols	A-R horizon Bed rock within 30 cm	>7.0		>100	SL L SiL	Very steep Slopes Cliff	Dolomite	Abandoned cultivated land Shrub forest and forest Grazing land	This soil is similar to Carcaric Regosols. Dolomite bed rock is exposed in places, and the land is barren and unsuited to cultivation. The land is used as coarse grazing land.
Eutric Cambisols	Cambic B horizon Umbric A horizon	5.5>	> 10 Forest < 10 Agriculture land	>50 B Horizon	L SiL Sic Cl	River terraces Hill slopes	Slate Dolomite Parent material with much basic rock	Terrace cultivated land (collapsed slopes) Forest (steep slopes)	Terraces are formed for cultivation in areas except for steep slope forest. The irrigated terraces do not lose their fertile surface soil during the rainy season, and high yields can be expected if only nitrogen and phosphorous are supplemented. The gentle slopes are almost totally under cultivation. Because soil erosion is apt to occur in areas of exposed soil on steep slope forest land, it is best to maintain the forest.

Table 4 Suitability of Soil Seen in Terms of Soil Character and Land Use by Soil Unit (2) (Example of Model Areas)

Soil Unit	Soil Characteristics							Land use and Vegetation	Soil suitability
	Key Horizon	pH (H2o) value	CEC Ahorizon	B-S (%)	Texture	Landform	Parent material		
Dystric Cambisols	Cambic B horizon Ochric A horizon	4.8-5.5	5-15	<50 B horizon	L SiL Sic CL	Mountain slopes Collapsed alluvial fan River terraces	Schist Mica-Schist Qurzait Slate		This is the representative soil over the whole Model Area. Weathering on the southern side slopes up to an altitude of 1,200 m is advanced, and the soil color is orange red (hematite color). Surface erosion would not occur on the gentle slopes if terraces were formed properly, but the high permeability means that there is a risk of slow slope collapse. The soil is suited to cultivation or grazing, but due to a lack of nitrogen and limited suitability, supplying organic fertilizer and limestone would be effective. The fertilizing effect of limestone and organic fertilizers is soon realized.
Humic Cambisols	Cambic B horizon Umbric A horizon	4.8-5.5	>10	<50 B horizon	L SL	Mountain slopes of altitude 2,000 m or more Collapsed gentle slopes	Schist Mica-Schist Qurzait Slate	Terrace cultivated land (collapsed gentle slopes) Forest (mountain slopes of 2,000 m or more)	This soil is sandy and has good permeability. As the surface soil is fertile if irrigated, the gentle slope areas form good cultivated land. If soil in the currently forested areas was exposed, even if the soil layer were thick, surface erosion and slope collapse would soon occur due to the steep topography and sandy soil. Thus, it is desirable to preserve the forest as it is.
Haplic Luvisols	Argillic B horizon	>6.0	+-10	>50	CL SiL L	Old river terraces Gentle ridges and slopes on hills	Various (river-carried deposits) Dolomite (hills)	Cultivated land (with irrigation) Grazing land (not yet irrigated)	In the sub-tropical climate, this soil originating from basic rock parent material can be fertile if irrigation is carried out. The B horizon is Clayey, and weathering from the Cambisols is advanced. The thick soil covering and abundant basic rock make the land suited to cultivation, but there is a lack of organic substances in the soil, and the surface soil is prone to being washed away. Thus, although there is no need to carry out acidic improvement, it is necessary to carry out fertilization to maintain the soil goodness, and form terraces and carry out irrigation to prevent surface erosion. If the surface soil is lost, the clay-like nature of the soil means that cultivation is difficult without irrigation.
Haplic Alisols	Argillic B horizon	5.5	5	>50	CL SiL	Old river terraces	Various (river-carried deposits)	Cultivated land (with irrigation) Grazing land (not yet irrigated)	The soil is dark red to red in color and mixes with the above-mentioned Luvisol. The basic rock saturation level is more than 50%, but the CEC value is lower than in Luvisol, meaning that the soil cannot retain its fertility. The suitable land use is the same as in the case of Luvisol, but the degree of fertility is lower.
Haplic Acrisols	Ochric A horizon Argillic B horizon	<5.0	5	<50	CL SiL C	Gentle hills	Schist Mica-Schist	Cultivated land (terrace) Grassland (abandoned cultivated land)	This red-colored soil containing a thick layer of clay appears on old topographical surfaces and is well eroded. The pH level is less than 5.0, and this soil is generally rare in steep areas such as the Model Area. The low pH level and lack of basic rock makes the soil poor in quality, but, within the overall Model Area, it is not very stony and can be cultivated, so terraces are formed for cultivation. The land is covered by forest and crops that are suited to a low pH level. It is desirable to cultivate rice, etc. which is resistant to low pH levels. It is difficult to achieve a fertilization effect. The thick layer of red clayey soil which appears in places on eroded slopes and ridges could possibly be relic soil formed in a warmer era (interglacial), and it has become more complex as a result of more recent formation.

Note:							
L:	Loam	SiL:	Silt Loam	Sic:	Silt Clay	CL:	Clay Loam
SL:	Sandy Loam	C:	Clay	S:	Sand	Si:	Silt
LS:	Loamy Sand	SiCL:	Silty Clay Loam	SC:	Sandy Clay	S:	Silt

(4) Geological Survey

(Objectives)

To clarify the geological and geomorphological conditions of the Study Area and to prepare geological maps, landform maps, cross-sectional maps, etc. to prepare basic data for hazard prediction, formulation of erosion control plan and integrated watershed management plan.

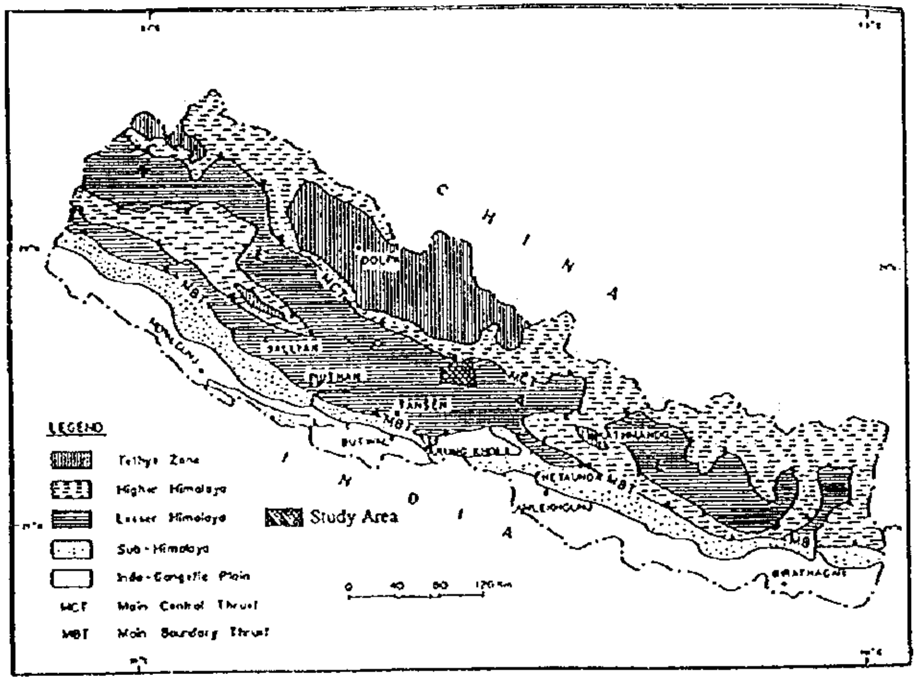


Fig. 6 Major Rock Units of the Nepal Himalaya
The Location of the Study Area Is Shown in the Inset.

Geological survey is conducted through collection of existing data, interpretation of aerial photographs and topographic maps and field survey. Survey items could be as follows.

① Survey items

a. Geologic unit
b. Geologic structure

② Geological factors that could be used for preparing hazard maps:

a. Hardness of rocks
b. Sheared zone
c. Consolidation of overburden
d. Thickness of overburden
e. Distribution of dip slope
f. Distribution of erosion front

③ Criteria for classification of geological factors

The Model Areas were classified into several categories in accordance with the following criteria on the each factors mentioned above.

A. Strength of rocks

a. Very hard (Massive quartzite, dolomite, and limestone)

The rock mass consists of stiff rock with a unconfined compression strength of more than 1,000 kgf/cm^2. No distinct separation (fracture) exists in the rock mass.

b. Hard (Gneiss and meta-sandstone)

The rock mass consists of stiff rock with a unconfined compression strength of more than 1,000 kgf/cm^2. Separations (fractures) exist in the rock mass with an interval of 10 cm to 1m.

c. Moderate (Phyllite and slate)

The rock mass consists of moderately stiff rock with a unconfined compression strength of 300 kgf/cm^2 to 800 kgf/cm^2. Separations (fractures) develop in the rock mass with an interval of 5 cm to 1m.

d. Weak (Schist)

The rock mass consists of moderately stiff rock with a unconfined compression strength of 300 kgf/cm^2 to 800 kgf/cm^2. Numerous separations (fractures) develop in the rock mass.

e. Very weak (Alternated rock intercalated with soft layers)

The rock mass consists of soft rock with a unconfined compression strength of less than 300 kgf/cm^2 and contains thin, very soft layers.

B. Intensity of shearing

a. Non-sheared

The rock mass is not affected through geotechnical disturbance except schistosity and separation which exist in common metamorphic rocks.

b. Slightly sheared

Fractures and foliated portions exist in the rock mass, but clayey portion scarcely exist.

c. Moderately sheared

Fractures and foliated portions exist in the rock mass containing thin clayey intercalations.

d. Strongly sheared

The rock mass is fragmented of foliated through geotechnical disturbance such as faulting and folding, and it contains thin clayey intercalations.

C. Consolidation of overburden

a. absent

The thickness of overburdens are less than 1 m.

b. Semi-consolidated

Matrix of the sediment stiffened due to cementation with calcite and/or compaction of fine materials.

c. Unconsolidated

Matrix of the sediment is unconsolidated and loose.

D. Thickness of overburden (T)

a. T 1 m (absent)

b. 1 m < T 3 m

c. 3 m < T 6 m

d. 6 m < T

E. Dip slope

a. absent

b. Indistinct

c. Distinct

F. Erosion front

a. absent

b. Indistinct

c. Distinct

④ Geomorphological features

a. Recent river plain
b. Alluvial fan
c. Talus (colluvial gentle slope)
d. Terrace
e. Erosion front
f. Karst
g. Dip slope
h. Bare rock
i. Gully
j. Rock slide
k. Soil slide

Several kinds of metamorphic rocks that belong to the Lesser Himalaya or Precambrian to early Paleozoic in geological age are widely distributed in the Study Area. High-grade metamorphic rocks that belong to the Higher Himalaya of Precambrian in geological age occupy the remaining area. The rocks are thrust over the Lesser Himalaya rocks at the northern edge of the Kaski North Model Area. Both rocks are underlain by the following unconsolidated to semi consolidated quaternary deposits.

a. Recent river deposit

b. Alluvial fan deposit
c. Talus deposit (colluvial deposit)
d. Terrace deposit

The rocks in the five Model Areas, for example, were divided into 9 geologic units (formations) based on their lithology and metamorphic grade. Among the engineering features, hardness of rock was found to have a great effect on slope stability and it seems to be an important factor for preparation of a hazard map.

