



FOOD AND AGRICULTURE
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OF NEPAL



UNITED NATIONS
DEVELOPMENT PROGRAMME



A RECONNAISSANCE INVENTORY OF
THE MAJOR ECOLOGICAL LAND UNITS AND
THEIR WATERSHED CONDITION IN NEPAL

MINISTRY OF FOREST, DEPARTMENT OF SOIL CONSERVATION AND
WATERSHED MANAGEMENT
INTEGRATED WATERSHED MANAGEMENT
TORRENT CONTROL AND LAND USE DEVELOPMENT PROJECT

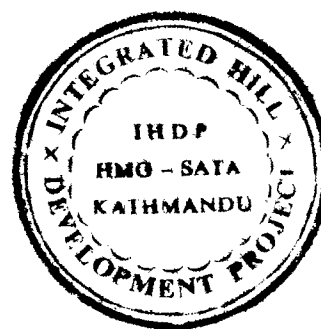
A Reconnaissance Inventory of

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IN NEPAL



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Department of Soil Conservation and Watershed Management

Food and Agriculture Organization

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FOREWORD

One of the major obstacles to the development of Nepal, or any other developing country, is its lack of knowledge of its lands and natural resources. (This report is an overview of the lands of Nepal. It was made expressly to support soil and water conservation planning.) In meeting this need however it was necessary to record the major characteristics of the key natural resources underpinning agriculture and forestry: topography, geology, vegetation, climate and soils.) This information is presented in an integrated format as components of specific units of land. The focus of the inventory work leading to this report was on units of land with the condition of the land and the individual resource descriptors of those units. The rationale for this approach is that it is the land as an integrated whole that determines how man uses the land and what his impact on the landscape is.

As the title makes clear, this is a reconnaissance inventory. This means that it is a preliminary, low-intensity examination of the lands of Nepal with heavy use of literature, remote sensing and extrapolation of field observations. The intent of the inventory was to satisfy a national-level information need as rapidly as possible. The user is cautioned against attempting to use the report for more detailed planning without considerable additional data collection in the specific area of interest.

A major contribution the inventory makes to an understanding of Nepal is through the framework of land units identified in the course of the inventory. This is the product of a sequential stratification of the country. The land units serve as "containers" for observations, further data accumulation and recording of land use experience. They can serve as the common ground necessary for communication among those interested in land use and natural resources. The communication role is particularly pertinent in co-ordinating the efforts of the several donor groups in Nepal. The land units were developed mainly through interpretation of satellite imagery with modifications resulting from over flights and field work. Like the descriptive information for each land unit, the delineations for the land units are subject to considerable change with additional knowledge. The user is encouraged to look for the units discussed in the report, to test those units, and to make refinements and corrections as needed.

One of the challenges facing people involved in work with natural resources in Nepal is the collection of the basic references pertaining to those resources. This was repeatedly evidenced by individuals from government departments and national and international organizations who visited the project offices. A week would seldom pass without representatives from one or more groups coming to the offices of the Integrated Watershed Management Project to get the basic literature needed in the formulation of their project. This report presents a list of many of the more valuable and accessible publications. It also contains condensations and summaries of publications, and groups of publications on key natural resources.

The map made from a mosaic of satellite imagery gives a photograph-like view of the entire Kingdom. It is somewhat unique and in itself should go far to convey an appreciation for the pattern and complexity of lands in Nepal.

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- A1.1 Index to Landsat Imagery

Part 1. THE INVENTORY*

The lands of Nepal form a rich and varied mosaic reaching from the plains of the subtropical Terai to the ice covered spines and pinnacles of the highest mountains on earth. This report is an inventory of these lands. It was made to give an overview of the soil and water conservation problems in Nepal for national planning purposes.

The inventory was made by His Majesty's Government personnel and members of the Integrated Watershed Management Project staff. This is a F.A.O./U.N.D.P. project attached to the Department of Soil Conservation and Watershed Management. The project document describes the inventory as a "reconnaissance on a broad-scale land system basis, so as to identify major problem areas of erosion, landslides, torrents in upper catchments."

Its purpose is to serve, "as a first step planning tool.....and (to) help the Department of Soil and Water Conservation set its priorities and to select catchments for demonstrations and more detailed survey work."

Watershed condition is a function of a system composed of land - its physiography, vegetation, soils, climate, geology; and people - their numbers; and the kind, duration and intensity of land use. Government enters the system through regulations, services and land use policy. Watershed condition, in the maze of interacting factors making up the complete human environment, becomes an indicator or symptom of how well the land-people-government system is operating. This inventory focuses on watershed condition in its physical environment. In a sense then, it is incomplete because it deals with only part of the system. In spite of this shortcoming, this report is a starting point for understanding, and therefore for solving, the watershed problem in Nepal.

The inventory gives an overview of the pattern and intensity of erosion in Nepal. In the inventory process, a framework of land units was developed to make a systematic examination of the country possible. The map of ecological land units in the back of the report is one of the outputs of the inventory. Although at a reconnaissance level, it provides a structure for viewing all the land of Nepal, and as such, can serve as a communication tool for people with diverse interests and experience in the development of Nepal's resources. The text, Part 2, gives a brief description of four levels of land units, three of which appear on the map mentioned. The fourth level, landtype, was too detailed to map within the time and materials constraints of the project. This more detailed level, the landtype, is used to describe the next higher level, the land system.

* "The inventory" will be the term used in the text to refer to this work in lieu of the long title given on the title page.

Part 2. THE MAJOR ECOLOGICAL LAND UNITS IN NEPAL

Introduction

The land unit descriptions and interpretations which follow are written with a minimum of technical terminology so as to make them understandable to as wide a range of people as possible. We hope the use of jargon has been kept to a tolerable level also. The reader needs some idea of the structure of this section and a few definitions before the descriptions will make sense to him. The following is intended to satisfy this need. Additional background information is given in Part 3, How The Inventory Was Made.

1. Organization and Symbols.

Four levels of land units were identified. Each level represents an intensity of examination of the land. The four levels used are :

- a. Zone - Zones are the most general mapping units used. See figures 2.1 and 2.2. These are widely recognized divisions of the country. The Transition Zone is probably new however. Zones are land units with similar elevational ranges, climates, vegetation and geological structure.
- b. Regions - The five zones were each divided into three to twelve regions. Regions are land units with similar regional precipitation rates and local geologic structure. Regional maps are at 1:1,500,000 scale in this report. See figure 2.3.
- c. Land Systems - The twenty seven regions were each divided into two to six land systems. The exceptions are that the Terai and some Siwalik regions consist of a single land system. A land system is a land unit with a repetitive pattern of similar landtypes. The map in the back of the report, with a scale of 1:500,000, is a land system map of the country.
- d. Landtype - Each land system was further divided into two to six landtypes. Landtypes are the most elemental unit used. They are usually individual slope facets, but in some places because of lack of information, they are rather complex land units with a wide range of properties.

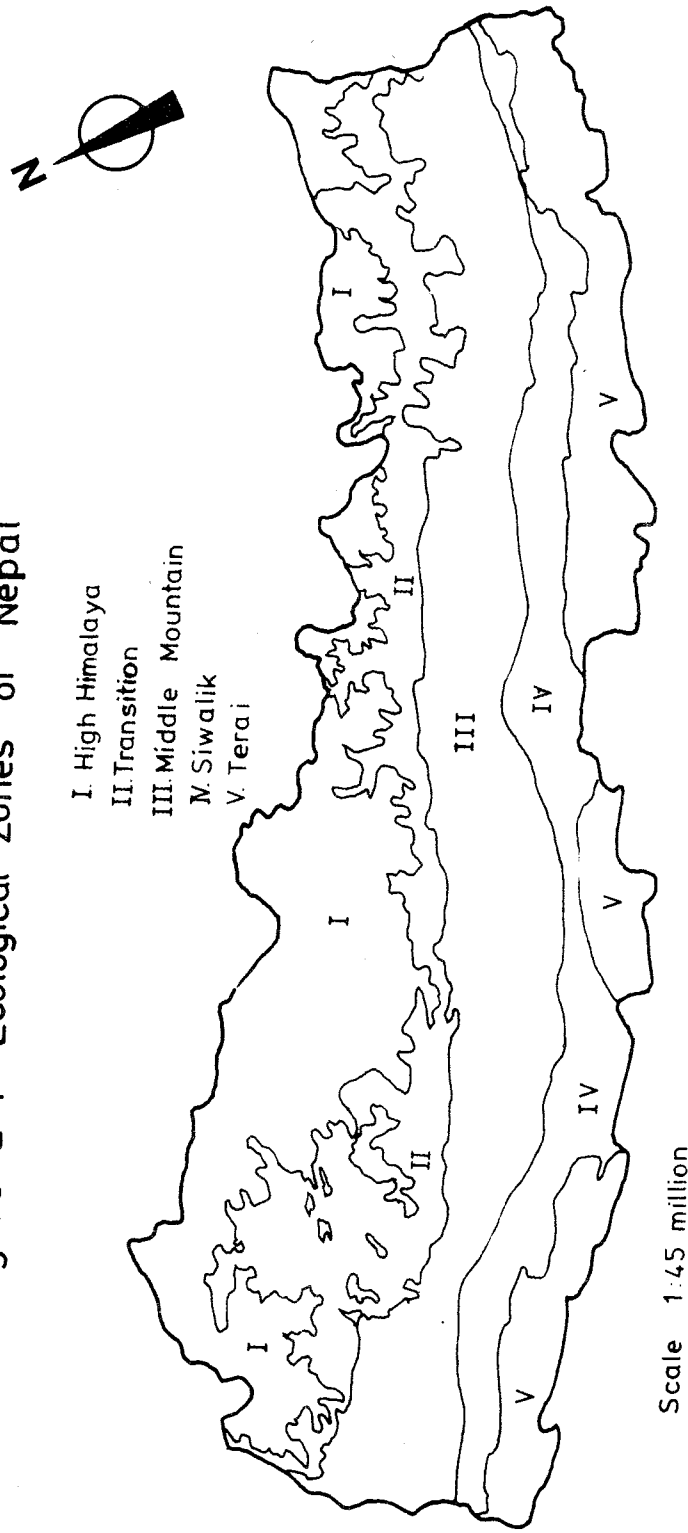
The descriptions and interpretations of these land units are organized hierarchically with all land units separated under the five zones. The identity of each land unit is indicated by its symbol. The symbol for a zone is a Roman numeral, the region has an upper case Roman letter, the land system has an Arabic numeral, and the landtype uses a lower case Roman letter. These numerals are used cumulatively.

For example, the High Himalaya Zone is identified by the Roman numeral "I". The western region of this zone has IA for its symbol. The region's valley land system in this region is IA2 and the valley floor landtype is IA2a.