Table 5 Geological Unit in Model Area

Zone	Group	Unit	Main rock type	Geologic feature	Engineering geological feature
The Higher Himalaya		Kyanite Schist and Gneiss Unit	Gneiss (Mylonitic augen gneiss and banded gneiss)	Massive and course-grained high-grade metamorphic rock characterized by gneissose structure (banded structure of white and black stripes).	Hard (stiff rock pieces and massive with wide joint intervals). Sometimes deeply weathered along joints to be sandy.
			Kyanite schist.	Light- to dark-grey and medium- to coarse-grained medium- to high-grade metamorphic rock with kyanite, possessing a schistosity and an obscure banded structure.	Moderately hard (relatively stiff rock pieces but a letter flaky along schistosity). Weathered to be sandy to silty.
The Lesser Himalaya		Graphitic Schist and Marble Unit	Graphitic schist	Intensely deformed, dark-grey to black, and medium-grained medium-grade metamorphic rock possessing a good schistosity and originated from peritic rock.	Weak (relatively soft rock pieces intensely deformed and very flaky along schistosity). Weathered to be silty.
			Calcareous schist	Intensely deformed, green- to light-grey, and medium-grained medium-grade metamorphic rock possessing a good schistosity and originated from carbonaceous peritic rock.	Weak (relatively soft rock pieces intensely deformed and very flaky along schistosity). Weathered to be silty.
			Calcareous quartzite and dolomitic marble	Massive, light- to yellow-grey to white, and fine- to medium-grained calcareous metamorphic rock intercalated in the schists above.	Very hard (very stiff rock pieces massive with relatively wide joint intervals). Hardly weathered.
		Garnetiferous Schist Unit	Garnetiferous schist	Intensely deformed, grey to green- or dark-grey, and medium- to fine-grained medium-grade metamorphic rock with garnet, possessing a good schistosity.	Weak to very weak (soft rock pieces intensely deformed and very flaky along schistosity). Weathered to be silty to muddy.
			Gneiss (Augen gneiss)	Strongly foliated and course-grained high-grade metamorphic rock composed of thick (3 to 5 mm) light colored bands and thin (about 1 mm) dark colored bands.	Hard (stiff rock pieces and massive with wide joint intervals). Sometimes deeply weathered along joints to be sandy.
	Lower Nawakot Group	Kuncha Formation	Phyllite, gritty phyllite and quartzose phyllite	Green-grey to dark-grey and medium to fine-grained metamorphic rock originated from poor-sorted sedimentary rock, accompanied by phyllitic meta-sandstone and quartzite.	Moderately weak (slightly soft rock pieces and flaky along foliation). Weathered to be silty to sandy.
		Fagfog Quartzite	Quartzite	Medium- to thick-banded (0.5 to 2 m), white to light green, and medium- to course-grained siliceous metamorphic rock accompanied by phyllite lenses, and thick and massive amphibolite.	Very hard (very stiff rock pieces massive with relatively wide joint intervals). Hardly weathered.
		Dandagaon Phyllite	Quartzose phyllite and gritty phyllite	Green-grey and medium- to fine-grained medium-grade metamorphic rock accompanied by olive-green quartzite, meta-conglomerate lenses and dark-green amphibolite lenses.	Moderately weak (slightly soft rock pieces and flaky along foliation). Weathered to be silty to sandy.
		Nourpul Formation	Slate and phyllite	Purple-, green- to dark-grey, fine- to medium-grained low-grade metamorphic rock accompanied by grey-green fine- to medium-grained meta-sandstone.	Moderately weak (relatively soft rock pieces and relatively flaky along cleavage or foliation). Weathered to be silty.
			Quartzite	Light-grey, coarse-grained, and cross-laminated low-grade siliceous metamorphic rock accompanied by green-grey and thin-banded phyllite lenses.	Very hard (very stiff rock pieces massive with relatively wide joint intervals). Hardly weathered.
		Dhading Dolomite	Dolomite	Blue- to light-grey, very thick-banded non to slightly metamorphic carbonate rock accompanied by purple siliceous dolomite and thin bedded black slate.	Very hard (relatively stiff rock pieces massive with wide joint intervals). chemically weathered to be silty to muddy.
	Upper Nawakot Group	Benighat Slate	Slate	Dark-grey to black, fine-grained, highly cleaveged, and often laminated non to slightly metamorphic rock intercalating carbonaceous films.	Moderately weak (relatively soft rock pieces and relatively flaky along clavage). Weathered to be silty to muddy.

(5) Hydrological Survey

(Objectives)

To clarify the current condition of water resources and to provide basic data for hazard prediction and erosion control plan, etc.

① River system

The Study Area is drained by Madi River, Seti River and Kaligandaki and their tributary Kholas. The drainage pattern of the area generally exhibits a tree-like or dendritic pattern. A drainage pattern map is produced using topographic maps. An example of a drainage pattern map (Kaski North Model Area) prepared using topographic maps of the Scale 1/25,000 is shown in Fig. 7.

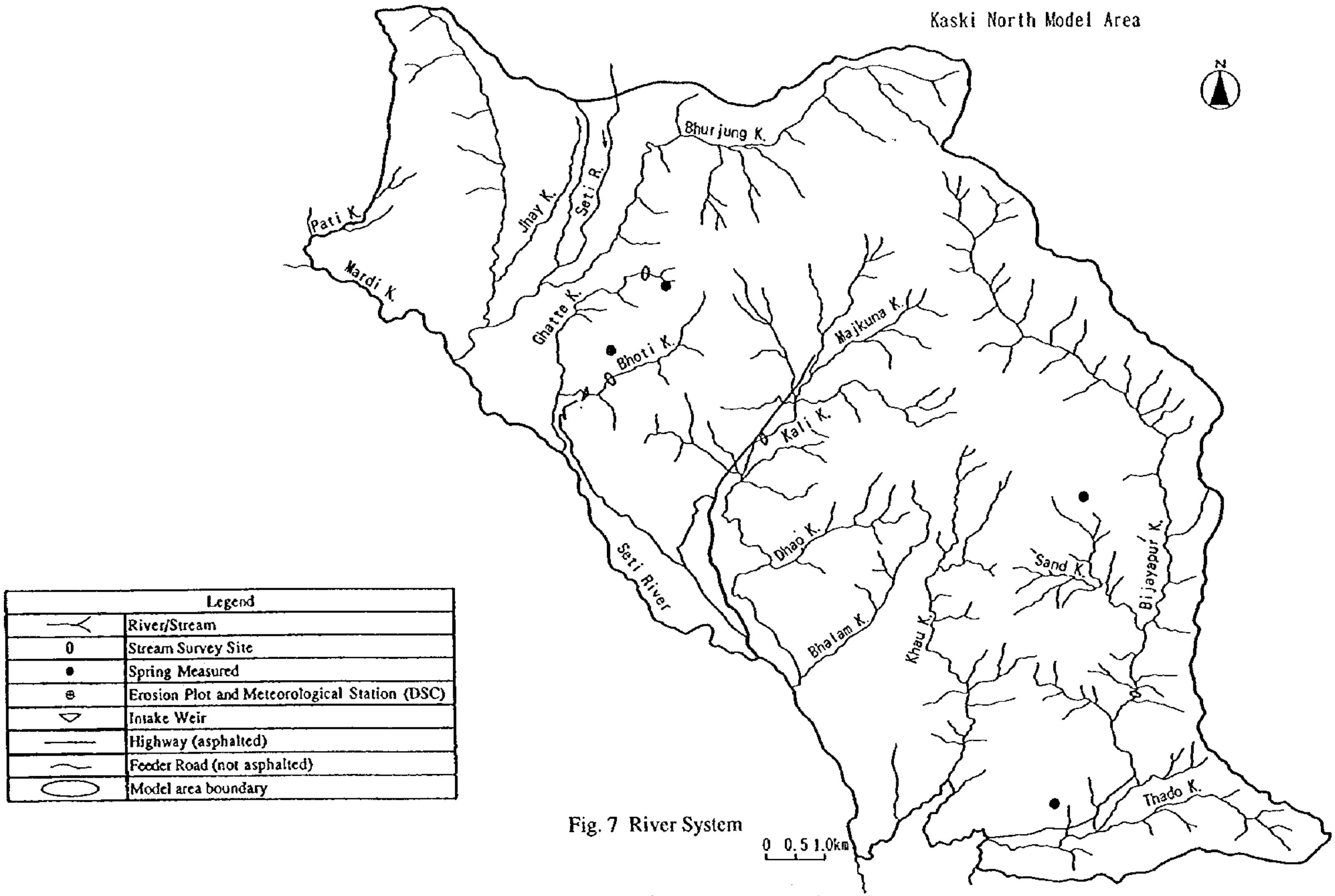


Fig. 7 River System

② River flow (discharge)

In the Study Area, river discharge is measured by the Narayani Basin Office, Department of Hydrology and Meteorology (Table 6).

Discharge measurements by the office is occasionally carried out during the dry and monsoon seasons and regularly measured full discharge data for the area are unavailable. It's desirable to conduct regular measurements of river discharge (daily, monthly etc.) for preparation of hydrographs and investigation of river flow condition.

Table 6 Stream Discharge in Model Areas

River/Khola (Model Area)	Discharge (m^3/sec.)		Measurement period	Remarks
	Lowest measured flow in dry season (Recorded date)	Highest measured flow in monsoon season (Recorded date)		
Seti River (Kaski North)	2.1 (Feb. 18, 1990)	383.8 (Aug 18, 1973)	Jan. 1, 1964 ~ Aug. 27, 1992	Measurement discontinued after 1992
Bijaipur Khola (Kaski North)	0.3 (Apr. 7, 1980)	15.2 (June 25, 1986)	June 2, 1975 ~ Mar. 28, 1988	Measurement discontinued after 1988
Harpan Khola (Kaski West)	0.6 (Apr. 21, 1975)	11.9 (Oct. 15, 1979)	Jan. 20, 1964 ~ Jan. 21, 1983	Measurement discontinued after 1983
Madi River (Kaski East)	2.8 (—)	523.0 (Aug. 3, 1977)	Feb. 8, 1973 ~ up to 1996	Measurement continues
Modi Khola (Parbat North)	0.5 (Apr. 26, 1995)	253.2 (Aug. 25, 1989)	May 25, 1975 ~ up to 1996	- Measurement continues - Modi Khola is a tributary of Kaligandaki & forms some 3500m northwestern boundary of Parbat North Model Area
Lamaya Khola (Parbat North)	0.02 (May 17, 1988)	4.3 (Sept. 10, 1984)	—	
Seti Khola (Parbat South)	0.6 (Apr. 11, 1992)	80.7 (Aug. 9, 1984)	Feb. 22, 1976 ~ up to 1966	Measurement continues

Note: Prepared from data provided by the Narayani Basin Office (Pokhara) of the Department of Hydrology and Meteorology.

③ Surface water

Surface water consists of river water, rain water, pond water and is mainly used for irrigation and domestic use. The water use as well as the conditions of irrigation canals, weirs, ponds, etc. are investigated.

④ Ground water

As for as the ground water is concerned, temporary and permanent springs are investigated.

⑤ Discharge measurement

Flow of water or discharge in a channel is the product of velocity and the cross-sectional area through which the water flows as is shown in the equation below.

$$Q = AV$$

Q = Discharge (m^3/sec.)
A = Cross-sectional area (m^2)
V = Velocity (m/sec.)

In small streams velocity at the surface of the water in the middle of a straight portion of the stream can be estimated by timing the downstream movement of a chip or twig. To obtain the average value the estimated value is multiplied by 0.75. Cross-sectional area can be quickly measured width a tape.

⑥ Simple method of measuring discharge

This method is useful in small streams or springs which can be diverted into a calibrated bucket or bottle, etc. Liters of water caught in a measured number of seconds is easily converted to discharge rate in any unit. An example of discharge measured in the Model Areas using this method is show in Table 7.

Table 7 Flow Rates of Some Springs in the Model Areas

Surveyed: February and March, 1996

Location		Flow rate	Water use	Water source vegetation	Remarks
Spring name	Ward No., VDC, Model Area	(L/sec.)			
Mauja	1, Mauja, Kaski North	0.5	Domestic use	Bush & shrubland fenced by local inhabitants using bamboo sticks.	The flow rate will decrease to roughly half in April (local inhabitants).
Upplo Kaure	3, Puranchaur, Kaski North	0.2	Domestic use	Alnus nepalensis young forest & grassland. Signs of grazing in the area.	
Chitepani	6, Puranchaur, Kaski North	0.3	Domestic use	Sparse natural broad leaved forest. Signs of grazing inside forest	Tension cracks in upper slope.
Bhir Pani	5, Arba, Kaski North	0.2	Domestic use	A few large size trees of Ficus & Fraxinous	Will dry up in April (local inhabitants)
Pyauli Khola	5, Deurali, Kaski East	0.6	Domestic use	Dense natural broad leaved forest & a few farms up slope	Pipe will be used (planned) to carry water to nearby community.
Donduri Khola	9, Thuli Pokhari, Parbat North	0.2	Domestic use	Alnus nepalensis, Bamboo, Schima wallichii, Castanopsis spp., etc.	A small (10-15m^2 approx.) landslide on the left slope.
Thulopaho	Bhangara, Parbat North	0.1	Domestic use	Natural broad leaved forest of Schima wallichii, Castanopsis spp., etc.	
Makare Khola	Tribini, Parbat South	4.5	Irrigation water	Bush land & natural broad leaved forest	
Tribini	Tribini, Parbat South	0.5	Domestic use	Paddies	The spring is located on the river terrace along Seti Khola.

⑦ Streams

The actual conditions of streams/rivers flowing in an area are investigated through field surveys. Survey items could be as mentioned below.

a. Condition of stream erosion, bank erosion, flooding, etc.
b. Longitudinal profile of the streams
c. Surrounding area land use, water condition and other related items.

Examples of stream survey in Model Areas are shown in Fig. 8 and Table 8.

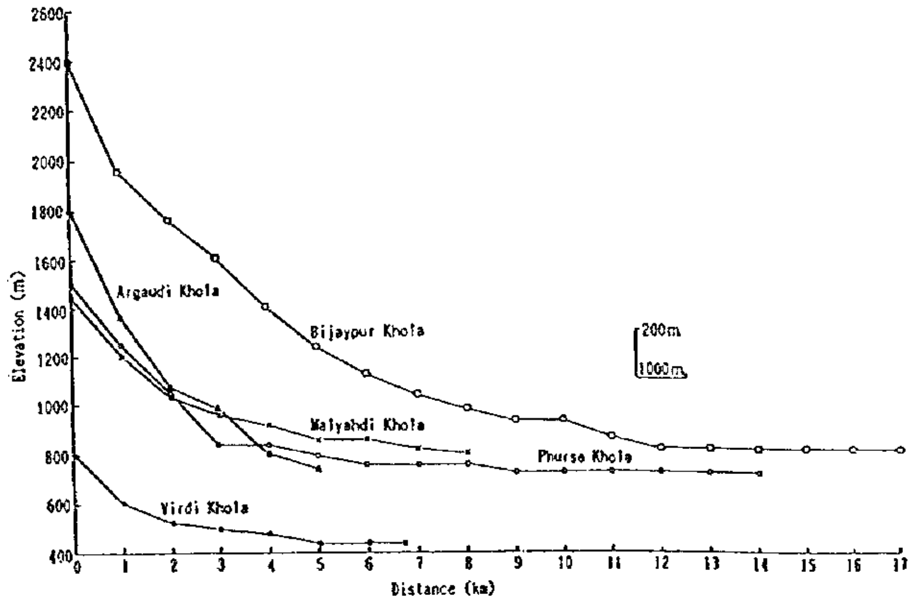


Fig. 8 Longitudinal Profiles of Some of the Kholas in the Model Areas

Table 8 Conditions of Some Streams in Model Areas (An Example)

Surveyed in Feb. and March, 1996

Stream (Model Area)	Stream width (m)	Water condition			Bed slope (°)	Bank erosion condition				Land use in vicinity	Remarks
		Surface width (m)	Depth (m)	Colour		Height (m)	Depth (m)	Slope (°)	Existing control measure		
Bijayapur Khola (Kaski North)	190.0	4.5	0.12-0.18	Transparent & colourless	2.5	2.4	1.2	80	None	R. Arba Bijaya School yard. L. Terraced land & shrub land.	- Flood mark height at R. 1.1m. - River flow is reduced to 1/4 in March & April (villagers).
Kali Khola (Kaski North)	67.0	3.6	0.09-0.12	Transparent & colourless	2.5	3.0~4.0	1.0-1.5	50-70	Gabions (poor condition)	Paddies along both banks	- Some paddies on the R. were destroyed during Aug. 1995 flooding. - In March-April river flow is reduced to roughly 1/2 of current amount (villagers)
Bhoti Khola (Kaski North)	22.5	2.2	0.05-0.10	Transparent & colourless	1.5	0.8	1.0	80	None	Paddies along both banks	- Paddies on both sides of the river are flooded up to some 50-80m from the banks during the monsoon (villagers). - Baseflow appears some 100m upstream from surveyed point.
Virdi Khola (Kaski East)	56.5	3.5	0.05-0.15	Transparent & colourless	5.0	0.6-1.4	1.0	80	None in survey points. Near river mouth traditional round shaped bamboo structures & conventional gabions.	Paddies along both banks	- Paddies on both sides of the river are flooded up to some 60-70m during monsoon (villagers) - Intake of Polyangtar Irrigation Canal in the midstream R.

Note: ① R. and L. denote the right bank and left bank of a stream respectively.
② When one figure is given for bank erosion condition it means that erosion was significant only at one bank.

(6) Erosion Survey

(Objectives)

Existing erosion types such as gully erosion, bank erosion, landslide, surface erosion, etc. are investigated to collect basic data for preparation of erosion control plan in the Study Area.

① Landslide

Surveys on landslides are conducted through aerial photo interpretation and actual field investigations. The following items are investigated.

a. Type of landslides
b. Dimension
c. Possible causes
d. Conservation objects
e. Existing countermeasures type and conditions
f. Other items when necessary

An example of landslide survey in Model Areas is shown in Table 9.

Type of landslide

Landslides can be classified according to the type of movement, dimension, material composition, history of movement, etc. Here some examples of landslide classification by material composition and size are given below.

a. Material composition
   (a) Debris slide
   (b) Rock slide
   (c) Slides which consist of (a) and (b) or complex landslides

b. Dimension
   (a) Small landslides (for example, 1.0 - 3.0 m depth, 100 - 3,000 m^2 affected area)
   (b) Large size (for example, more than sizes in (a).)

Table 9 Characteristics of Some Active Small Landslides in the Model Areas (An Example)

Surveyed in February and March, 1996

Location: Ward No., VDC, Model Area	Type and geology	Scar specification: Length (m)	Width Max. (m)	Width Mean (m)	Depth Max. (m)	Depth Mean (m)	Slope (°)	Area (m^2)	Volume (m^3)	Date occurred	Conservation object	Existing counter-measure	Immediate cause	Surrounding area land use	Remarks
1, Lahachok, Kaski North	Debris slide, Schist	150 E	17	15	2.2	1.8	36	2,250	4,050	July, 1995	A trail & 2 irrigation canals	None	Weak geology, steep slope & water seepage from canals	Upper slope degraded grassland Lower slope paddy land & Alnus nepalensis trees	- 2 destroyed canals supplied irrigation water to some 100ha of paddies - Tension cracks in upper slope (10-20cm wide)
6, Armala, Kaski North	Debris Slide, Schist	80 E	37	30	2.5	2.5	34	2,400	6,000	Aug., 1995	Rain-fed Paddy fields	None	Weak geology, steep slope & concentrated rain water from upper slope farms	Rain-fed paddy fields	
1, Mauja, Kaski North	Debris slide, Schist	20	11	8	2.1	2.0	31	160	320	Significant enlargement in Aug., 1995	Buildings in the upper part	None	Same as above	Degraded grassland	
3, Puranchaur, Kaski North	Rockslide, Schist	40	27	26	3.0	2.5	41	1,040	2,600	1988 or 1989 E	Trail & terraces	None	Stone excavation, weak geology, steep slope	Alnus nepalensis (H.=8-10m), level terraces	Tension cracks (15cm-40cm wide) at the left side slope
5, Arba, Kaski North	Debris Slide, Phyllite	35	12	8	3.0	2.5	34	280	700	Tension cracks appeared some 8 yrs ago & sliding in 1993	District construct-ed road & a trail	None	Weak geology, steep slope, concentrated rain water from upper trail	Degraded grassland & sparse natural broad leaved forest	Debris from the slide deposited on road surface creating a hummock

Note: E means estimated

② Bank erosion and flooding

The actual condition of bank erosion and flooding is surveyed through photo interpretation, field survey and interviewing local people. An example of current condition survey of bank erosion in Model Areas is shown in Table 10.

Table 10 Current Condition of Bank Erosion (An Example)

(Feb. and March 1996 Survey)

Location		Estimated stream lengths affected by bank erosion	Estimated existing revetments along streams	Remarks
Model Area	Stream	(km)	(km)	
Kaski North	Bijaipur Khola	11.0 (2.5)	1.0	Including Khau Khola and Thado Khola
	Kali Khola	7.0 (2.0)	0.5	Including Dhao Khola and Gharmi Khola
	Bhoti Khola	3.0	-	
	Bhatte Khola	2.5	-	
	Sub-Total	23.5 (4.5)	1.5	
Kaski East	Khalte Khola	6.0 (1.0)	0.8	
	Virdi Khola	5.0 (1.0)	0.8	
	Anpu-Phushre Khola	7.0 (2.0)	1.0	Including Phidi Khola.
	Sub-Total	18.0 (4.0)	2.6	
Kaski West	Magsoli Khola	4.0 (1.5)	0.4	
	Phurse Khola	7.0 (2.0)	1.5	Including Khade Khola, Bhunge Khola and Kalimaki Khola
	Harpan Khola	4.0	0.2	Including Handi Khola
	Sub-Total	15.0 (3.5)	2.1	
Parbat North	Malyabdi Khola	5.5	0.8	
	Lamaya Khola	4.5	0.4	
	Sub-Total	10.0	1.2	
Parbat South	Seti Khola	9.0	1.4	Including Boke Khola and Makre Khola
	Mardi Khola	2.5	1.0	
	Sub-Total	11.5	2.4	
Total		78.0 (12.0)	9.8	

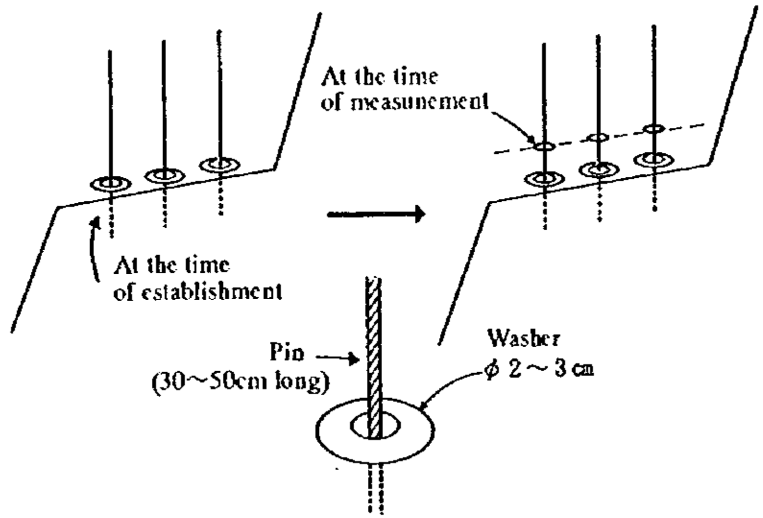
Note: ① The estimated lengths of bank erosion and existing revetments include both left and right banks of a river
② Figures in parenthesis ( ) are stream tributary lengths affected by bank erosion where riprapping will be carried out.

③ Surface erosion and gully erosion

a. Soil loss estimation due to surface erosion

Information on soil loss could be obtained from existing references, or from permanent soil loss plots established by land use type or by other factors. Where information on soil loss is unavailable, soil loss could be estimated by establishing erosion pin plots, which is a simple and cheap reconnaissance method measuring both cycle of erosion and deposition in a site. An example of the soil loss data obtained through investigating existing references and from erosion pin plots (2 m × 5 m), established in Model Area, is shown in Table 11.

b. Method of estimating soil loss from erosion pin plot(s)



The soil loss from erosion pin plot(s) readings could be estimated as mentioned below:

(a) Sum-up the recorded values for erosion (-) and deposition (+). The value obtained will show a rough estimate of the depth of surface soil that was eroded and will be either in millimeter or centimeter units, depending on the reading of pins.

(b) Multiply the figure by 10,000m^2 to obtain an estimate of m^3 of eroded soil in one hectare. To obtain the figure for eroded soil in Tons, multiply the figure for m^3 by the figure for bulk density of the soil concerned. Bulk density of soils in the Study Area is estimated by NARC to be 1.2.

(c) Actually the experiment should be conducted several years to obtain soil loss value in Ton/ha/year, but in this study it was carried out during only one monsoon season and the final figures were presented in Tons/ha/year in DF/R and F/R.

Tolerable soil loss

Basically, a sustainable use of land without progressive deterioration can be achieved when the rate of soil loss is no greater than the rate of formation of soil. The rate of formation of soil can't be precisely measured but the best estimate of soil scientists is that when the disturbances and aeration and leaching actions are speeded up by tilling the land, it will take something like 100 years to form 25mm of soil (N. Hudson: Soil Conservation, 1995). Other estimates put the rate of soil formation at 25mm in some 30 years. Assuming a bulk density of 1.2 (according to NARC, values for soils in the middle mountains of Nepal vary from 1.0 to 1.4) these rates of soil formation are approximately 3-10 ton/ha/year.

The value of acceptable soil loss will also depend on the soil depth and condition of weathering. For example, the loss of 3-10 ton/ha/year soil from a deep soil with high rate of weathering will be less serious than from a shallow soil on a rocky terrain. Nevertheless, as a tool to assist the process of planning 10 ton/ha/year was assumed as upper limit of tolerable soil loss for this study.