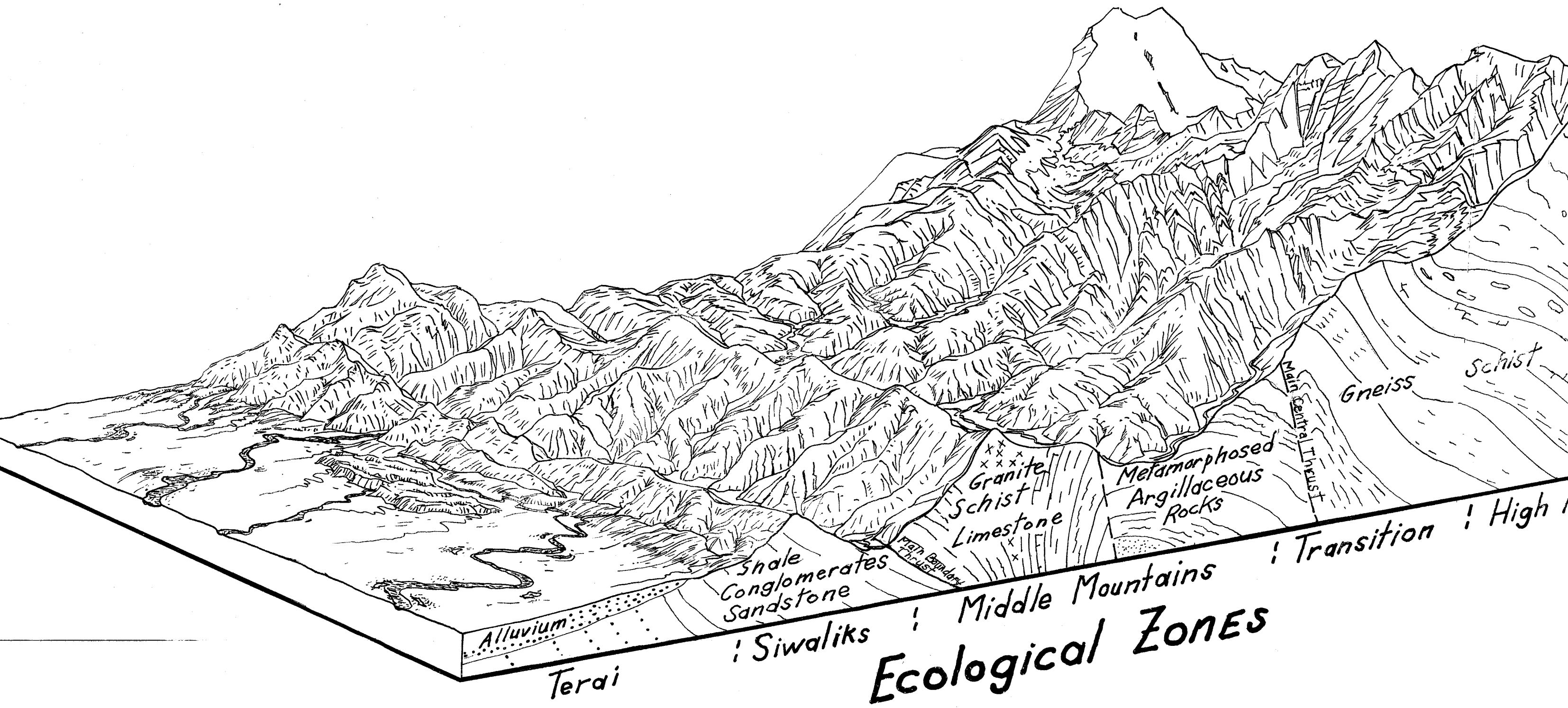
2. Cover Types.

Estimates of the percentages of land units occupied by three major kinds of cover types were made.

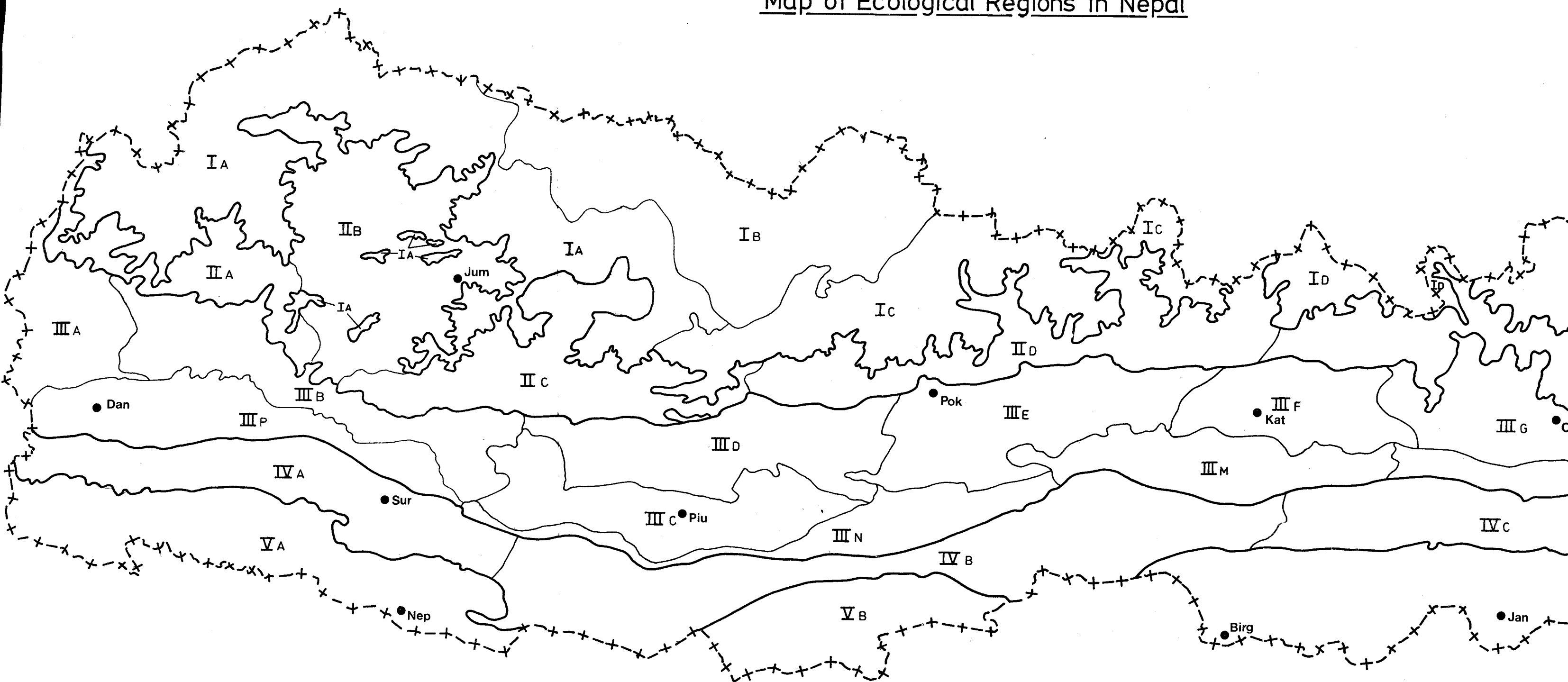
Figure 2.1. Ecological Zones of Nepal



The Ecological Zones of Nepal



Map of Ecological Regions in Nepal



- a. Agriculture - Cultivated lands.
- b. Forests - Lands with at least 50 percent tree crown canopy cover.
- c. Other or Brush - This refers to grass or shrub lands in most of the country. In the High Himalayas it identifies the ice, snow and rock masses as well. Details of the meaning of this category are given in the regional description box where a summary of cover types and watershed condition are given.

3. Watershed condition.

This interpretation is an estimated index which means the current state of soil erosion in an area in comparison with the soil erosion estimated for that area under natural or "well managed" conditions. "Soil erosion" is used as a generic term for physical indicators of site deterioration, mainly sheet, rill and gully erosion, but includes loss or significant change in vegetation, occurrence of landslides and condition of stream channel. The five classes of watershed condition are :

- Class 1. Excellent. In or near undisturbed condition. Natural erosion processes, including landslides, may be present.
- Class 2. Good. Minor amounts of disturbances may be present. Correction can come about through normal management practices. Education and extension have a major role here. Productivity of land is not significantly impaired.
- Class 3. Fair. Significant disturbance in the soil mantle and/or stream channel exist. Productivity of land is diminished. A combination of education and structural remedies are required.
- Class 4. Poor. Disturbance by accelerated erosion is serious and results in considerable stream sedimentation and reduced land productivity. Extension, structural and land use changes are required to upgrade the land to a productive condition.
- Class 5. Very Poor. Accelerated erosion is advanced. Agricultural and forest productivity is absent or greatly reduced. Sediment production and extreme runoff conditions have effectively destroyed the natural character of the streams. Rehabilitation requires structural protection and high investment cultural practices.

Watershed condition classes are summarized by land units in Appendix 2 and on the land system map in the back of the report. An FAO technical report, "The Watershed Condition of Nepal," is based on the findings of the inventory and contains discussions pertinent to watershed management.

4. Vegetation.

The principal vegetation types are described in terms of key tree species where identification is possible. Grass, shrub and forb species are

usually not described by species groups because the species were seldom known for these forms of vegetation. Part 4c gives more information about the vegetation.

5. Location.

This is described for regions in terms of districts, major towns and river systems.

6. Elevation, relief and slope gradient.

Elevation in meters above mean sea level is given as a range between the estimated lowest and highest points in the region or landtype. Relief is the estimated difference in highest and lowest points occurring in a typical valley-ridge cross-section of the average drainage within the map unit. Slope gradient is given by percentage.

For making interpretations, the following classes were used:

Slope Gradient Classes

<u>Class</u>	<u>Percent</u>
1. Very low	less than 20
2. Low	20 - 30
3. Moderate	30 - 40
4. Moderately steep	40 - 60
5. Steep	Over 60

Relief is given in terms of the following classes:

<u>Class</u>	<u>Difference in Elevation</u>
Very low	100 meters or less
Low	100 to 500 meters
Moderate	500 to 2000 meters
High	2000 to 3000 meters
Very high	Over 3000 meters

7. Climate.

Climate is described in terms of a general climate designation, a range in mean annual precipitation and a Köppen climatic classification. More information on climate, including definition of classes, is given in the climate section in part 4a.

8. Geology.

An effort was made to name the most extensive bedrock type and the controlling geologic structural features. Many of the metamorphic rock bodies blend with indefinable boundaries. The dominant types were described in such cases.

9. Soil.

Soil is described by depth class, major soil texture class, (usually of the B horizon) and coarse fraction content in percent and size. The depth and textural classes are as follows:

Soil Depth

<u>Class</u>	<u>Depth</u>
Very shallow	less than 0.2 meter
Shallow	0.2 to 0.5 meter
Moderate	0.5 to 0.7
Moderately deep	0.7 to 1.0 meter
Deep	over 1.0 meter

Soil Texture

<u>Class</u>	<u>Texture</u>
Very fine	Clays
Fine	Clay loams
Silty	Silt loam
Medium	Loams
Medium coarse	Sandy loams
Coarse	Loamy sands, sands

Surface Rock

<u>Class</u>	<u>Percent Cover</u>
1	less than 2
2	2 to 4
3	4 to 6
4	6 to 8
5	over 8

10. People.

The population is described by ethnic group (see figure 4.9) and population density. This latter is by people per square kilometer and people per hectare of crop. The classes used are as follows:

Population per square kilometer

<u>Class</u>	<u>Number</u>
Very high	over 150
High	80 to 150
Moderate	10 to 80
Low	less than 10

Population per Hectare of crop

<u>Class</u>	<u>Number</u>
Low	3 or less
Moderate	4 to 8
High	9 to 12
Very high	13 or more

More information is given on population in Part 4d.