Table 11 Actual Rate of Soil Loss from Surface Erosion by Land Use Type in Study Area and Other Parts of Nepal

Land use	Soil loss (Ton/ha/year)		Remarks
	(a)	(b)	
Farmland			
Sloping terrace	17.0-100.0	60.0-70.0	All (a) data is from outside Study Area
Abandoned terrace	20.0	-	
Level terrace	2.0-10.0	-	
Home garden	-	30.0	
Grassland			(a) include data from Phewa Tal Watershed located inside Study Area
Overgrazed	7.7-200.0	110.0	
Protected	1.0-9.4	-	
Forest			
Dense	0.4-10.0	-	
Degraded	15.0	-	

Sources: (a) 1. B. Carson, ICIMOD Occasional Paper No. 1, 1985: Erosion and Sedimentation Process in Nepalese Himalaya, Pp. 6, 7, 28.
2. DOSC, UNDP, FAO, 1991: Summary on run-off and soil loss data from surface run-off plots. Phewa Tal soil loss data from 1978 (full year).
3. Soil fertility and erosion issues in the middle mountains of Nepal. Workshop proceedings Thikhu Khola Watershed April, 1991, Pp. 25, 85, 208-211.
4. T. Partap and H. R. Watson, ICIMOD Occasional Paper No. 23, 1994: Sloping agriculture land technology (SALT), Pp. 4-5
5. W. J. Ramsay, The University of British Columbia, 1985: Erosion in the middle Himalaya, Nepal with a case study of the Phewa Valley (MSc. Thesis) Pp. 21-27.

(b) Erosion pin plots
- Plot size 2m × 5m (sloping terrace 3 plots, grassland 1 plot, home garden 1 plot)
- Pin distance 1m × 1m (18 pins in one plot)
- Plot establishment date: Feb. 16-March 8, 1996
- Final reading date: Nov. 4-Nov. 15, 1996

c. Gully erosion

Gully erosion is investigated through actual field surveys, photo interpretation and available maps and data. An example of gully erosion survey in the Model Areas through actual field investigation is shown in Table 12.

Table 12 Current Condition of Some Active Gullies in the Model Areas (An Example)

Surreyed in February and March, 1996

Location	State of Progress	Length (m)		Main channel (m)				Bed gradient	Existing Control	Conservation	Land use in	Remark
				Depth		Width						
		Main channel	Branch	Max.	Mean	Max.	Mean	(°)	measure	Object	Vicinity	
Gaire Sawara, Ward No. 1, Purunchaur VDC, Kaski North Model Area	Active & continous. The gully head is eroding actively towards the trial & farm land	36	-	6.0	4.5	10.0	6.5	26	None	Traial & farm lands at the gully head	Irrigated paddies & grazing land	The gully has a U shape & consists of only one main channel.
Kaure, Ward No. 3, Purunchaur VDC, Kaski North Model Area	Active & continous	200 E	10 E	3.4	2.3	10.0	6.5	22	None	Farm land, trial & drinking water tank	Rainfed paddies, grazing land, etc.	The gully has a U shape & consists of main channel & one branch.
Ward No. 2, Arba VDC, Kaski North Model Area	Active & continous. The gully already destroyed a portion of paddies in its head & sides	105	-	6.5	3.7	21	13.5	7	None	Rain-fed paddy fields	Rain-fed paddy fields	The gully has a V shape & started some 3 years ago.
Same as above	Same as above	102	76	4.5	4.0	17	14	7	None	Same as above	Same as above	Same as above
Ward No. 9, Tribini VDC, Parbat South Model Area	Active. Unstable sediment on gully bed	150 E	-	2.2	2.0	13.5	12.0	15	None	2 trails & irrigation canals	Bush land & overgrazed grassland	The gully forms a part of the south-east boundary of the Model Area

Notes: 1) U Shape: is formed when the erosion resistance of the subsoil equals that of the top soil.
V Shape: is formed when the erosion resistance of the subsoil is stronger than that of the top soil.
2) E: Estimated

(7) Hazard Prediction (Preparation of hazard maps)

(Objectives)

To provide information on the distribution of hazardous sites and the level of hazard to local inhabitants and watershed management planners.

① Preparation method

a. Maps showing the distribution of factors related to erosion hazard, such as geology, geomorphology, soil, land use etc. are prepared. Proper ratings are assigned to each factor based on the actual condition of the factors in the field. The maps are overlaid by using the GIS and draft hazard maps are prepared.

① Examination of factors related to hazard

a. Landslide or erosion distribution
b. Rock type, etc. from geological report
c. Slope classes obtained using topographic maps
d. Hydrological data such as ground water
e. Land use type

b. Rating

Ratings are assigned to each factor depending on whether the factor in question is acting positively (preventing instability) or negatively (creating failure) based on the field knowledge of the surveyor or expert. Details on rating for Nepal could be found in "Mountain Risk Engineering Handbook" (ICIMOD, 1991).

c. Hazard related factors and ratings (An Example from Model Areas)

(a) Geological characteristics for hazard assessment

Factor	Category	Rating
A. Rock type		
Soil (Factors C and D)	a. Absent (Soil)	0.0
Massive Quartzite, Dolomite, Limestone, Marble	b. Very hard	0.0
Massive Gneiss, Meta-Sandstone	c. Hard	1.0
Phyllite and Slate	d. Moderately hard	1.5
Schist	e. Weak	2.0
Alternate rock intercalated with weak layers	f. Very weak	2.5
B. Weak zone		
	a. Absent (Soil)	0.0
	b. Non-sheared zone	0.0
	c. Slightly sheared zone	1.5
	d. Moderately sheared zone	2.0
	e. Fault and strongly sheared zone	2.5

(b) Soil characteristics for hazard assessment

Factor	Category	Rating
C. Consolidation of overburden		
	a. Absent	0.0
	b. Semi-consolidated	1.0
	c. Unconsolidated	2.0
D. Thickness of overburden		
	a. $T \leq 1m$	0.0
	b. $1m < T \leq 3m$	2.5
	c. $3m < T \leq 6m$	2.0
	d. $6m < T$	1.5

(c) Geomorphological characteristics for hazard assessment

Factor	Category	Rating
E. Dip slope		
	a. Absent	0.0
	b. Present but indistinct	1.0
	c. Present and distinct	2.0
F. Erosion front		
	a. Absent	0.0
	b. Present but indistinct	2.0
	c. Present and distinct	4.0

(d) Land use categories characteristics for hazard assessment

Factor	Category	Rating
G. Land use		
Forest	a. Dense cover, reduced run-off, deep root (crown density 40-70% & >70%)	0.0
	b. Moderate cover, reduced run-off deep root (crown density <40%)	0.5
Khet land	c. Managed drainage, reduced run-off	1.0
Shrub land	d. Moderate cover, shallow root	1.5
Bari land	e. Poorly managed drainage, high run-off, bare surface	2.5
Grassland	f. Highly degraded, bare surface, high run-off	3.5

(e) Slope class characteristics for hazard assessment

Factor	Category	Rating
H. Slope (%)		
$0 \leq S < 3$	a. Flat to nearly flat	0.0
$3 \leq S < 15$	b. Gentle	0.5
$15 \leq S < 30$	c. Moderately steep	1.5
$30 \leq S < 60$	d. Steep	3.0
$60 \leq S$	e. Very steep	4.0

(f) Hydrological characteristics for hazard assessment

Factor	Category	Rating
I. Hydrology		
(groundwater)	a. Dry	0.0
	b. Wet (Seepage)	1.5
	c. Permanent spring (flowing)	1.0

d. The ratings for each factor are added in meshes established on the factor maps and levels of hazard are determined. An example of Model Areas is given below.

Hazard level	Rating
Low	0 - 70
Medium	71 - 109
High	>109

② Verification

Two methods could be used for verification.

i) Landslide or erosion distribution maps prepared through photo interpretation and field work could be overlain on draft hazard maps. The majority of landslides or erosion (70 - 80%) should be within the medium or high hazard zone in the draft hazard maps.

ii) Draft hazard maps are spot-checked in the field. When the hazard level shown on the draft maps do not coincide with the field condition, ratings for the related subjects have to be adjusted.

③ Use of the erosion hazard maps

Erosion hazard maps could be used for planning hazard mitigation, land use improvement, infrastructure improvement, etc. The hazard maps prepared for Model Area, using the method as mentioned above, indicate the potential of the occurrence of slope failures, small and large landslides, etc. The maps are not intended for use in evacuation, choosing of centers for refuge, etc. during disasters, which will require the preparation of more large scale hazard maps based on detail survey.

(8) Socioeconomic Survey

(Objectives)

- To clarify the current socio-economic conditions and the characteristics of different locality.
- To grasp the social and economic needs of local people in different locality.
- To understand the relationship between socio-economic factors and watershed degradation.
- To raise the awareness of local people about watershed degradation and the solution.
- To establish baseline database, 'ex-ante' condition, to measure the effects of watershed management plan to be formulated and implemented.

① Socio-economic baseline survey

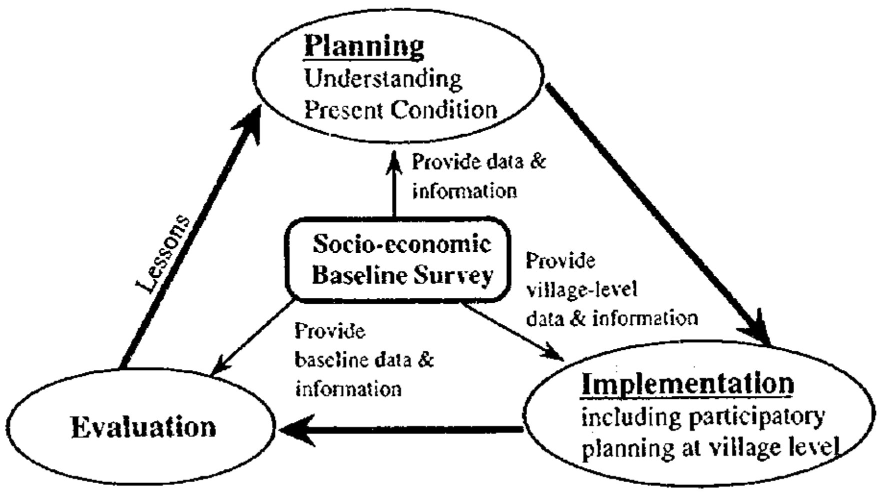


Fig. 9 Use of Socio-economic Baseline Survey

There has been a fundamental shift over the last decade in the approach to watershed management from a focus on centralized planning and management by governmental agencies to a more participatory approach which balances social, environmental, and economic objectives. Understanding socio-economic factors related to watershed degradation and the social and economic needs of inhabitants is crucial in this context for preparing a sustainable watershed management plan. In addition, the socio-economic factors and people's needs should be clarified by different locality because they, like natural conditions of watershed, vary to a large extent from place to place. However, such site-specific socio-economic data and information are rarely available.

In the context, a socio-economic baseline survey can be an important tool that provides the necessary information for the formulation of watershed management plan. It can also provide

② Steps in socio-economic baseline survey

vital information to the project at the implementation and evaluation stages as shown below:

In general, the planning and implementation of the baseline survey takes the following steps:

a. Determination of key data and information
b. Determination of the survey method
c. Preparation of questionnaires
d. Determination of sample size and sampling method
e. Preparation of operation plan of entire survey period
f. Selection and training of enumerators
g. Field survey
h. Data processing and analysis
i. Report preparation

③ Key data and information

It is necessary to determine specific key data and information needed for achieving the objectives of the baseline survey. For the purpose, the first step to be taken should be to collect and study any relevant existing documents such as:

a. reports from relevant projects or programs
b. relevant research and discussion papers
c. relevant policy documents and strategy papers

④ Survey methods

The information needed for the formulation of watershed management plan can be broadly categorized into three: social and economical data of different locality; individual household characteristics; and felt needs and interest of individuals. In line with the information characteristics, the socio-economic baseline survey should be conducted through three different surveys as follows:

In the context of watershed management, the key information usually includes some or all of following:

a. social factors of the people who are affected by watershed degradation (including gender roles)
b. felt needs and common interest of people
c. how people use and manage watershed resources
d. issues relevant to watershed degradation and the relative importance
e. how different people perceive the issues
f. how the issues are being tackled

a. Administrative survey

This survey collects and compiles the data and information on socio-economic as well as physical characteristics of individual wards and VDCs. Because most of the data are unpublished or uncompiled, they must be obtained directly from the offices of District Development Committee, chairmen of VDCs and wards and/or from other key personnel.

b. Household survey

This survey attempts to obtain the characteristics of sample household from the heads or adult members of the sample households. The information should include family composition and their background information, resource utilization, crop production, etc. This survey is undertaken through direct interviews to sample respondents using questionnaires.

c. Household member survey

This survey attempts to clarify the gender differences of roles, concerns or interests, experiences of community activities, and recognition about watershed problem. This survey is also undertaken through direct interviews to sample respondents using questionnaires.

⑤ Preparation of questionnaire

a. Survey items

There should be separate questionnaires for the three kinds of survey, reflecting the characteristics of information needed.

The survey items should be selected considering the key data and information already decided. In choosing the items, it is important to be selective and realistic about the amount of information that can be analyzed. If one attempt to address too many questions, it may not be possible to answer any of them satisfactorily. It would be better to answer a few question properly, while bearing the other in mind.

If there are many competing key questions, one way to select those that should be addressed is to use the following criteria:

- Can the question be answered ?
- What is the importance to the watershed management plan of answering the question ?
- What is already known about the issue ? Is it worth more survey ?

It is also important to be flexible, so that questions can be altered, deleted or added during the process of questionnaire construction, if necessary. Items surveyed by JICA Development Study are referred to.

(a) Questionnaire for Administrative Survey

The questionnaire used by JICA was prepared in a form of data presentation. (see the Development Study Reports on Socioeconomic Baseline Survey)

i. Area and location
   - Settlement, distance to major towns & land use.

ii. Demography
   - Households, ethnic group composition, population,

age distribution, educational level, occupation, migration, etc.

iii. Community organisation

iv. Availability of public facility
   - School, health facility, drinking water supply, electricity, etc.

v. Agriculture / livestock
   - Dominant cropping pattern
   - Major crops grown
   - Crops that are in deficit or surplus
   - Major horticulture crops grown
   - Major livestock raised

vi. Forest
   - Number of community forest and the status
   - Forest products sold

vii. Cottage industry
   - Number of households involved in the selected types of cottage industry

viii. Natural disasters in the past
   - History of natural disasters and the damage in the past (landslide, floods, forest fire etc.)

xv. Development projects
   - Features of projects undertaken in each ward

(b) Questionnaire for Household Survey

Examples of the questionnaire are given in the Development Study Reports on Socioeconomic Baseline Survey.

i. General information
   (i) Detail of respondents (name, age, sex)
   (ii) About family member
      • Total family member
      • Sex, age, education & occupations

- Organizational membership of family members
- Temporary absentees among family members

(iii) Cash income sources

(iv) Length of settlement

ii. Living Condition

(i) Sources, distance and sufficiency of Drinking Water

(ii) Sources and availability of Fuel

(iii) Annual consumption of fuelwood

(iv) Distance to Fuelwood sources

(v) Food availability at home and deficit period

(vi) Health and family planning

(vii) Availability of toilet facility

iii. Agriculture

(i) Khet and Bari land area owned, rented, and leased

(ii) Frequency and the area of farm land affected by disasters

(iii) Cropping Pattern in Khet & Bari land

(iv) Cultivated area, production, disposal and selling price of major crops

(v) Major crop damage

iv. Livestock / Animals

(i) Livestock nos. and types.

(ii) Main feed & Sufficiency

v. Forests

(i) Participation in community forest

(ii) Ownership of private forests

(iii) Type and ownership of horticultural trees

(iv) Other trees privately owned

In the JICA Development Study, possible answers to each question should be listed on the questionnaire and

b. Pre-testing of questionnaires

Pretesting is the final stage in questionnaire preparation and one of the most important. A draft questionnaire should be used for the pretest to identify flaws on the contents as well as the format. The questionnaires should be revised, if necessary, as a result of the pretest.

precorded for efficient survey and easy data entry and analysis.

(c) Questionnaire for Household Member Survey

Examples of the questionnaire are given in the Development Study Reports on Socioeconomic Baseline Survey.

i. Participation and engagement of household members (adults) in various activities.
ii. Activities that household members want make it easy.
iii. Degree of present concerns / awareness of household members for given topics.
iv. Experience of participation in collective activities and receiving external support for given topics.
v. Willingness to participate in collective activities of given topics.
vi. Importance of forest and proposed measures to improve it.
vii. Proposed preventive measures for landslide.
viii. Proposed measures to reduce terrace destruction.

In the JICA Development Study, possible answers to each question should be listed on the questionnaire and precorded for efficient survey and easy data entry and analysis.

The analysis of pretest should focus on all aspects of the questionnaires, such as:

(a) question wording,
(b) question order,
(c) redundant questions,
(d) missing question,
(e) inappropriate, inadequate, redundant, or confusing response categories,
(f) poor scale items, and
(g) insufficient space for answering open-ended questions.

In addition, the time required for completing the survey should be checked to avoid lengthy questionnaires that will alienate respondents. Further, comments and opinions from respondents should be solicited and integrated in the revision of the questionnaires.

The pretest should be conducted in the same manner as the final survey. The respondents should have the exact characteristics in the final survey so that they should be randomly selected in the survey area. In general, two or three pretesting will be enough for the initial pretesting. If much correction is required, an additional pretesting should be carried out.

⑦ Survey sampling

a. Determination of sample size

(a) Statistical method

The equation used for finding the statistically appropriate sample size is shown below:

$$\frac{(Py)*(Pn)+Std.Error^2}{Std.Error^2+\frac{(Py)*(pn)}{N_1}}=N^{1}$$

Py and Pn represent the proportion of people responding to each of the categories in a dichotomous variable.[2] Since there is no real data to examine before starting the baseline survey, we have to estimate the probable values of Py and Pn. But, the estimation of Py and Pn that would work for every question in the survey is an almost unachievable task because the distribution of responses will vary by question. The easiest and safest (the most conservative) way to arrive at a value that would work for all question is to set both Py and Pn at 0.5 to maximize the value of Py*Pn.

Standard error is determined by the following formula:

$$\frac{Acceptable\ level\ of\ error}{t\ distribution\ coefficient}=Standard\ Error$$

The t distribution coefficient is determined by the chosen level of confidence, i.e., 1.65 for 90%, 1.96 for 95%, 2.58 for 99%, and so on. For a confidence level of 95% and 5% of acceptable error, the standard error² is $(0.05/1.96)^2$ or 0.0006507.

N^1 is the size of universe[3], the total number of the unit of analysis.

1 There are other, slightly different version of this formula, although all principally do the same thing.

For example, when an absolute error of plus or minus 5% at the 95% confidence level is expected and the total number of households in a target ward is 100, the appropriate sample size is 80 or 80% of the universe, as follow:

$$\frac{0.5*0.5+0.0006507}{0.0006507+\frac{0.5*0.5}{100}}=80$$

Needless to say, the sample size of 80 in the above example is the maximum number of sample size under the given error and confidence level. It shall be noted that the proportion of sample size tends to decrease as the size of universe increases. For instance, when the universe is 10,000, the calculated sample size is 371 or 3.7% of the universe under the same error and confidential level as the above example. This indicates that sample size depends on how the sample may have to be subdivided during data analysis, e.g., either VDC level or ward level.

2 A dichotomous variable is one which has only two response choices, such as "Yes" and "No" or "Male" and "Female". Even multiple-category or continuous variables can be thought of as dichotomous.

3 The sum total of all the units of analysis is called "universe". The unit of analysis in the context of watershed management in Nepal includes a ward, a VDC, a model area, and a caste.

(b) Practical method

Statistically speaking, the size of the sample depends on the size of the universe to be sampled, given error and confidence level. There are many considerations, however, that come into play when designing a baseline survey. Compromises are always made on sample size based on the availability of resources such as time and money.

For example, a ward is the smallest level of analysis in the JICA Development Study because of the intention to integrate the survey results into participatory planning at the implementation stage. Because the average total number of households per ward is about 70 in the model areas, the sample size calculated is 59 or 84% of the universe when an absolute error of plus or minus 5% at the 95% confidence level. There are 20,759 households in 307 wards in the model area. If 84% of total households is taken as samples in each ward, the total number of sample households is 18,113 which appears rather unrealistic. The JICA Development Study sampled 30% of the total number of households in a ward. In view of this, a realistic number of samples is determined in the following manner.

a. In the case of a ward being the survey subject:
   - (i) Total number of households of 100 or more: 30 households (upper limit)
   - (ii) Total number of households of 15 to 99: 15 households
   - (iii) Total number of households of less than 15: all households

b. In the case of an area (watershed) being the survey subject: 100 to 400 households

b. Sampling method

Sampling of households in target areas will be done at random. To do so, the lists of households in all target wards must be prepared prior to the sampling, with the help of ward chairmen or other key personnel. Then each household were assigned a number. The sampling should be carried out based on random numbers generated by a calculator.

⑧ Preparation of operational plan

Operational plan should be prepared to monitor and control the progress of the survey as well as to ensure the timely completion.

It should be a bar diagram for the entire survey period: from field survey to the preparation of database and report. The manpower and cost to be required for the survey should also be estimated.

In case the survey is conducted in remote area, following logistic plan should be also made up separately:

a. How the filled questionnaires shall be sent to office.
b. How the communication between survey teams and the head office shall be maintained.
c. How the safety of the survey team shall be ensured.
d. How the lodging and food shall be arranged

⑨ Field survey

a. Selection and training of enumerators

Preferably enumerators should be adaptable, friendly, responsible, and familiar with interview survey.

(a) Selection of enumerators

The selection should be carried out in two-steps: screening of application documents and an interview. Criteria for the screening includes qualification, experiences of similar work, and the area from where they come. For candidates who passed the screening, an interview will be conducted to test their technical capability, personality, and ways of handling problems.

(b) Training of enumerators

Enumerators must be familiar with all the words in all the question and must understand all instructions in the questionnaire. Meanwhile, they may face with incomplete, vague, or no answers during field survey. In this case, a probe or follow-up question is necessary to lead the respondents to answer more completely and clearly. Probe techniques should be taught to the enumerators during training. They include:

i. Repeating the question.
ii. Repeating the answer.
iii. Indicating understanding and interest to respondent's answer.
iv. Giving a neutral question or comment to the respondent like "how do you mean that?"

Training consists of in-class orientation and field training. The in-class orientation teaches the enumerators the following matters:

- the subjects, wording, and terminology in the questionnaires,
- map identification and sketching techniques,
- interview and data collection techniques (including probes)
- social, economic, cultural and administrative background of the survey area,
- local measurement units and the conversion into standard units,
- duties and responsibility of enumerators,
- quality control of data, and
- survey administration.

The in-class orientation should be undertaken through lectures, group discussions, role play, question and answer sessions supplemented by lectures and demonstration of communication skills.

The field training will be done at the end of the training course. This should be basically on-the-job training. After completion of few surveys by enumerators, the filled questionnaires should be checked by trainees. Trainees should give comments and suggestions and answer to the questions of enumerators.

b. Interview techniques

The interview is a special case of social interaction between two persons and as such is subject to some rules and restrictions. Apart from the possible biases and errors that stem from the questionnaire instrument itself or sampling design, the social nature of the interview has the potential for all sorts of bias, inconsistencies, and inaccuracy. Followings are some interview techniques that should be followed:

(a) When approaching respondents

- tell the respondents who the interviewer is and whom he or she represents.
- tell the respondent the objectives of the survey.
- tell how the respondent was chosen, emphasizing that the respondent was singled out randomly from the survey area.

(b) When conducting the interview

- ask questions as worded or as explained in training sessions.
- questions should be repeated when respondent request repetition or when his or her answer clearly indicates misunderstanding.
- do not lead respondents.
- ask audiences, if exist, to refrain intervention in interview.
- make the respondent feel comfortable by, for example, talking about respondent's home and family.

c. Quality Control of Solicited Information

Missing answers and unrealistic figures in questionnaires are often detected during data entry and analysis stages. Such errors should be avoided as much as possible because they affects the quality of the survey.

The checking mechanism used in JICA Development Study is described below as a reference.

The following three stages of checking mechanism was employed by a local contractor working for the socio-economic baseline survey.