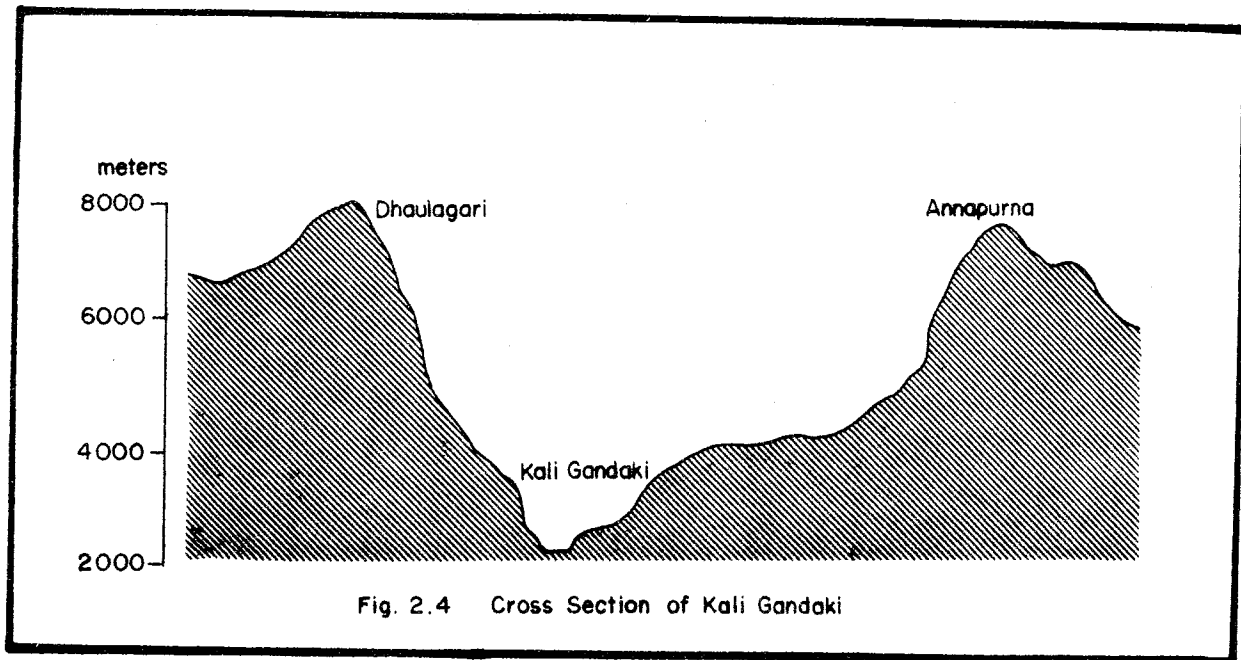
11. Interpretations.

In addition to watershed condition, these interpretations were made: landslide hazard, soil erosion hazard and terrace suitability. The class designations are 1 - 5 with 1 the least hazardous and most suitable and 5 the greatest hazard and least suitable. More information is given in Part 3.

LAND UNIT DESCRIPTIONS

I. High Himalaya Zone

The High Himalaya Zone occupies 23 percent of Nepal. It lies between the forest line at about 4000 meters and the crests of the Himalayan Mountains. It is an area of rocky, ice-covered massifs, rolling upland snow fields, valley glaciers, and sweeping meadow lands. Included in this zone for purposes of the inventory are the Trans-Himalayan lands of Dolpo and Mustang. The zone is unique and spectacular. Eight of the world's fourteen peaks above 8000 meters are in this zone. The Dolpo area is an enclave of Tibetan culture. These mountains form the boundary between the Indian subcontinent and the high plateaus of central Asia. They form one of the most rigid climate barriers in the world, marking the northern extent of monsoon Asia. On their southern slopes precipitation reaches 3470 mm in Pokhara. It is less than 300 mm on its north side. In spite of its formidable height and barrier role, in every other way the Himalayas are not the watershed divide. Several river systems which flow to the Ganges have their headwaters on the Tibetan Plateau north of Himalayas, and pass between blocks of mountains in some of the earth's deepest canyons. Figure 2.4 is a diagram of this. The Kali Gandaki canyon between Annapurna and Dhaulagiri Himal has a relief of over 6000 meters.



Nepal occupies the central part of the Himalayan chain which reaches from ~~Pakistan to Burma~~. These mountains are thought to be a product of plate tectonics : the Indian plate is moving north under the Asian plate. The Himalayas lie along the rumpled zone of contact.

Hard rocks, gneisses mainly, and sedimentary rocks of the Tibetan plateau dominate the zone. Meadows are the most widespread vegetation type. A steppe community covers the Trans-Himalayan region. One-third of the zone is ice-snow-rock lands with lichens and cushion plants the only life. The zone is sparsely populated with people of Tibetan extraction. The lower slopes are used seasonally for grazing.

The zone has extremes in watershed condition. Most of it is in a natural state, uninfluenced by man. In parts of the main Himalayan chain, meadows on the slopes of glacial valleys have been overgrazed with resulting sod breakage and soil movement. In the dry Trans-Himalayan Region, grazing animals have denuded many of the valley slopes and bottom lands with lands in the vicinity of villages particularly hard hit. The search for firewood in this area has led to cutting and uprooting of shrubs and the few trees. Perhaps as damaging is the use of dung for fuel instead of fertilizer. The major conservation problems here result from the climatic extremes of the area: short growing seasons, low temperatures, and in the Dolpo Mustang region, very low rainfall. Disturbed areas are very difficult to stabilize because of low natural recuperative powers. In spite of the ruggedness of the landscape, the lands are very fragile.

Land use pressures in the zone increased considerably with the influx of refugees in the early 1960's, and the recent tightening of restrictions on grazing in Tibet. Tourism is creating a growing environmental pressure that is also felt in the forests of the Transition Zone, where much of the firewood is cut. This land use requires control measures before the problem gets too big. The grazing problem may solve itself if grazing lands deteriorate further. Scientific grazing management is needed to maintain grazing as a viable land use and to protect or restore the soil condition.

The zone can be divided into two subzones: the main Himalayan range and the Trans-Himalayan region of Dolpo and Mustang. The main Himalaya range is mapped in three regions: Western, Central and Eastern. The Dolpo and Mustang valleys are mapped in one region (IB) because of their similar climate, geology and landscape.

IA. Western High Himalayas Region

This is the high country of western Nepal. It consists of the chain of peaks, serrate ridges and upland shoulders and benches above the tree line west and north of Dhaulagiri Himal. The Ringmo valley, lying below the tree line, is a small inclusion in this zone mapped as a separate land system. This western third of the high Himalayas in Nepal is somewhat lower in elevation than the high Himalaya regions to the east. Here, only three peaks are above the 7000 meter line, Api, Siapal, and Kanjiroba. Another difference is that instead of forming a straight line of massifs as is the case in the more easterly regions, the Western High Himalayas are in a semicircle, nearly enclosing the Humla-Jumla region of the Transition Zone.

Summary of Region

Area 13108 sq Km

39 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Other	1	2	3	4	5
3	Trace	97	100	0	0	0	0
Other: About 40% rock, ice, snow; 60% upland meadows.							

Location: Karnali Zone - Dolpo, Mugu, and Humla districts.

Seti Zone - Darchula, Bayhang and Bajura districts.

Ringmo, Mugu, Pulkilaida, and Chaubisha are a few villages here.

Elevation/Relief: From 3400 meters on the Upper Suli Gad below Ringmo to 7100 meters on the summits of Siapal and Api. Relief is mostly moderate within the region. It is high with the valleys of the Transition Zone included.

Climate: Alpine. Mean annual precipitation is estimated at 500 to 1500 mm. According to Köppen's classification it is tundra, high altitude/humid continental with severe, dry winters (ETH/Dwb). This region appears to have a bimodal precipitation pattern with summer monsoonal rains and winter snows.

Geology: Sandstone and limestone dipping to northeast. Granite and gneisses on higher ridges.

Vegetation: The higher peaks and ridges have no vegetation. The slopes just below the rock and snow support a high alpine vegetation group. Here the group consists of xerophytic mat patches, and closed alpine mat and shrub communities. The latter has a large component of dwarf forbs and sod-forming grasses.

Birch and rhododendron reach into this unit in protected areas.

The vegetation in the Ringmo area is blue pine and juniper.

People: There are few settlements and little cultivated land within the higher component of this region. Mugu is probably the best known village because of its role in the salt trade. Ringmo and Phoksumdo Tal may eventually be important tourist centers with the development of a national park in this area. Much of the area is grazed by stock owned by people in the adjacent low land: Bhotias in the north part and people of Aryan extraction across the south.

The population density (number per square kilometer) is very low. Ringmo people have a village on the Upper Suli Gad, a tributary to the Thuli Bheri in this region. Based on cropland area, the population density is moderate to high.

Comments: This is the least known and visited region in the Nepal Himalayas. Its comparative isolation and lack of peaks in the top ten in Nepal has kept it in obscurity. The closing of the Tibetan border to most trade and grazing migration has had an impact on the region. Grazing has intensified in the Limi area sufficiently to cause deterioration of the forage resource. Yak grazing has increased considerably in the high slopes of the Thuli Bheri in the Balangra pass area because of these closures.

Subdivisions: Two land systems were mapped here: the High Ridge Land system and the Ringmo area system. We visited only the lowest ridges of the High Ridge system. Further study would probably justify separation of the Api-Siapal section of the region from the lower, broader ridge lands and the Kanjiroba area.

IA1. High Ridge Lands Land System

This land system comprises more than 95 percent of the region. It is the High Himalayas of western Nepal. It has a zonal pattern of landtypes, topped by the ice and rock of peaks over 7000 meters and descending to the grass and shrub covered lands at about 4000 meters.

Land System Summary

IA1 makes up 95 percent of the region, and is subdivided into 3 different land types.

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IA1a	40	70-100 +	0	0	100 rock, ice	0	1	5	-	-
IA1b	30	80-100 +	0	0	80 rock 20 grass	0	1	5	1	-
IA1c	30	10-100 +	10	0	85 grass 5 rock	L	1	2-4	2	-

Landtype Descriptions

IA1a. Mountain Crests, no vegetation.

This is the ice and rock that form the peaks and rugged ridge slopes above 5200 meters. Small glaciers and hanging icefields are common. The lower slopes here are covered with angular rubble.

These are spectacular landscapes. They are hazardous to cross because of avalanches and rock fall. The climate is at an extreme. Hydrologically these slopes are in excellent condition. Studies here would be valuable to determine the role of snowpeaks and ice-fields in maintaining the regimens of streams beginning in this landtype area.

IA1b. Secondary Ridges, cushion plants - lichens - broken sod cover.