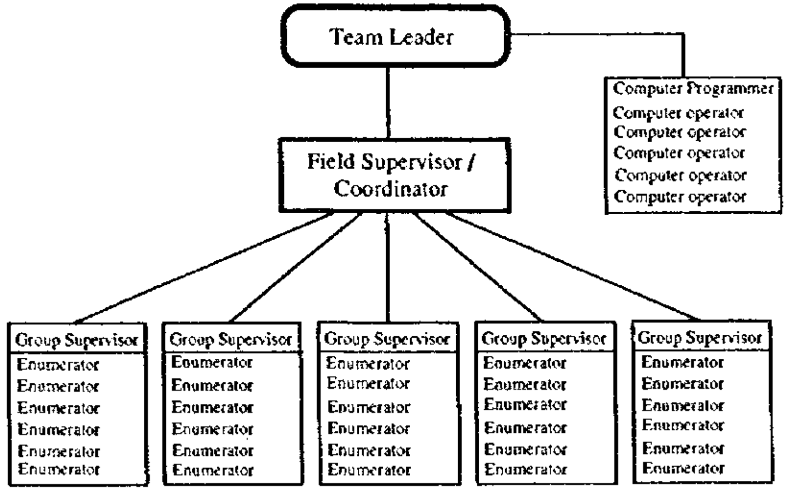


Fig. 10 Survey Organization (an example)

(a) Enumerators were divided into five groups and a group supervisor was assigned in each group as shown in Fig. 10. The initial checking of filled questionnaires were done everyday by the group supervisor in the field. He or she examined the questionnaires to find out missing information and unrealistic figures.[4] If questionnaires were found incomplete, it was send back to the responsible enumerator for correction. Re-survey was sometimes carried out to correct the errors.

(b) A field coordinator was stationed in the field office established near the survey site. The questionnaires passed the initial checking were sent to the field office for secondly checking by the field coordinator. Incomplete questionnaires,

4 Because of the large number of filled questionnaires, the group supervisors could check only 60% of them.

if detected in this stage, were sent back to the responsible survey group (enumerator) for correction. In addition, the field coordinator passed his comments and suggestions to the group so as not to repeat the same mistakes.

(c) The questionnaires were sent to the head office of local contractor in Kathmandu. The tertiary checking was thoroughly carried out here by looking over each completed questionnaire, searching for incomplete answers, cases where questions were misunderstood, answers that could not possible be correct, answers that conflict with answers from other questions, and so forth. Comments, suggestions, and inquiries about the incomplete answers were regularly sent to the field office for incorporation and further improvement of the survey quality.

⑩ Database Construction

a. Data Entry

(a) Preparation for data entry

In open-ended questions, the answers should be modified to some form suitable for analysis, the process is called as data reduction. Data reduction generally consists of coding the data, often to make them suitable for computer analysis. But in case of closed-ended questions for which the answer categories are known and precoded in advance or questions for which the answers are expressed numerically, data reduction is unnecessary. In the socio-economic baseline survey conducted by JICA development study, almost all questions are closed-ended ones and thus data reduction was not needed.

(b) Data entry

The data obtained through the baseline survey should be entered into computer.

b. Data Cleaning

Checking of illegal entries, called data cleaning, should be done to improve the quality of database.

There are basically two ways of data cleaning: (1) by proofreading printouts of the entire data file and (2) through the use of database program. The latter method is much easier and timesaving. One should be aware that possible entry data cleaning is only a compromise measure that is no substitute for complete verifying and proofreading. The only errors that can be detected by possible-erntry data cleaning are those involving illegal punches.

⑪ Presentation of Survey Results

It is necessary to present the results of the survey to readers in an understandable and convincing form.

a. Presentations in tables and graphs

The results should be at first presented in tabular form. The formats should be pre-determined to save the time required for the data processing. By using database, it is easier to make desired tables. Graphs should also be used for easy understanding of the results.

Examples of table presentation are given the Development Study Reports on Socioeconomic Baseline Survey.

b. Use of GIS

The socio-economic baseline survey provides various data and information of different locality in tabular form or chart. But such presentation may not depict the information accurately and effectively. A computerized GIS is a powerful tool to portray the socio-economic status on maps in order to have a more realistic presentation of the situation. It is also an effective means in abstracting socio-economic information at a glance and can be used for the planning of the watershed management.

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3. Toolkits : A Practical Guide to Assessment, Monitoring, Review and Evaluation, Save the Children (1995)
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Related Problems and Their Causes

(Objectives)

To clarify problems concerning watershed degradation in the Study Area and to analyse their causes on the results of actual field surveys. Flow of problem clarification and analysis is as shown in Fig. 11.

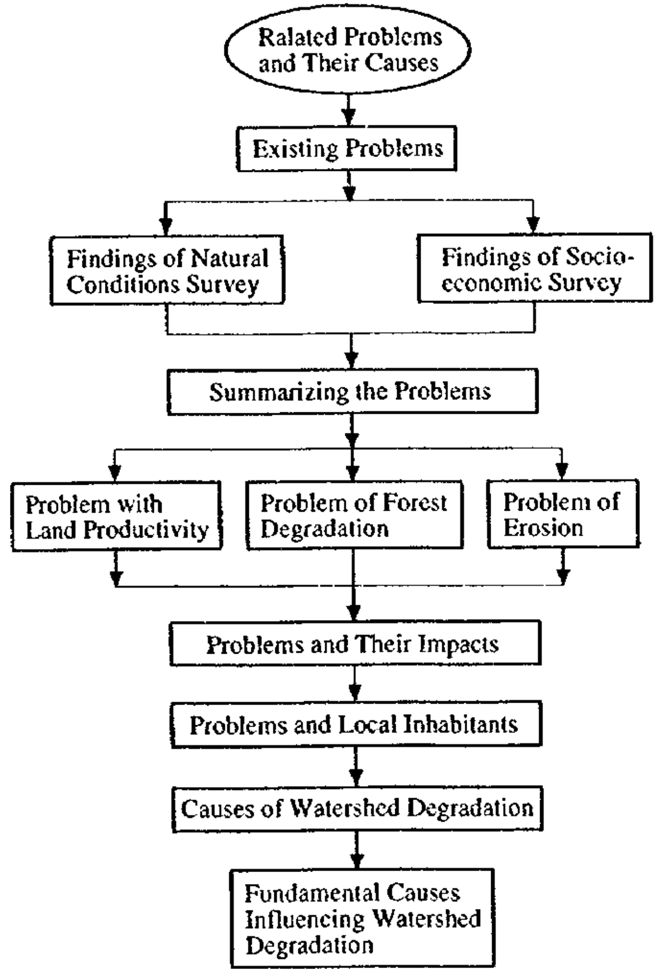

Fig. 11 Flow of Problem Clarification and Analysis

(1) Findings of Natural Conditions Survey

The problems associated with the types of land use and forest conditions, etc. is clarified. The items below are those analysed for the Model Areas. In the case of items other than those discussed below, they should also be analysed.

① Types of Land Use

From the land classification, conducted using soil survey results, the type of current land use is clarified.

a. Using the results of soil survey, land classification as mentioned in Table 13 is conducted.

Table 13 Land Classification (An Example)

Class	Site Classification
1	Not suitable for agriculture land use. (The land can't be cultivated) Can be used for stock raising and forestry
2	Agriculture land use can be done, but a definite yield can't be realized without intensive land improvement (irrigation, terrace improvement, etc)
3	Agricultrure land use can be done, and a definite yield can be obtained. At some places, an appropriate yield may be obtained.

b. Applying the land classfication as mentioned in Table 13 to soil and slope, the degree of farming on land unsuitable for farming is established.

Table 14 Site Classes Based on Soil and Slope Classes (An Example)

Soil unit	Slope classes (%)		
	Gentle (0 - 15)	Medium (15 - 30)	Steep (30 -)
Dystric/Eutric/Calcaric Fluvisols	3	2	1
Calcaric Fluvisols	2	2	1
Dystric Regosols	3	2	1
Calcaric Regosols	2	1	1
Dystric Leptosols	2	1	1
Rendzic Leptosols	3	1	1
Eutric Cambisols	3	3	2
Dystric Cambisols	3	2	2
Humic Cambisols	3	3	2
Haplic Luvisols	3	3	2
Haplic Kuvisols/Alisols	3	2	2
Haplic Alisols	3	2	1
Haplic Acrisols	2	2	1
Others	1	1	1

c. The land use and vegetation and the land suitability classification maps are overlaid using GIS to establish the land suitability classification results for each type of land use.

d. The survey results for the Model Areas, for example, indicate that 25% of bari land and 10% of khet land is currently located on land unsuitable for farming.

② Problems with forest

a. Problems concerning soil and water conservation functions of forests.

(a) Condition of crown coverage is investigated through photo interpretation.

(b) Crown coverage classes of LRMP could be used.

0 - 10%	Problematic vis-a-vis soil and water conservation
10 - 40%	Care is necessary concerning soil and water conservation
40 - 70% 70% -	No serious problem concerning soil and water conservation

(c) Forest condition is investigated through forest survey (plot survey). Survey items could be as follows.

i. Condition of understory vegetation
ii. Traces of grazing
iii. Traces of forest fire

b. Problems concerning forest resources utilization

(a) Forest type maps are prepared through photo interpretation and the land area of each forest type is determined. An example from Model Areas is as shown below.

Forest	Shrub	Grassland	Bari land	Khet land	Others	Total
18,362	490	2,259	11,663	4,365	4,004	41,143

(b) Demand and supply balance is examined as mentioned in (1) and (2) below using data from Basic Guidelines for Sub-Watershed Management Planning, prepared by DOSC or other available material on the subject area.

i Food Requirement and Supply

(i) Requirement

Category	Population A	Requirement per capita B	Total requirement kg (ton) A × B = C
Paddy Wheat Maize Millet			
Total		230 kg	

(ii) Supply

Land use	Category	Area of cultivation (ha) D	Yield (ton/ha) E	Total food production D × E = F	Harvest loss (ton) G	Total food available (ton) F − G = H
Bari land	Paddy					
Khet land	Wheat Maize Millet					
	Total					

(iv) Harvest loss

Category	Harvest loss (%)	Seed storage (kg/ha)	Recovery loss /MT	Moisture loss /MT
Paddy	10	55	37.15	1.75
Wheat	10	100	4.00	1.00
Maize	10	20	3.00	1.00
Millet	10	20	7.00	-

(iii) Yield of main crops

Area	Paddy kg/ha	Wheat kg/ha	Maize kg/ha	Millet kg/ha
Parbat N	1,841	1,303	1,140	1,342
Parbat S	1,972	1,192	1,259	1,300
Kaski E	2,087	1,075	1,011	1,174
Kaski N	2,117	1,029	1,071	1,160
Kaski W	1,642	941	1,089	1,241
Model Area	1,914	1,151	1,116	1,249
Kaski D.	2,100	1,414	1,558	1,136
Parbat D.	2,204	1,305	1,600	1,083
Western Hill	2,048	1,375	1,519	1,075
W Terai	2,412	1,491	1,778	1,042
Western D.R.	2,270	1,435	1,540	1,073
Nepal	2,402	1,407	1,598	1,079

Source:

Agricultural Development Office in Parbat District and Kaski District VDC/Ward rofile prepared by Multi Disciplinary Consultant (P) Ltd. (1996)

Statistical Year Book of Nepal 1995: CBS HMG

(v) Demand and supply balance

Category	Supply H	Requirement C	Surplus/Deficit H-C
Paddy Wheat Maize Millet			
Total			

ii Fodder

(i) Requirement

Category	Number A	Conversion Factor	BLU Total A × B = C	Cattle Animal unit D	Total DM requirement C × D = E
Milking cow		0.8		2.35	
Buffalo		0.9		2.35	
Sheep		0.06		2.35	
Goat		0.06		2.35	
Pony		0.9		2.35	
Total		—		—	

(ii) Supply

Category	Area (ha) F	DM production ton (kg)/ha G	TDN H	Production (ton) F × G = I	TDN in ton (ton) I × H = J
Paddy		572 kg	0.66 ton		
Maize		715	0.28		
Wheat					
Millet		1,530	0.61		
Fodder tree		0.065 ton	0.05		
Plantation		1.87	1.44		
Shrub land		1.00	0.77		
Grazing		1600 - 8000 kg	0.41		
Forest		0.66 ton	0.86		
Total					

(iii) Demand and supply balance

Category	Supply J	Requirement E	Surplus/Deficit J - E

iii Demand and Supply of Timber and Fuelwood

Category	Demand (A)	Supply (B)	Surplus/Deficit
	Population × Fuelwood demand	Area × Yield	(B) – (A)
Timber	Population × 0.086 = A	Area × 1.5 = B	
Fuelwood	Population × 588 = A	Forest × 3.0 = B1 Shrub × 0.5 = B2 Fodder × 0.5 = B3 Agriculture residue × 0.4 = B4	
		Total B	

[Basic Guidelines for Sub Watershed Management Planning]
B.D.Shrestha; 1994 (DOSC, HMGN)

③ Problems with soils

From the result of soil survey (soil sample analysis, soil properties analysis, etc.) the problems with soils could be clarified.

In the Model Areas, for example, from the results of soil sample analysis the following items were evaluated in connection with soil productivity.