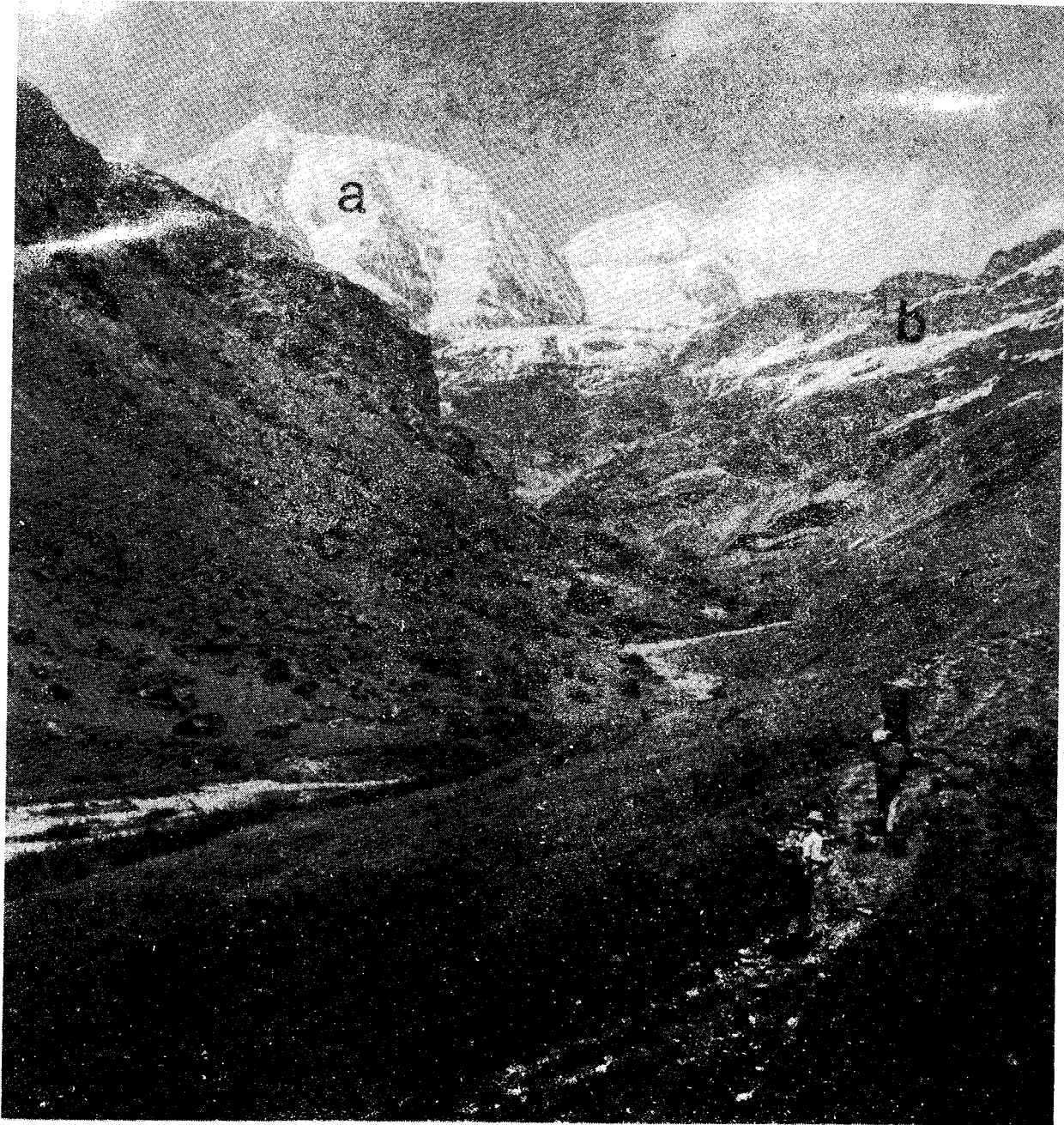
These are rugged, often serrate ridges with a shallow, parallel dissection pattern. The elevation range is 4300 to 5200 meters. Slopes are over 100 percent. The rocks are gneisses. Little soil is on these ridges. Vegetation consists of patchy sods and cushion-forming plants. These are nonglaciaded high ridge lands. Debris avalanches appear to be a slope forming process.

IA1c. Base Slopes and Lower Ridge Crests, alpine shrub - grass.

This land type has a variety of landforms: bedrock controlled upper ridge slopes, upland rimland with cirques, and straight to concave, basal slopes below rocky ridge crests. Slope gradients range from 10 to 30 percent on some surfaces to over 100 percent on basal slopes and ridge crests. The elevation here is 4000 to 5400 meters. The rocks are schists and gneisses. The soils are shallow to moderately deep, silt loams; loamy fine sands and loam. The surface horizons are very dark brown (10YR 2/2) indicating high organic matter content. The vegetation is a meadow and alpine shrub type. There is a large component of forbs including Potentilla sp, Agrostis sp, Aster sp, Pedicularis sp, and Geranium sp. Birch form stands in protected areas. These high ridges are grazed in summer. Yak grazing on steep slope causes considerable sod breakage, exposing bare soil. However, the overall landtype is in good to excellent condition.

IA2. Ringmo Valley Land System

This is an inclusion in the western High Himalaya Zone. It consists of the upper valley of the Suli Gad and the Phoksumdo Tal basin. It is distinguished from the lower Suli Gad valley by the absence of extensive forest cover. This is a very small unit in comparison with the rest of the Western High Himalaya Region and contains one of the few areas of cultivated land in the region. Other areas of agricultural land such as in the Mugu valley could not be visited. Two landtypes were identified here.



2.5 Western High Himalayas, land systems of the High Ridge Lands Region (IA1): Mountain Crests (IA1a), Secondary Ridges in central part (IA1b), Base Slope Ridges (IA1c) in foreground.

Land System Summary

IA2 comprises less than 5% of the region, and is subdivided into 2 different landtypes.

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IA2a	40	10-70	30	30	40	0	1	1-3	3	-
IA2b	60	5-100+	10	0	70 Br 20 rock	L	1	1-4	4	2-5

IA2a. Basinland, juniper.

This landtype is the valley floor and lower slopes of the Ringmo valley, the valley of the Lulo Khola and the hilly area between these valleys. Ringmo valley has the appearance and position of a terminal moraine. Close examination of materials and the adjacent side slopes suggest a large landslide as the more likely origin of the valley floor materials. The Lulo Khola and the upper Suli Gad valley has been deeply entrenched, leaving high terraces on each side. The elevation is 3000 to 4000 meters. The materials are alluvial and colluvial deposits. The two main valleys are connected by a broad canyon filled with thick, weakly cemented conglomerates. Sandstone of the Tibetan series dipping to the north are exposed. The soils are moderately deep to deep, fine sandy loam over silty clay loam in the Ringmo basin. The vegetation is an open stand of juniper (*J. indica*) and blue pine. The lower side slopes support birch and blue pine. Sod grass groundcover is in openings.

There is a small block of cultivated land at Ringmo village. Nearly all the landtype is heavily grazed by yak, resulting in considerable bare ground. Deforestation is not critical under present land use levels but could be a problem if tourism becomes important. The general area has several attractions that would make it a popular tourist spot, including the beautiful Ringmo Falls.

Soil erosion is confined to small patches of sheet erosion. Development of pastures and a systematic grazing program are needed here.

IA2b. Phoksumdo Tal Valleys, birch - blue pine.

This is a gorge-like valley containing Phoksumdo Tal and the two U-shaped valleys leading into the lake from the north. The elevation is 3000 to 4200 meters. The upper slopes blend into the main western High Himalaya land system (IA1). Limestone is the main bedrock. Deep landslide and alluvium deposits fill the valley floor. The soils on the walls above the lake are shallow gravelly loams. The pH is 7. In places the walls above the lake are nearly vertical, solid rock. There is no shoreline

except at the ends of the lake. On the slopes above the tributary valleys the soils are moderately deep to deep, sandy loam; loam and silt loam. The valley bottoms have moderately deep gravelly loam soils. The vegetation is dominantly common juniper (Juniperus communis) and bunch grasses on southerly aspects. Blue pine occurs as scattered individual trees on south slopes but forms small, closed stands with birch on north-facing slopes. Caragana sp., willow and a low rhododendron, with pockets of birch are on the valley floors above the lake. The upper valleys, both bottoms and side slopes, are grazed by yak with no apparent damage. One block of pine along the trail near the upper forest line was burned. As a whole the area is in excellent condition. If a National Park is established, efforts must be made to insure an adequate supply of fuel without destroying the forests and



2.6 Ringmo Valley System (IA2) of Western High Himalaya Region. Basinland landtype (IA2a) with Phoksumdo Tal in foreground. Steep forested ridges are in upper ridge and canyon slopes landtype of the Thulo Bheri Inner Valley Land System (IIC4), the snow-covered area is in the Mountain Crest landtype (IA1a).



2.7 Phoksumdo Tal Valley (IA2b). Mountain Crests (IA1a) is on the skyline.

IB. Dolpo-Mustang Region

The Dolpo-Mustang Region makes up the Trans-Himalayan part of Nepal. It is a treeless area of high, rounded hills and steep walled gorges. High ridges (over 6000 meters) enclose the principal river valleys. It is noted for its desert-like environment resulting from its rainshadow position behind the Annapurna and Dhaulagiri Himals. It is believed to be a last stronghold of traditional Tibetan culture, making it a unique and historic region in Nepal. It is drier than any other part of the country. The Kali Gandaki valley of Mustang has been the highway between south and central Asia for centuries.

The region is in two distinct parts, Dolpo and Mustang, which in many ways could be mapped separately. They share similar climatic, geologic, and cultural characteristics. The Dolpo district, drained by westward flowing rivers to the Karnali watershed, is the larger, more isolated of the two. The Mustang district forms the headwaters of the southward flowing Kali Gandaki drainage and has been the main route between the subcontinent and Tibet.

Summary of Region

Area 7734 sq Km

23 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush*	1	2	3	4	5
0	1	99	49	12	38	1	0
* includes rock and snow 10%.							

Location: Dhaulagiri and Karnali Zones.

Elevation/Relief: 1800-6100 meters, with most of the region between 4000 and 5400 meters. Relief is low in the central part of the region, and moderate to high along the northern margin.

Climate: Tibetan. According to Köppen, it is a cold steppe climate (BSfk), with no specific dry period. This region is shielded from the monsoons by the Annapurna and Dhaulagiri Himals. In this rain shadow it receives only 250 to 700 mm of precipitation. The winters are cold and snow blocks most of the passes.

Geology: Rocks are in the upper part of the Tibetan series and include limestone, shales, sandstones and detrital deposits of sandstone and conglomerates. Granites are on the divide between Dolpo and Mustang and are along the northern boundary of Dolpo.

Vegetation: Steppe group. There is a pattern of low shrub communities covering about three-fourths of the region. Caragana gerardiana, and Artemesia sp. are on the lower slopes; Caragana brevifolia-Lonicera spinosa

dominate upper slopes. A cushion plant formation is on the higher ridge crests. There are narrow stream-side communities - Sophora morcroftiana/Oxytropis sericopetala in the Mustang valley and willows in the Dolpo area.

People: The general group is Bhotia with Dolpas in Dolpo and Lopa, Bargaunle, Paurchgaunle and Thakali in the Mustang-Thak Khola areas. Tibetan refugees make up a small percent of the population. The population of the two principal districts in the region, Dolpo and Mustang, totals less than 50,000 making them two of the least populated districts in Nepal. With less than 8 people per square kilometer, the population density is in the very low class. Based on cropland area, the population density is moderate in Dolpo and high in Mustang. The population of Mustang district dropped by nearly 20 percent in the 1961 - 1971 period, presumably because of the disruption of trade with the Tibetan part of China.

Comment: The dryness of this region makes it distinctive and limits agriculture to the arable lands in the major river valleys. Migratory grazing of goat, sheep, and yak is common throughout the region. Trading, probably once the biggest income producer in the region, has diminished to a comparative trickle with the restrictions imposed by the Chinese. Traditional grazing patterns were also significantly altered by the closing of the border to herd movements. A significant impact was felt when Tibetan refugees with their herds moved into the region in the early 1960s. The vegetation communities and the soils were disturbed by the added pressure, and their capacity as forage producers continues a downward trend.

A total lack of trees in all but the river valleys and a few irrigated terraces is a striking feature of the region. The cover types are approximately as follows: forests - 1%, cultivated land - 1%, brush, grass and wasteland - 98%.

Subdivisions: Land systems were separated on the basis of landform. The most fundamental physiographic units here are the Dolpo subregion - high basin land drained by the Panyong Khola; and Mustang subregion - a great, open valley drained by the Kali Gandaki.

IB1. Central Dolpo Land System.

This land system forms the bulk of Dolpo. It is a basin containing broad rounded ridges and narrow valleys. The arable lands and consequently the few population centers are on benches and gentle slopes above the main drainageways. The elevations are from 4500 meters to 6100 meters. The landscapes are stark in this high arid, treeless area. This is the only part of Nepal where shales are a major rock type. These rocks are responsible for the softness of the topography and the fact that mass movement, mainly landflows, is a principal land-forming process.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IBla	15	5-30	0	0	100	very low	3	2	4	5
IBlb	80	30-70	0	0	100	very low	2-4 (trace of 5)	4	4	5
IBlc	5		0	16	84	low				
IBlc1		3-15	0	40	60		2	2	2	1-2
IBlc2		40-100 +	0	0	100		1-4	5	3	5
IBlc3		0-5	0	0	100		1-3	1	1-3	-

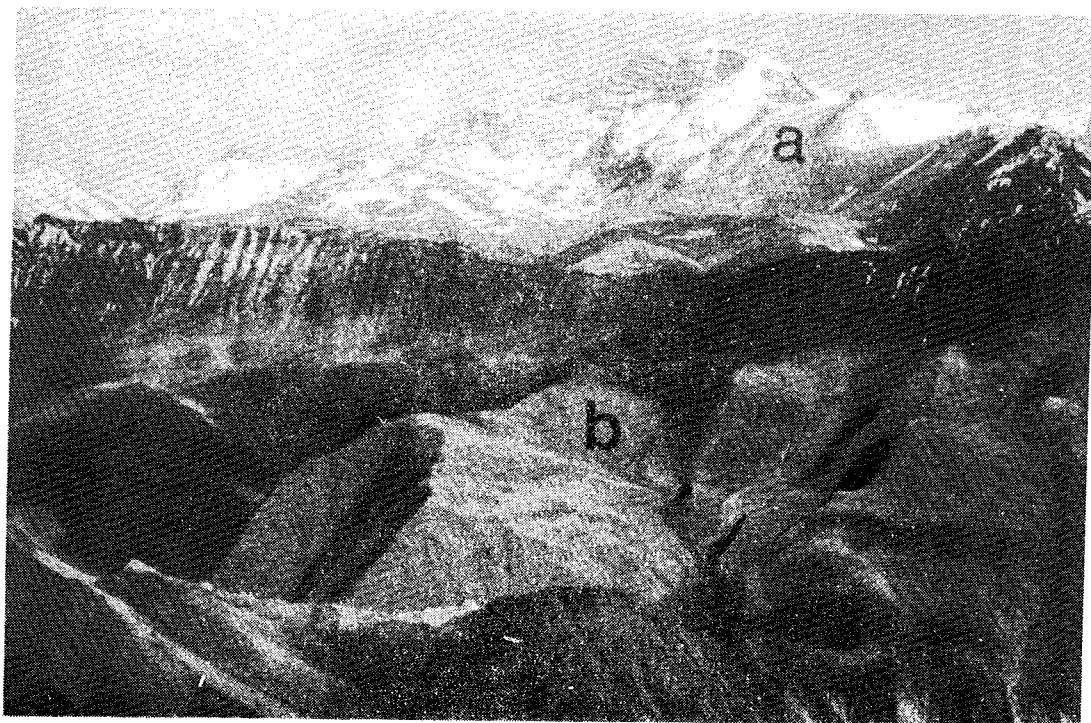
IBla. High Ridge Crests, bare ground - cushion plants.

Mostly broad, convex, sparsely dissected, upper slopes and ridge-crests above 5200 meters. In places, there are blocky peaks of interbedded limestone, sandstone, and shales with cliffs up to 200 meters. Rubble land is at the base of these peaks and cliffs. Shale is the most common rock type. The soils are shallow, moderately alkaline, gravelly sandy loams. In many places they are severely rilled or show polygonal cracking due to dessication and repeated freezing and thawing. The vegetation consists of cushion plants, grasses and sedges. Bare ground is 30 to 60 percent. Soil has been eroded from some heavily used sites exposing finely fractured shaley bedrock.

Trail terracettes indicate intensive grazing use. These high ridges are sources of runoff which cause gullies on lower slopes. Protection, rehabilitation, or increasing the forage production here appears improbable because of their slope positions and the harsh environment. Vegetative and soil improvement would result from a general decrease in grazing pressure.

IBlb. Midslopes and Hilly Lands, Caragana/Lonicera Shrub.

Convex to straight, ridge sideslopes and hilly uplands between 4300 and 5300 meters. Slope gradients are mostly 30 to 70 percent. Some gradients over 100 percent are on the lower slopes next to the valley bottom. The rocks are shales and limestones. Land flows and slumps of all sizes are natural features of the landscape due to the shaley materials and solifluction processes. Small depressions, hummocky patches and benches are



2.8 Central Dolpo Land System (IB1) with High Ridge Crests (a) landtype on skyline and midslopes, (b) Hilly Lands in foreground.



2.9 Midslopes and Hilly Lands (IB1b). Gravel-choked drainageways are common in the upper part of the drainages.

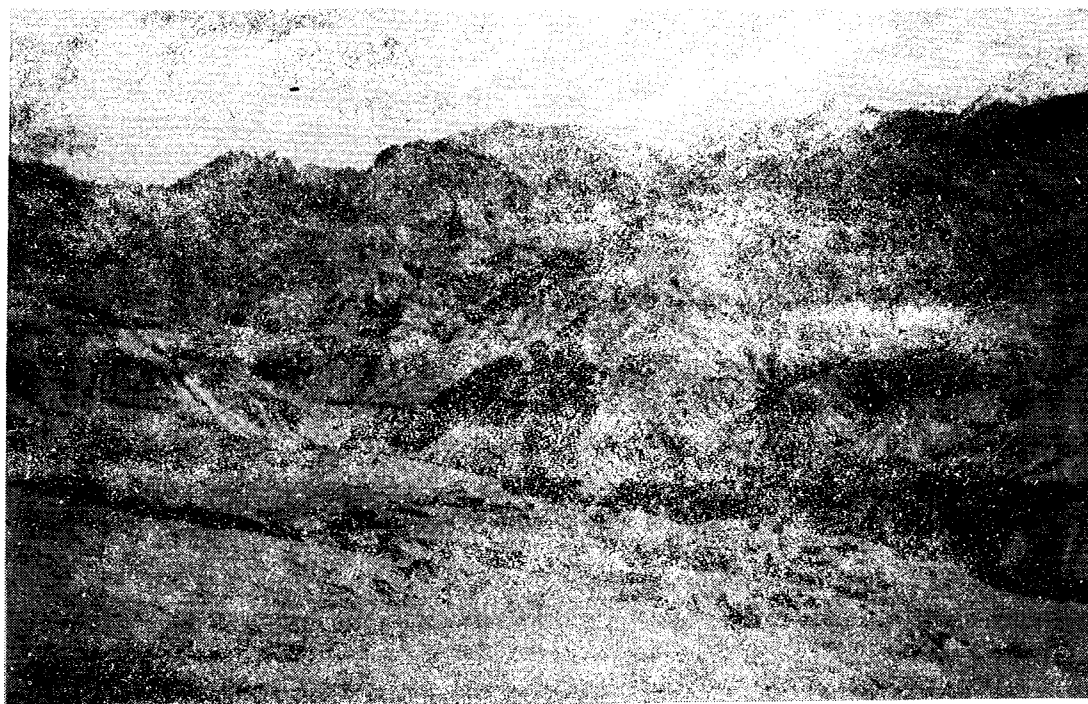
expressions of this. The soils are moderately deep to deep, alkaline, stone-free sandy loams; silt loams and silty clay loams. The vegetation is a nearly continuous cover of low spiny shrubs with sod grasses, sedges and dwarf forbs.

This is the most extensive landtype in the Dolpo area. It is grazed by goats, sheep, or yak throughout its extent. In places all herbaceous plants have been removed. Generally, the shrub cover here is effective against soil erosion. Several bare eroding sites were noted where soft, shaley parent materials were exposed. Eroded sites are very slow to heal because of the cold and dryness of the environment. In a few places erosion is severe. Drainage bottoms are filled with outwash-like rubble in places at high elevations. Herders here said that forage production had decreased significantly over the last ten years. The influx of Tibetan refugees with their herds has probably contributed to this decline.

IBlc. Valley Land, Caragana/Lonicera Shrub.

The unit is composed of three sublandtypes: benches and shoulders, open bottomlands, and rocky gorges. Although relatively small, this is the site of all permanent settlements, cultivated land and the main travel routes in Dolpo. The elevation is from 4500 to 5600 meters. The slope gradients on benches and shoulders are 3 to 15 percent, the bottomlands are at stream gradient, and the gorges have very steep, in places vertical, walls. The gorges are cut in sandstones and limestones. The benches are covered with fan materials. The bottomlands are small flood plains with deep deposits of shale materials. Water-worked gravels to boulder size materials are plastered over these land units up to 60 meters above some of the streams. These deposits are very easily disturbed. Deep landslide deposits have been cut by the Nangung Khola below Saldang, creating very unstable canyon slopes. The bench and shoulder surfaces are straight to undulating and have shallow to moderately deep, loamy sand to sandy loam textures. The dominant natural cover is a shrub type. A few willows, birches and sodgrass meadows were noted in the bottomlands. In most places however the bottomland is bare rubble. The gorges have a few willow trees and an occasional birch.

The benches and shoulders are the only lands sufficiently flat and near enough to water sources to make irrigated agriculture possible. Fields have been constructed. Canals, some with cantilevered buttresses, cross cliff faces. Willows have been planted and are guarded in the villages. They are tree size and apparently are the only source of structural timbers. Slopes adjacent to the villages have been denuded by heavy grazing and fuelwood collection. Abandoned fields were noted in a few places. One explanation of this is that productivity dropped to an uneconomic level because dung is used as a fuel rather than fertilizer. Other explanations are that the economy was based on trade and farming. With the loss of trade, farming alone could not support the household. Agriculture here is dependent on irrigation. The water source is often tenuously connected to the fields by hillside ditches. A landslide, a washed-out ditch, or a dry year could doom the water supply and the crop.



2.10 An erosion hotspot near the village of Saldang. This is in the Midslopes and Hilly Lands (IB1b) and Valley Land (IB1c) landtypes. Note the benches, shoulders and gorges of the Valley landtype.

IB2. Southern Dolpo Mountain and Valley Lands Land System

This is a block of high, rugged ridges and deep, open valleys in the southeastern part of the Dolpo area. It includes the upper valleys of the Tarap Chu and Barbung Chu (Bheri Khola). There are several villages here including Tarap, Tsharka and the twelve villages in Barbung Chu valley called Baragaon. These valleys, enclosed by the high ridges, are especially dry. Cultivation is limited to a few benches and stabilized landflow deposits where water for irrigation was available. Two complex landtypes were identified in this land system. Our observations in this system were very limited. More work is definitely needed.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	I.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IB2a	70	60-100 +	0	0	100	0	1	5	2	5
IB2b	30	10-100 +	10	5	85	L	2	4	3	2-5

IB2a. Ridge Crests and Upper Ridge Slopes; bare rock, cushion plants - steppe shrubs.