- CEC (Cation exchange capacity)
- Soil texture
- Base saturation (B-S)
- pH

a. CEC (Cation Exchange Capacity)

(a) Meaning of CEC

CEC stands for cation exchange capacity. Colloids, which are composed of clay and organic matter in soil, have a minus electric charge and have the capacity to adsorb positively charged ions such as calcium, magnesium, potassium, sodium and ammonia, etc. The amount of adsorbed positive ions is the CEC, and the higher this value becomes the greater is the capacity to hold cations. The CEC is determined by the type of clay minerals and the amount of organic matter in the soil, and it normally becomes higher when there is much clay minerals and organic matter in the soil. Conversely, the CEC value will go down in the case of sandy soil or when there is little organic matter.

(b) Standard value of CEC

A high CEC level is desirable in that it leads to good soil fertility, however, because the CEC is determined by the basic nature of the soil, it is difficult to raise the level in the same way as with cations or phosphoric acid.

For this reason, it is necessary to set a target value and try to approach it, although there is little meaning in

b. Soil texture

c. Base saturation percentage

investigating the quality of soil based on this. It is best to use the CEC value as basic data for applying appropriate fertilizer or carrying out soil improvement. For example, in the case of sandy soil with a low CEC value, fertilizing in one go will lead to excessive fertility, but it is better to fertilizer a little at a time on numerous occasions and use a fertilizer that has a delayed effect.

Here, the soil texture is used as an index for the permeability as shown below.

Permeability Class	Soil Texture Type
High	SC; LiC; SiC; HC
Medium	SCL; CL; SiCL
Low	SL; FSL; L; SiL; S; LS

- Meaning of base saturation percentage

The base saturation percentage is obtained by dividing the sum total of the exchangeable cations Na^{+}, K^{+}, Ca^{+} and Mg^{2+} by the CEC value. In addition to these four main exchangeable cations, there are also hydrogen ion (H^{+}) and aluminum ion (AL^{3+}) in soil, so the base saturation percentage is a measure of the ratio of exchangeable cations.

If there are abundant exchangeable cations and the base saturation percentage is high, the cations will work favorably for crops, etc. and the soil can be described as productive. The base saturation percentage is also naturally linked to pH; the pH goes up when the base saturation percentage is high, and it goes down with an acidic reaction when the base saturation percentage is low.

Generally speaking, the pH value will be 6.5-7.0 when the base saturation percentage of soil is 100%, around 6.0-6.3 when the base saturation percentage is 80%, and around 5.5-5.8 when the base saturation percentage is 60%.

One thing that requires attention, however, is that when the soil contains the soluble ions of Na, K, Ca, Mg, etc., these will be counted as exchangeable ions, meaning that the base saturation percentage may sometimes exceed 100% or differ even in the same soil sample.

- Standard Value of Base Saturation Percentage

The generally given standard for obtaining good yields in normal crops (rice family plants such as rice grown in a dry field, wheat and soybeans, etc.; bean family plants such as beans, kidney beans and groundnuts, etc.; potato crops such as sweet potatoes, white potatoes and taros, etc.) is 60-80%, but in soil where the CEC is 15 or less, such a base saturation percentage may result in a deficiency of lime in the crops. This is because crops absorb lime during growth, in turn causing the pH value to fall and suppressing the crop growth.

There are cases on intensive farmland where the CEC exceeds 50%, but this is due to high concentrations of organic matter and, when the organic matter is exhausted, there is a risk of bases (cations) becoming too excessive. In such cases, it is necessary to make a reduced exchange capacity the standard.

From this it can be seen that in the Model Areas, which are located in hilly area and are characterized by soil with a low CEC, it is necessary to supply large quantities of bases and on numerous occasions. Also, it can be seen that it is necessary to supply organic fertilizer.

d. pH

pH is one of the most basic elements of soil chemical diagnosis. The combination of soil constituents and the solubility of soil will vary depending on the pH conditions of the soil, and even the physiological state of plant roots and microorganisms are affected by pH in the soil.

It is possible to find out a lot about soil conditions just through carrying out pH measurements, in addition to studying the results of a site survey and interview survey.

Measurement of pH in soil is carried out by adding pure water (pH 5.6) or 1-normal potassium chloride (1 N KCL) to the soil and measuring the pH value with a pH meter. The measurement is generally that obtained using pure water (pH (H_2O)), but the measured value (pH (KCL)) obtained using 1-normal potassium chloride (1 N KCL) makes it possible to extract AL^{3+} and other hidden acidic substances. The pH (H_2O) value is normally lower than the pH (KCL) value, and a large difference between the two indicates a high content of organic matter, and so on.

(a) Meaning of pH

pH indicates the size of the hydrogen ion concentration (H^+) in soil and, because the two values are inverse numbers, the pH is lower the higher the hydrogen ion content becomes. pH is expressed between 0-14.0, and a value of 7.0 indicates neutrality. The pH range observed in soil is relatively narrow, with pH 4-9 being the norm. The classifications of acidity and alkalinity are generally as indicated in the table below.

In areas of much precipitation, exchangeable cations are unstable and there is almost no alkaline soil.

PH	evaluation	pH	evaluation
>8.0	strong alkaline	6.0-6.5	slightly acidic
7.6-7.9	weak alkaline	5.5-5.9	weak acidic
7.3-7.5	slightly alkaline	5.0-5.4	strong acidic
6.6-7.2	]neutrality	<4.9	very strong acidic

(b) Standard value of pH

Weak acidic soil does not pose any problems, but when soil becomes very acidic, hydrogen ions can directly hinder the growth of plant roots. In indirect terms, aluminum ions that are harmful to vegetation growth are generated in acidic soil. Furthermore, acidification makes it difficult for soil to absorb nutrients such as nitrogen, phosphoric acid, potassium, calcium and magnesium, etc.

When soil becomes too acidic, minute quantities of elements such as manganese, iron, copper and zinc, etc. sometimes become soluble and too excessive. Conversely, in the case of alkaline soils, it becomes difficult for soil to absorb manganese, iron, copper and zinc, etc., leading to deficiencies in such elements.

Generally speaking, a pH value of between pH 5.0-7.0 is desirable, but the optimum value will slightly differ depending on the type of crop.

The general standards to look for regarding pH are shown in the table below. However, combinations with aluminum and other substances which hinder growth and cause low pH values are not considered in these values.

Degree to pH	Species of plant	
	Vegetables and potatoes	Grain·Grass and Others
Strongly for low pH (4.0-5.0)	Taro Potato	Tea plant. Tobacco. Rice. Buckwheat. Pineapple
A little strongly for low pH (4.5-6.0)	Sweet potato. Turnip. Japanese radish. Runner bean. Carrot. Cucumber. Parsley	Wheat. Corn. Millet. Soybean Nepia Grass. Oats
A little weakly for low pH (5.5-6.5)	Tomato. Aubergine. Cabbage. Cauliflower. Celery Pea bean Melon	Adzuki bean. Chinese milk vetch
Weakly for low pH (6.0-7.0)	Spinach Onion Leek Burdock Asparagus Red pepper	Barley Rye Cotton

(pH (H_2O) value)

Moreover, an example of the results of the soil sample analysis in Model Areas are given below.

Table 15 Soil Properties of Model Areas: An Example

Item	Kaski North	Kaski East	Kaski West	Parbat North	Parbat South
Cation Exchange Capacity (CEC)	9 - 15	around 10	around 10	high	low
Soil Texture	loam/ sandy loam	loam	clay/silt/ loam	clayey loam	loam
Base Saturation (B-S)	around 10	5 - 40	low	low	low
pH	around 5.0	around 5.0	5.5 or less	alkaline/acid	around 5.0

From the results given in the table, the following observations can be made.

i The CEC value indicating the nutrition retaining capacity is low and, therefore, such slow effect fertiliser as compost should be more effective.

ii The soil texture generally shows a high permeability, allowing sufficient groundwater supply.

iii The level of base saturation indicating the soil fertility is low.

iv The level of fertility may further decline without proper management as the soil fertility in the Model Areas is low to start with because of erosion.

④ Problem of erosion

a. The actual condition of surface erosion is investigated through reviewing the existing references or by conducting simple experiments such as installation of erosion pin plots, for example. (For details on erosion pin experiment conducted under this study refer to ③ of (6) Erosion Survey under the heading "Understanding of Current Conditions".

(a) Actual soil loss by land use.

The complete data on the soil loss by surface erosion is unavailable in Nepal. The available data from the Study Area and other parts of the country as well as erosion pin survey results are as mentioned below.

Table 16 Actual Soil Loss by Land Use

Land use	Soil loss (ton/ha/year)	Remarks
Forest	0.4 - 10.0	Figures in ( ) are from erosion pin measurements conducted under the study.
Grass land	7.7 - 200 (110)	
Bari land	17 - 100 (60 - 70)	
Khet land	2.0 - 10.0	

(b) Tolerable soil loss

Tolerable soil loss for the Study Area was estimated at 10 ton/ha/year. Soil loss in dense forest and Khet land was not higher than tolerable soil loss.

b. Landslide

The relation between landslide occurrence and land use and slope categories are clarified based on the results of landslide survey.

(a) Landslide and land use

Landslide occurrence by land use category could be determined by overlying landslide distribution maps on land use maps. Landslide distribution by land use category, for example, was determined for Model Areas and is shown in the table below.

Table 17 Landslide Distribution by Land Use
(An Example)

(Landslide/100 ha)

Land use	Small landslide	Large landslide	Total
Forest	0.94	0.27	1.21
Shrub	1.45	0.18	1.63
Grassland	5.54	1.44	6.98
Bari land	1.65	0.25	1.90
Khet land	0.41	0.44	0.85

(b) Landslide and slope

Landslide occurrence in each slope category could be determined by overlying landslide maps on slope maps. Landslide distribution by slope category for Model Areas, for example, were determined and is shown in the table below.

Table 18 Landslide Distribution by Slope Category
(An Example)

(Landslide/100 ha)

Slope category (%)	Small landslide	Large landslide	Total
0 - 3	0.0	0.0	0.0
3 - 15	0.1	0.0	0.1
15 - 30	0.32	0.0	0.32
30 - 60	1.52	0.41	1.93
60 -	2.24	0.26	2.50

c. Hazard

Appropriate countermeasure are decided according to the location and level of hazard of such mass movements as landslides, slope failures, etc. which affect the lives of local people.

The level of hazard by land use type is determined by overlying the hazard maps on land use/vegetation maps. The level of hazard by land use for Model Areas, for example, was summarized and are shown in Table 19.

Table 19 Land Use Categories and Level of Hazard (An Example)

ha, (%)

Land use	Low Hazard	Medium Hazard	High Hazard	Total
Forest	15,147 (80)	3,654 (19)	24 (1)	18,825 (100)
Shrub	269 (51)	217 (42)	37 (7)	523 (100)
Khet land	5,489 (70)	2,316 (30)	28 (0)	7,833 (100)
Bari land	2,554 (22)	8,057 (69)	1,051 (9)	11,662 (100)
Grass land	225 (10)	1,263 (55)	812 (35)	2,300 (100)
Total	23,684 (58)	15,507 (38)	1,952 (5)	41,143 (100)

(2) Findings of Socioeconomic Survey

The results of socioeconomic survey will show various problems which affect the lives of local inhabitants in the subject area.

Main problems and analysed items for Model Areas, for example, were as follows:

① Shortage of food

a. Can be clarified through references on production and consumption balance.
b. People's needs

② Shortage of fuelwood

a. Is clarified through fuelwood consumption data
b. People's needs
c. Existence of alternative energy sources

③ Shortage of fodder

a. Consumption by livestock
b. People's needs

④ Shortage of water

a. Water shortage is clarified
b. People's needs
c. Access to water source

⑤ Disasters

a. Level and nature of disaster
b. People's needs
c. Absence/presence of countermeasure

⑥ Poverty

a. Working oppotunity
b. Heavy work load
c. Farmland area

d. Fertilization
e. Shortage of resources
f. Cash income
g. Population
h. Education
i. Health and hygiene
j. Agriculture extension
k. Soil conservation projects

(3) Summarizing the Problems

The problems as clarified through socioeconomic survey and natural conditions survey findings have to be summarized.

An example of Model Areas is given below.

① Low land productivity
② Forest degradation
③ Widespread erosion

(4) Problems and Their Impacts

Degradation of the watershed environment has various impacts on the lives of the people living in the relevant watershed. Fig. 12 shows examples of the major causes and impacts of degradation of the watershed environment.