This is a rugged mountain area with peaks, weakly developed cirques, spine-like ridges and stratified, often folded mountain blocks. Permanent snow fields cover much of the landtype. Straight, weakly dissected and in places benchy slopes, extend from the rocky peak zone. The elevations are 5200 to 7000 meters. The materials are sandstone, shales and limestones. The soils below the rocky peak zone are generally shallow to moderately deep, gravelly loamy sands and sandy loams. Vegetation is lacking in the upper part of the landtype, the slopes below the peaks have cushion plants and a Caragana/Lonicera shrub cover.

There are no settlements or cultivation here but seasonal grazing occurs on the lower slopes. With its inaccessibility, this landtype receives little intensive use. Watershed condition is therefore good. Long steep-sided channels have been cut into shaley landslide deposits but these appear to be natural.

IB2b. Valley Slopes, steppe shrub - cultivated land.

This is composed of a complex pattern of long valley slopes, including straight, steep, creep slopes; crumpled, land flow deposit slopes; and short, nearly vertical slopes of truncated spurs and toe slopes. The elevation is 4800 to 5500 meters. Slope gradients range from 10 percent on some bench surfaces to over 100 percent on gorge walls adjacent to the river. The rocks here are shales and limestones mostly. The soils are generally deep, gravelly sand loams and loamy sands. The vegetation is a Caragana/Lonicera shrub type on some of the lower slopes.

Benchs here are cultivated. Most of the slopes are grazed. With its dryness, steepness of slope and sparsity of vegetation, the land here is quite sensitive to disturbance. Rilling and long gullies scar many slope faces. Control of grazing, especially in the vicinity of the villages is needed.

IB3. Border Ridges Land System.

This land system was mapped in two segments: a large segment along the northern margin of Dolpo which curves to the north in its eastern extent to form the upper slopes on the west side of the Mustang Valley. A spur of this segment extends to the south along the ridge separating the Dolpo area from Mustang Valley. The second segment was mapped in a north-south belt along the east side of the Mustang valley. We did not visit this second area but it was mapped as part of this land system because it appeared to be similar to the first segment when compared on the satellite imagery. The elevation, vegetation, geology and general landscape are also similar to that on the west side.

This is a parallel series of high elevation ridges and valleys (5000-6800 meters). It is very sparsely populated with seasonal grazing the main land use. The land system was divided into landtypes on the basis of observations made in the segment along the northern border of Dolpo. There is an abrupt line between sedimentary rock and granitic rocks here. This line is roughly parallel to the border and at right angles to the grain of the drainage pattern. A

second separation of landtypes was made based on slope position: bottomlands and ridge slopes. These two criteria, rock type and slope position, were used to separate the four landtypes described below.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IB3a	35	60-100 +	0	0	100	0	1	2	1	5
IB3b	10	5-30	0	0	100	0	2	1	2	5
IB3c	50	50-100 +	0	0	100	0	1	5	3	5
IB3d	5	5-10	0	0	100	L	2	2	2	5

IB3a. Granitic Ridge Lands, cushion plants.

This is an area of narrow ridge crests and steep upper ridge slopes. Most are straight to slightly concave. In several places these ridges form massive, nearly vertical peaks. More typically, the peaks here have subdued pyramidal shape. The elevation is 5000 to 6800 meters. The relief is moderate. The slopes are 60 to over 100 percent. The rocks are light grayish, coarse-textured granites without any conspicuous inclusions. Much of the landtype is covered with bouldery rubble. The soils are shallow, stony, loamy sands and sandy loams. Vegetation is a cushion plant community in pockets between the rocks. These slopes provide essentially no forage although herds cross through these lands between pastures. Some steep slopes have a shallow parallel dissection pattern but most are smooth and undissected.

A good part of the year they are snow covered with permanent snow fields hanging on high, north facing slopes. This land system is in excellent hydrologic condition because of the lack of land use and the armor of boulders.

IB3b. Upland Valley Bottoms, sod grasses.

This ecological landtype consists of the lower slopes and valley bottoms that accompany the ridgelands described above. These are mostly broad and benchy valleys, somewhat U-shaped, containing meandering streams in a narrow bottomland flat. There are numerous small side valleys above the main valley. Small ponds and lakes have been formed by ice excavation in some of these valleys. The elevation is 5200 to 5600 meters, slopes are 5 to 30 percent. The relief is low and the rock is dominantly granite but long outcroppings of shales are also present.

Alluvium fills most of the narrow bottomlands. Glacial rubble was noted in some higher valleys. The soils are deep, neutral to moderately alkaline gravelly loams. Cryoplanation processes i.e. stone stripes, patterned ground, pingos, solifluction slumps, etc. are evident here. The vegetation is a sod grass and cushion plant community.

Summer yak grazing is heavy here. This has resulted in some broken sod and erosion. Most of the landtype however has complete vegetation cover.

IB3c. Sedimentary Ridgeland, cushion plants - steppe shrubs.

These are narrow ridges with fluted, steep, straight side slopes. The elevation is 4700 to 5300 meters. Relief is low to moderate. Slope gradients are 50 to over 100 percent. The rocks are sandstone, limestone, and shales in rather thin beds dipping very steeply to the north. The soils are shallow to moderately deep, gravelly loam to gravelly clay loam. The vegetation is mostly a Caragana/Lonicera type. There are large exposed surfaces of weathered shales and talus material.

These slopes are grazed by sheep and goats. Watershed condition appears to be excellent except in the vicinity of villages. Steepness and rockiness make much of the area inaccessible.

IB3d. Sedimentary Valley Bottoms, steppe shrubs.

This landtype occupies the lower extent of the valleys formed by the ridge and described in IB3c. In the valleys in the eastern part of the system it is composed of convex toe slopes, a broad bench and a steep-walled gorge. The relief is higher and the valleys narrower in the western part of this landtype. Here this landtype has steep, coalescing cones and fans, rubble deposits in a braided channel and discontinuous stream level terraces. The elevation is 4600 to 5500 meters. Slopes are mostly in the 5 to 10 percent range. Relief is low. Soils are shallow to moderately deep, loamy sands to sandy loams over stream worked cobbles and gravels. The vegetation is a Caragana/Lonicera shrub type. Willows are along the streams. Grazing is heavy on the benches and toe slopes.

There is considerable bare ground, gully erosion, and recent fan deposits. Further to the east, at elevations below 4800 meters, there is some cultivation.

IB4. Western Dolpo Canyon Lands Land System.

This land system is a series of deep, narrow canyons and rocky ridges on the western edge of Dolpo. The Langu Khola has cut the main canyon through the centre of the land system. This rugged system has resulted from the dissection of the main High Himalaya range as it twists northward in the Kanjiroba Himal toward the Ladak Himal along the northern border of the Muqu and Humla areas. There are few villages here and very little cultivated land. The controlling characteristic of the land system is steepness and rockiness. The two landtypes recognized in the system occur in a general pattern related to density and depth of dissection.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IB4a	70	60-100 +	5	0	95	0	1	5	1	5
IB4b	30	20-50	0	5	95	L	1	4	3	3

IB4a. Rocky Canyon Slopes and Ridge Crests, bare ground - steppe shrub.

These are very steep, fluted, rocky canyon walls and ridges slopes. In places they are interrupted by open, rock-free slopes of landtype IB4b. The elevation is 3000 to 5500 meters. Relief is high. Slope gradients are 60 to over 100 percent. The rocks are sandstones and limestones. Long cones and talus deposits are on the lower slopes. The soils, on some shoulders, on colluvial slopes and in saddles, are mostly gravelly loamy sand and sandy loam. Depth depends on position, i.e. moderately deep to deep on colluvial slopes, shallow in saddles.

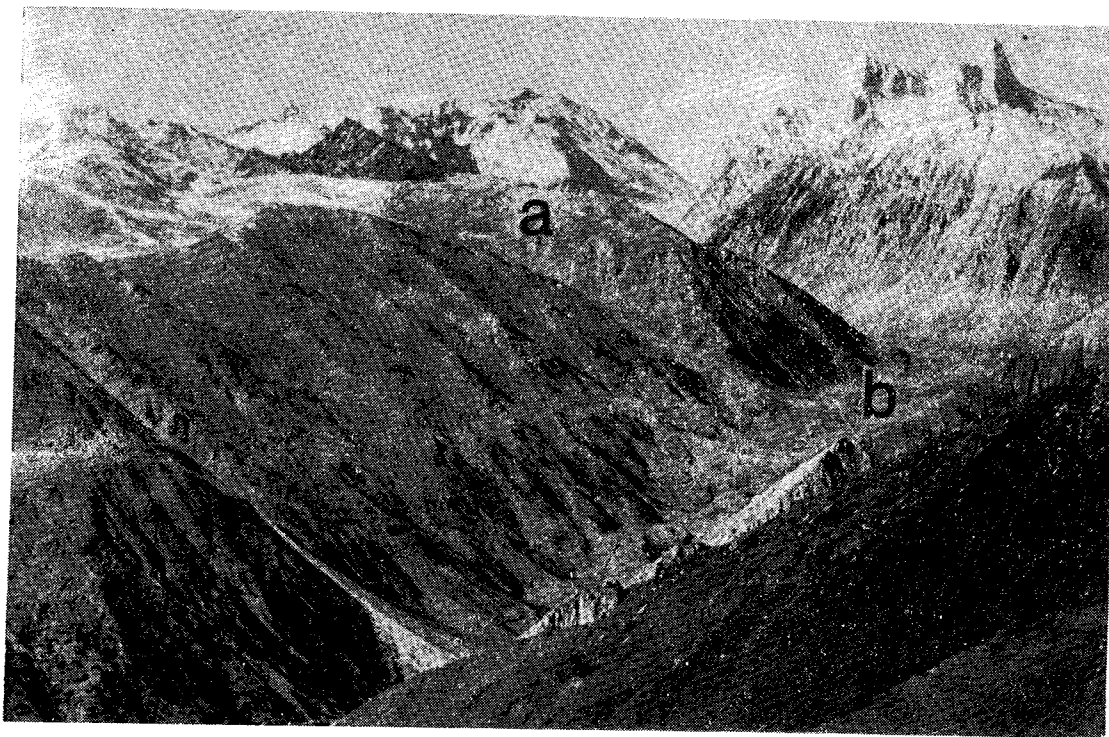
The vegetation reflects the great elevational range here, from birch-rhododendron cover with scattered blue pine at lowest elevation to bare soil and rock with occasional cushion plant on the ridge crests. Between are Caragana/Lonicera shrub cover and bunch grasses. Willow and juniper are in some of the higher valleys.

The ruggedness of this landtype makes it nearly impassable and unsuitable for grazing and agriculture. In spite of the natural high runoff and scattered debris avalanches, the landtype is in excellent condition.

IB4b. Rounded Ridges and Uplands, bunch grasses - steppe shrub.

These smooth, rock-free, coarsely dissected, moderately steep slopes almost appear to be inclusions in this landtype. They occupy upland and midslope positions. The relief is moderate. Shale in steeply dipping beds is a dominant rock type. The soils are moderately deep to deep, mostly loams over clay loams. The pH is neutral to moderately alkaline. The vegetation is bunch grasses with small shrubs, including rhododendron and willows.

Parts of this landtype are grazed. Landslides and solifluction slumps are natural phenomena here. At higher elevation, bare soil on the slopes ~~above the steep stream channels~~ are similar to excessively grazed areas. These slopes are very straight and lack any sign of trailing by livestock. It was concluded that the bare ground was part of a cryoplanation process.