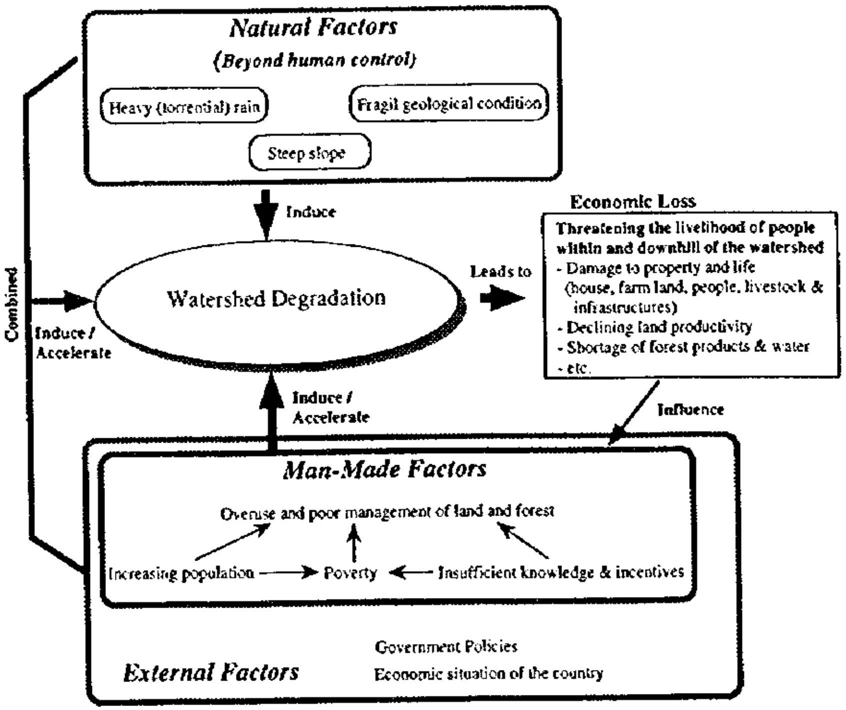

Fig. 12 Watershed Degradation and Its Implication

The causative factors of watershed degradation in an area could be largely classified into natural and socioeconomic (man-made factors).

Natural factors are characterised by the fact that they are normally beyond human control. In the Model Areas, for example, the topography is steep while a large part of the heavy annual rainfall is concentrated in the monsoon season.

In contrast, man-made factors can be improved. In the case of Model Aras, for example, these factors can be summarised as "the excessive use and insufficient management of land and forest resources" originating from population increase, insufficient technical and financial assistance and poverty, etc.

(5) Watershed Degradation and Hill Communities

People living in a watershed largely depend on the available resources in that particular watershed and their use of such resources is partly responsible for the degradation of the watershed environment.

An example of linkage between watershed degradation and hill communities in Model Areas is shown below.

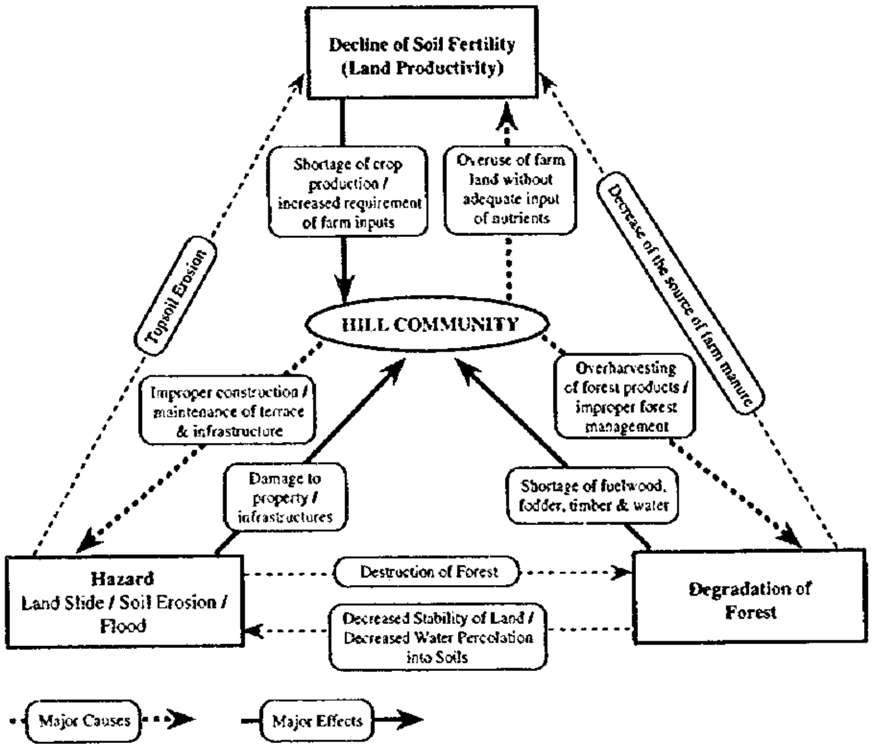

Fig. 13 Linkage Between Watershed Degradation and Hill Communities: An Example

Results from Model Areas, for example, are:

The main cause of the decline of land productivity on the part of local communities was found to be the excessive use of farmland without sufficient replenishment of the soil nutrients.

The problem of forest degradation was caused by the excessive use of forests and inadequate forest management and local communities are facing a shortage of firewood, tree fodder and timber.

The direct impacts of the activities of local communities on landslides, soil erosion and flooding include 1) the use of geologically fragile steep slopes as farmland, 2) the inadequate maintenance of terraces and 3) the lack of drainage facilities and the lack of treatment of cut and fill slope surfaces at roads and footpaths to prevent erosion.

(6) Causes of Watershed Degradation

The causes of watershed degradation are clarified through problem tree analysis method.

① Causes of decline of land productivity

The 3 main causes of land productivity decline in the Model Areas, for example, were found to be:

a. Overuse of farm land
b. Insufficient nutrient input
c. Washing away of soil nutrients by erosion

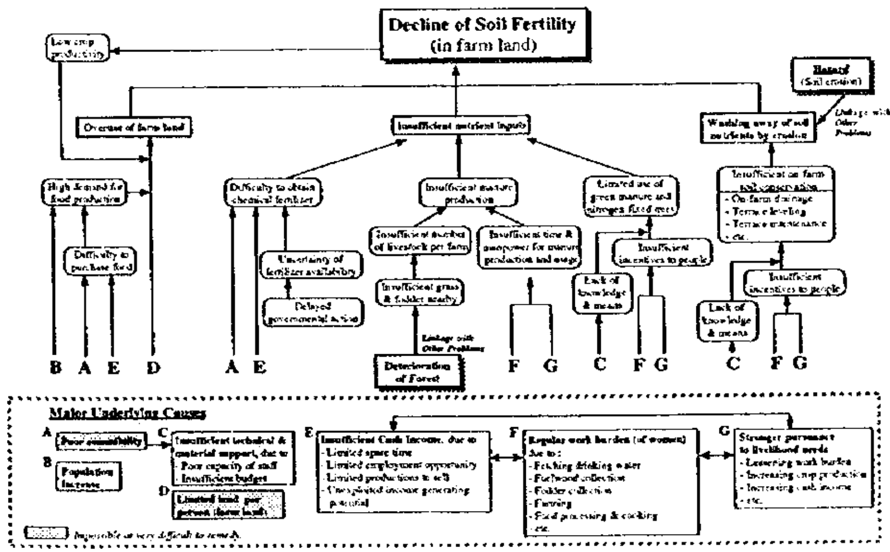

Fig. 14 Causes of Soil Fertility Decline of Farmland

② Causes of forest degradation

The main causes of forest degradation in the Model Areas, for example, were as follows.

a. Overharvesting of forest products
b. Inadequate protection and management of forest
c. Hazard (landslide, slope failure, etc.)

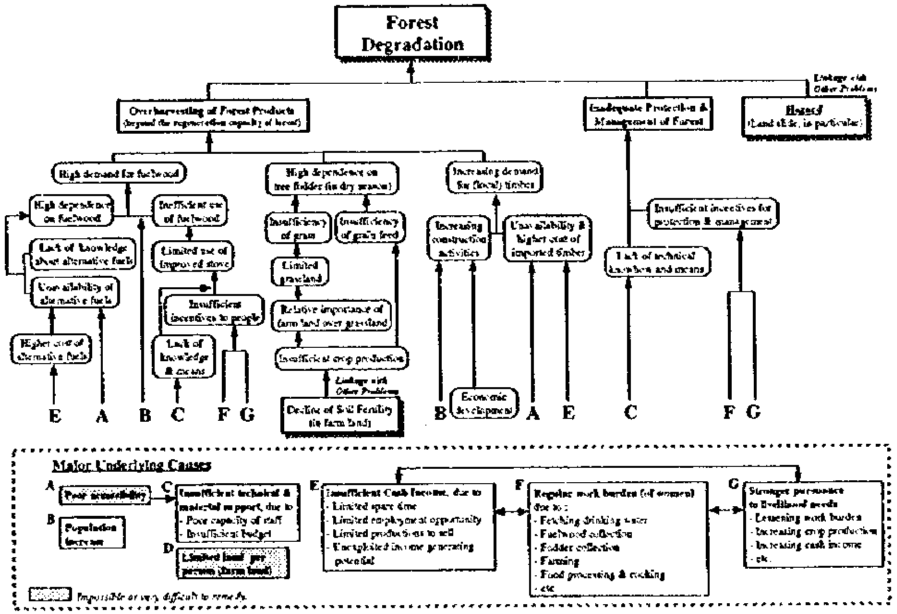

Fig. 15 Causes of Forest Degradation

③ Causes of natural disaster

The main causes of natural disasters in the Model Areas, for example, were as follows.

a. Degradation of forest
b. Inadequate prevention and rehabilitation measures

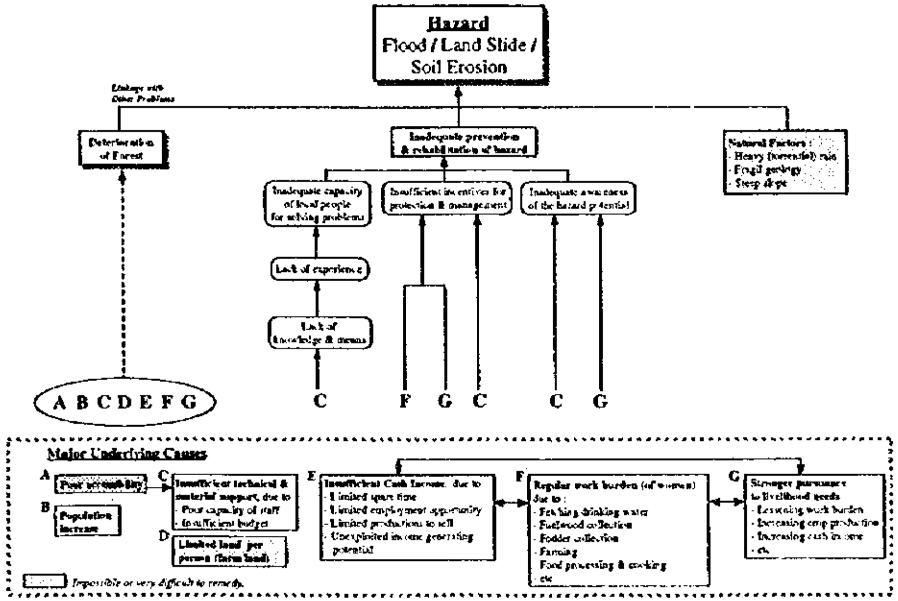

Fig. 16 Causes of Natural Disasters (Landslides/Soil Erosion/Floods)

(7) Fundamental Causes of Watershed Degradation

① Causes

The following seven fundamental causes are common to all problems of watershed degradation in the Middle Mountains of Nepal.

a. Poor accessibility
b. Population increase
c. Insufficient external support (technical and financial)
d. Shortage of farmland (compared to population size)
e. Insufficient cash income
f. Regular over-working
g. Priority of day-to-day needs

② Hidden causes of watershed degradation

Table 20 Hidden Causes of Watershed Degradation (Findings in the Model Areas)

Causes	Linkage with Watershed Degradation
1. Low Educational Level	- The planning and implementation of measures for watershed improvement may be obstructed by the acquisition, understanding and application of necessary technologies and information - Local people find it difficult to actively express their opinions at community meetings on watershed improvement activities
2. Emigration of People (particularly young men)	- The shortage of participants in watershed improvement activities makes it difficult to reduce the burden on women to allow them to participate in watershed improvement activities - Hinders the revitalisation of villages, resulting in delayed action to improve the watershed environment
3. Health Problems	- Worsens the shortage of labourers and participants in watershed improvement activities, increasing the burden on others - People have to use their spare time for paid work to pay the cost of medical treatment. As a result, the available time for watershed improvement activities is further decreased
4. Caste	- The organization of the community, important to implement watershed improvement activities, may be impeded