2.11 Border Ridgeland (IB3) with Granitic Ridgeland (IB3a).
Sedimentary Ridgeland (IB3c) in the foreground. Upland
Valley Bottoms (IB3b) are in the central part.

IB5. Upper Mustang Valley Land System.

This is a broad basin in the section of Nepal that protrudes into the Tibetan plateau. As with other parts of this region, it is dry and sparsely populated. The walled city of Lho Mantang is the principal population center. Cultivation is limited to a few oasis-like spots of irrigated lands. Ruins of forts and abandoned terraced lands suggest a higher population was here in the past. This and other land systems in the Mustang Valley have experienced partial desertification. The most probable cause was erosion or wash out of canals feeding the irrigated land.

The central part of the valley outside of the patches of irrigated land is a desert. Strong winds blow steadily up the valley during the day. The outwash terrace surfaces are covered with water-worked cobble. Steep slopes have been ~~eroded into badlands.~~

On the western and central part of the valley visited, four landtypes were identified. It appears that there is a mirror image duplication of these units on the east side of the valley.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IB5a	5	50-100+	0	0	100	0	1	4	2	5
IB5b	10	50-70	0	0	100	0	2	3	3	5
IB5c	25	5-10dom. 60-100+ canyons	0	0	100	0	3	3 can- yons	2	2
IB5d	60	3-10dom. 50-100+ canyons	0	5	95	L	4	2	4	2

IB5a. Upper Valley Slopes, sod grasses - steppe shrub.

This is a series of convex valley slopes and rounded hill lands between the higher granite ridges and the interior, low landtypes of this land system. The elevation is 4200 to 5200 meters. Slopes are 50 to 70 percent, with gradients over 100 percent in the canyons reaching into this unit. The rocks are limestones and shales. The soils are very dark grayish brown to black silt loams over clay loams. They are moderately deep, and mostly stone free. The vegetation is a sod grass cover.

There are inclusions here of shaley talus slopes. The unit is heavily grazed and has small slips and a few gullies. Grazing restrictions are needed to prevent further deterioration.

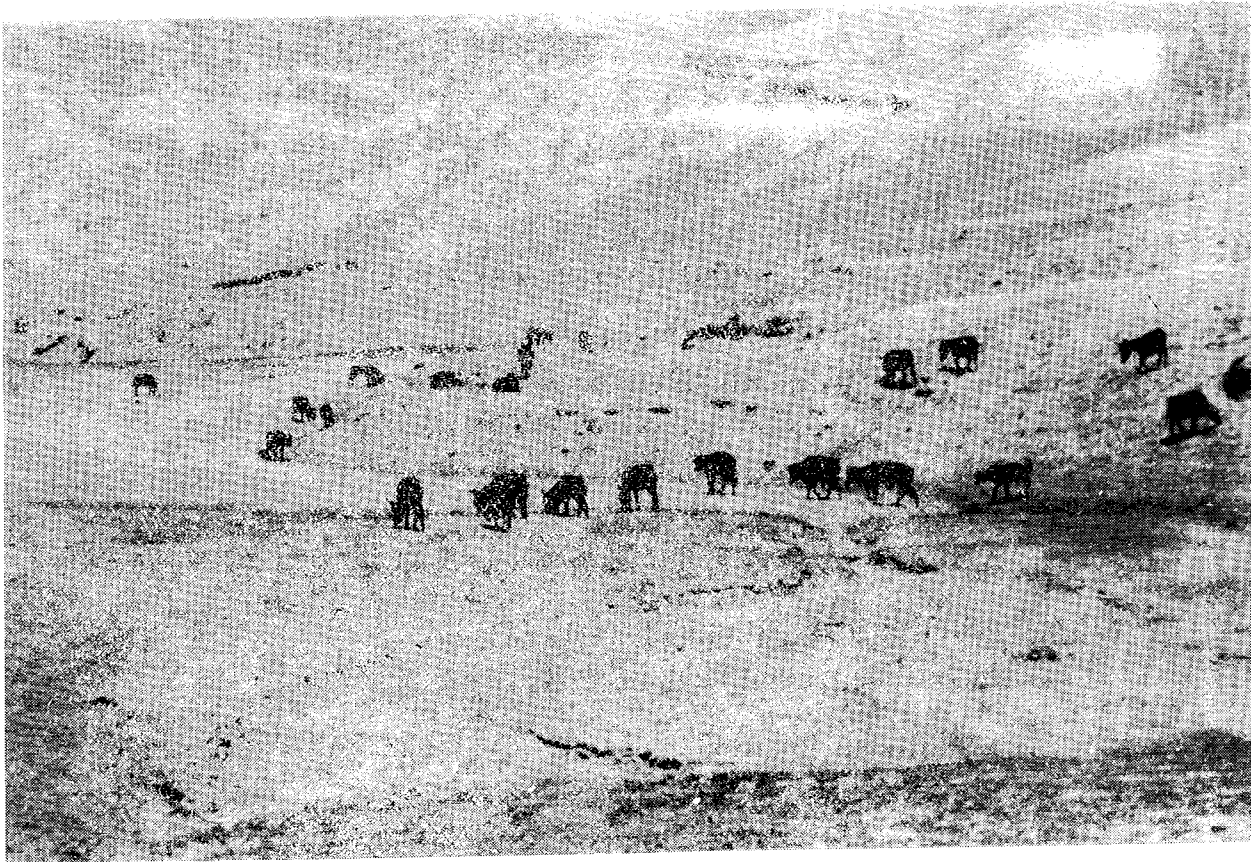
IB5b. Dissected Plateau Lands, sod grasses - steppe shrub.

This unit is in a piedmont-like zone at the base of the higher, enclosing ridges on each side of the Mustang valley. It has somewhat hilly to flat, interfluvial surfaces between sharp, V-shaped, incised gorges. The unit slopes gently toward the center of the valley floor. There is a general concordance between these surfaces and the Tibetan plateau to the north. This unit is more evident on the west side of the valley and occurs only in scattered remnants on the east side. The geologic materials are in the Thakkhola detrital formation which consists of sandstones, conglomerates and clay deposits. The soils are shallow to moderately deep gravelly sandy loams and loamy sands. The vegetation is a Caragana/Lonicera shrub type.

The unit is heavily grazed. The impact is particularly severe on the steep walls of the gorges that cross this unit. Grazing patterns and forage species should be studied to see if productivity can be increased.

IB5c. Mustang Valley Lowland Complex, bare ground - steppe shrub.

This landtype consists of a number of landforms: low ridges and hills, high terraces, outwash-covered benches, narrow, steep-sided stream valleys and narrow, stream side bottomlands. The west side of the valley has a large area of colorful badlands.



2.12 A landscape in the Mustang Valley Lowland Complex (IB5c).

The valley appears to be the product of the headward cutting Mustang Khola exposing the soft material of the Tibetan plateau.

The elevation is 3600 to 4100 meters. The slopes of the outwash surfaces are 3 to 10 percent. Other slope gradients are 50 to over 100 percent. Relief is low to moderately low. The geologic materials are mostly light grayish brown to white, soft sandstone, limestone and clay deposits. Cobbly outwash covers the terrace surfaces and slopes of the stream valleys that cut through the terraces. The vegetation is a Caragana/Lonicera type in most places, Caragana/Artemesia at lower elevations. There is much rilled and gullied bare ground.

The grazing pressure here from cattle, goats, sheep, donkeys and horses appears to have been heavy for many years. Shrubs are pulled up for firewood. The few trees are in irrigated plots in the villages or along the streams.

The erosion is the result of centuries of grazing on sensitive lands in a harsh environment. No remnant sites were seen to give an indication of what its restoration potential is. The key needs here are for increasing productivity of agricultural lands, and enlarging or reclaiming agricultural lands through improvement and building of irrigation systems. Trials on grasses and shrubs should be made to find plants suitable for stabilization of eroded lands and production of forage. The current livestock management situation needs to be studied to see if improvements can be made. Every opportunity for tree planting, i.e. along streams and fields, needs to be pursued to provide firewood and protection from the wind.

IB6. Western Mustang Valley Land System.

A somewhat different set of land units occupies a western section of the Mustang valley. This land system extends from Kehami to Chelegaon. It is less open and has higher relief than the northern Upper Mustang Valley land system (IB5). The most conspicuous difference is that it lacks the remnants of the Tibetan plateau materials. Four landtypes were recognized here.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IB6a	10	60-100 +	0	0	100	0	1	3	3	5
IB6b	40	50-100 +	0	0	100	0	1-3	2	4	5
IB6c	20	5-15	0	20	80	L	1	1	2	2
IB6d	30	70 vertical	0	0	100	0	1	4	2	5

IB6a. Canyons and Forest Slopes, grassland - steppe shrub.

This unit consists of the steep, truncated faces of the high lateral ridges of land system IB3. A fault line seems to separate the higher upland system from the Western Mustang Valley system. Also included here are the canyon slopes of major drainages entering the Mustang Valley from the west. Extensions of these ridges reach into the lower land as rounded ridges.

IB6b. Smooth Ridglands, steppe shrub.

These are undissected, east-west oriented ridges. The elevation is about 3500 to 4000 meters. Relief is low to moderate. The rocks are limestones, shales and claystones. The soils are shallow to moderately deep gravelly loamy sands. The vegetation is a shrub type dominated by Caragana sp. A few bunch grasses are present but bare ground is up to 10 percent on some slopes. A few juniper are present.

The area is heavily grazed but in most places there are few gullies. In the vicinity of towns, a few of which are deserted, watershed condition is poor as indicated by gullies and rills. Parts of this unit have been turned into classic badlands. It is interesting that no landslides were noted here. Other than grazing control little can be done for this landtype. It might be worthwhile to try a few species of imported grasses here.

IB6c. Alluvial Fill Terraces, steppe shrub - juniper.

These are deep, fill slopes in pockets between the ridges of IB6a and IB6b. They are cut by deep, vertical-walled gorges, some as deep as 150 meters. The elevation is 3000 to 3500 meters. The slope gradient is 10 percent and the aspect is east. The materials are thick, partially cemented gravel and cobble deposits. The soils are moderately deep to deep, gravelly sandy loam or loamy sand. Much of this landtype is cultivated. The remainder support an open Caragana cover. Juniper is present in a few places.

For the most part these terraces are in good condition. Some bare ground near livestock concentration areas were noted. The only cultivated lands in this land system are here. This is permitted by the comparatively slight slope gradient, the smoothness of the surface and access to streams. The settled lands here look like oases. Apparently the water or the water delivery systems have failed in a few places causing villages and terraced fields to be abandoned. There is a need to improve the volume and security of the water delivery systems. Some of the abandoned areas could be taken up again if the water problem could be solved.

IB6d. Rock and Breaklands, bare ground - steppe shrub.

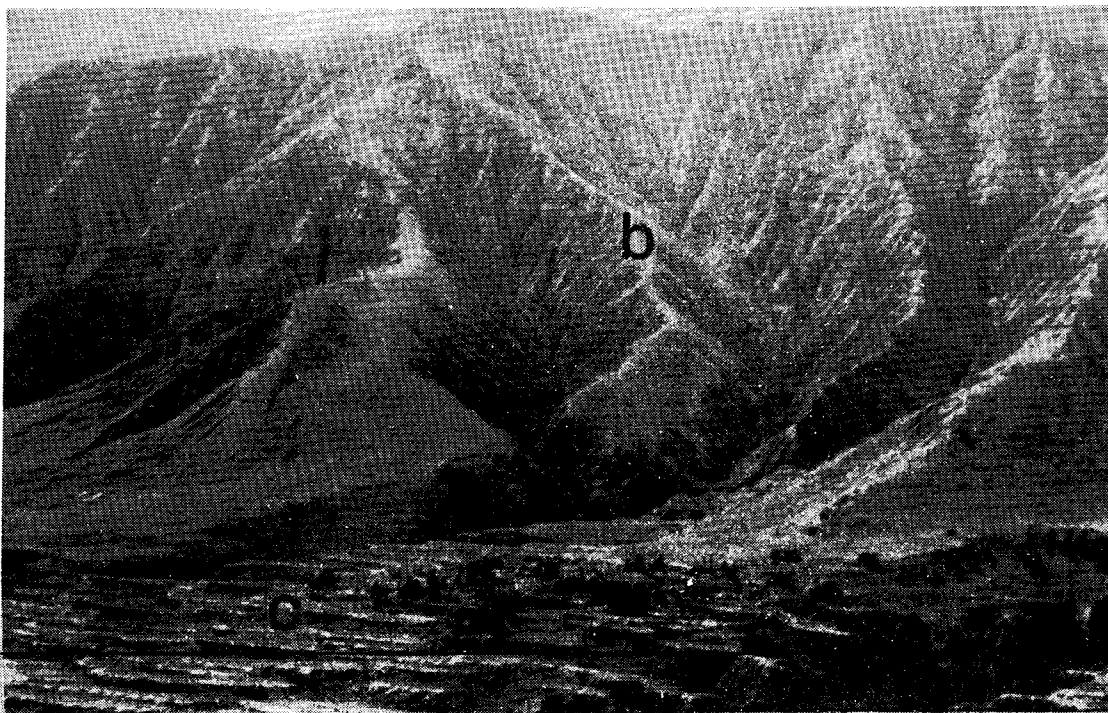
The ridges that cross this system from east to west have been eroded to form cliffs and pinnacles near the main canyon of the Kali Gandaki. The gorge of the Kali Gandaki is part of this type. The cliffs are mostly vertical, 50 to 100 meters high blocks of sandstone, limestone and conglomerates. The elevation is 3000 to 3700 meters. The inner gorge here contains the flood plain of the Kali Gandaki. The unit is quite scenic. The cliffs form a significant barrier between the villages on the terraces of IB6c.

IB7. Lower Mustang Valley Land System

This system spans the width of the valley between Chelegaon and Jomosom. It contains the group of communities called Panchagaon. The system is composed



2.13 Western Mustang Valley (IB6) with the following landtypes shown: (b) Smooth Ridgeland, (c) Alluvial Fill Terraces. The north face of Niligari, part of the Annapurna complex is shown on the skyline.



2.14 This is an example of abandoned terrace land, Alluvial Fill Terraces (IB6c) and the badlands carved in the Smooth Ridgeland landtype (IB6b).

largely of dry valley slopes and terraces that enclose the great, rubbly flood plain of the upper Kali Gandaki.

Three landtypes were recognized here.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IB7a	70	50-100 +	0	5	95	L	1	3	1	5
IB7b	20	10-15 low slopes 60-100 bench- surface	0	0	100	L	1	1	1	1
IB7c	10	<10	0	5	95 rubble silt	L	1	1	1	1

IB7a. Upper Hills, steppe shrub.

These are rounded, coarsely dissected hills that form the upper slopes on each side of the valley. The upper limit of the type are the barren slopes of the Himalaya zone. The benches, terraces and flood plains of the other landtypes in the system form the lower limit. The lower slopes of many hills are coalescing cones of soil and talus. Rock outcrop makes up 2 to 4 percent of the unit. There are extensive cliffs where the hills have been undercut near the Kali Gandaki River. Muktinath occupies a high basin within these hills. Other pockets of oasis-like cultivated lands are made possible by springs. The elevation range is 3700 to 4000 meters. The upper part of the type is snow covered for up to 6 months. The relief is moderate to moderately high. Slope gradients are 50 to over 100 percent. The sedimentary rocks are fossiliferous shales, limestones and gneisses. The soils are shallow to moderately deep, gravelly loamy sands to sandy loams.

The vegetation is an open cover of Caragana sp. Rose bushes are common in bottoms. A few scattered juniper and cypress are present. About 50 percent of the surface is bare ground. Most of the type shows no sign of erosion. Some steeper slopes in contact with streams however are crossed by long, parallel rills and gullies. Nearly all the area is grazed. Dry land grass species trials may show a potential for forage improvement. A grazing study should be made to determine the possible value of rest and rotational grazing system.

IB7b. Benchlands, steppe shrub.

These are the long, sloping, multi-tiered benches that lie adjacent to the Kali Gandaki and extend along the side valleys. The elevation is 2700 to 3100 meters. The relief is low, and slope gradients are 10 to 15 percent on bench surfaces, 60 - 100 percent between terraces and in dissections. The rocks are sandstone, shales and fossiliferous limestone. There is a thick layer of cobbly outwash in most places. The soils are limy, shallow to moderately deep, gravelly loamy sands, sandy loams and loams. The vegetation is a Caragana sp shrub type.

There is no water erosion here but evidence of wind erosion was noted in several places. Like IB7a, this type is grazed and would probably benefit from a grazing study to identify opportunities for improvement.

IB7c. Flood Plains and Terraces, bare rubble - cultivated lands.

This is the lowest type in the system with elevations between 2600 and 3100 meters. It consists of the main, rubble and silt choked, twisting flood plain of the Kali Gandaki and its major tributaries. In places it is covered by large fan deposits. There are also terraces here at 5 to 20 meter above the flood plain. These are the sites of villages. They are irrigated and cultivated, the relief is low, and slope gradients are mostly less than 10 percent. The materials are stream carried rubble to silt size deposits. The terraces are alluvial deposits. The soils on the terraces are deep, gravelly loams and loamy sands. The Kali Gandaki valley, and this landtype particularly, is known for its strong, daily, south winds.

The unit is enclosed by higher benches and hill slopes so the flood plain is not enlarging. The cultivated terraces are in good hydrologic condition. They seem to be well protected from the flood plain and streams that cross them. The lands adjacent to the terraces however show signs of erosion.



2.15 The Kagbeni area in the Lower Mustang Valley (IB7). Landtypes shown are the Upper Hill slopes (a), Benchlands (b), and Flood Plains and Terraces (c).

IC. Central High Himalayas Region

This region is the main Himalaya range between the Thulo Bheri on the west to the Langtang area on the east. It is an extremely rugged, high mountain chain with some of the most famous peaks in the world: Dhaulagiri, Nilgiri, Annapurna, Manaslu, Himal Chuli and Ganesh Himal. The high mountains are divided into five massifs by deep river valleys. A unique feature of this region is that river valleys cut very deeply into the mountain blocks here, nearly encircling and isolating them from the main, east-west Himalayan ridge. Two of these valleys, the Kali Gandaki and the Trisuli originate in the Tibetan Plateau. Several of these valleys are partially enclosed by the high ridges, creating a semiarid environment (back valleys) occupied by people of Tibetan origin.

Summary of Region

Area 6671 sq Km

20 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Other	1	2	3	4	5
3	1	96	31	18	15	36	0
Other: Rock, ice, snow 60%, meadow 16%, brush 20%.							

Location: Karnali Zone - Dolpo district; Dhaulagiri Zone - Mustang; Gandaki Zone - Lamjung, Kaski, Manang and Gorkha districts, Bagmati Zone - Dhading and Rasuwa districts. Jomosom is on the edge of the region. Larkya and Manangbhot are in back valleys here. The region is drained by most of the major rivers of central Nepal including the Thulo Bheri, the Kali Gandaki, Marsyangdi, Seti Khola, Buri Gandaki and Trisuli.

Topography/Relief: The elevation is 3800 to 7500 meters with some peaks over 8000 meters. Relief is high.

Climate: Alpine and Tibetan with precipitation on the south face of the range at 2000 to 4000 millimeters. On the north side and in the projected valleys it is generally less than 1000 millimeters. According to Köppen's classification this is in the eternal snow, high altitude climate (EFH), with Tundra, high altitude climate (ETH) on the upper slopes and cold steppe climate with dry winters (BSwk) in the enclosed valley land system, IC2.

Geology: This region lies north of the main central thrust. It is the core of a series of nappes that have been mapped along the axis of the Himalayas. The materials are primarily gneisses and schists with fossiliferous, locally metamorphic limestone.

Vegetation: There is a strong zonal vegetation pattern with the highest peaks essentially lifeless; a thin belt of lichens, mosses and cushion plants, giving way to alpine meadows with sod-forming grasses and low shrubs. Below these are the birch, rhododendron and fir thickets and forests. The back valleys have birch conifer forests on the northern aspects and blue pine, cypress and juniper stands on the lower slopes and valley bottoms.

People: The main groups are as follows: Larke, Shiar and Gurung in the Buri Gandaki catchment; Gurung and Nyeshang in the Marsyangdi Khola catchment and Thakali and Panchgaunle around and in the Kali Gandaki valley. This Ecological Region has a low population with all people concentrated in the valleys of the Land System IC2. There is however some temporary habitation during summer in Land System IC1 when cattle graze there. In some areas (as in the Manang Valley and in the Kali Gandaki Valley) population density has increased recently due to tourism. The Thakali settlements had a significant loss in population when their Tibetan trading routes were closed.

On a population per hectare of crop, the density ranges from 30 in the Dhading district (the highest in the country), to 2 in the Manang district, (the lowest in the country).

Comments: In deciding what action is necessary here to improve or protect the watershed condition, one can focus on the landtypes in the back valleys of this region. The High Himalayas are in a natural condition and can yield information on stream flow regulation and past climates, but are not subject to or threatened by significant physical impact by man. The back valleys are sensitive, and in places there are eroded lands which are the home of a unique group of people. These valleys would afford a grand opportunity for study, planning and implementation of a conservation project. The Manang valley is particularly recommended for such a project. The Marpha experiment station holds promise of making a contribution to all the agricultural lands in this region.

Division: The region was divided into two land systems: the main mountain range and the back valleys.

IC1. Alpine Highlands Land System.

This is the main mountain range. It makes up over 80 percent of the region and is characterized by its treeless landscapes with snow and ice fields and great, steep expanses of massive rock. Glaciers and glacial landforms such as cirques, morainal deposits and aretes are present. The elevation is above 3800 meters. The materials are gneisses.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IC1a	40	50-150	-	-	20 rock 80 ice, snow	-	1	5	5	not assessed
IC1b	25	80-150	-	-	10 ice, snow 70 rock 20shrub, grass	-	1	5	5	
IC1c	25	20-100	-	-	20 rock 80grass	very low temporary in summer	3	5	5	
IC1d	10	70-100	-	-	60 rock 40grass	very low temp. in summer	3	5	5	

IC1a. Rugged Upper Mountain Lands, no vegetation.

These are extremely rugged, rocky lands with many very high and steep rock walls. They are above 4500 meters. Most of these lands are under permanent snow cover and have no vegetation. They are in a natural watershed condition, although mass movement hazards (rockfall, rock-slides, talus, creep, avalanches) are extremely high. Canyons, cirques, glaciers and many of the high peaks are within this landtype. This landtype is noted for its great beauty and mountaineering challenge.

IC1b. High Ridgeland, sparse moist alpine vegetation.

The upper limit of this landtype is at 4500 meters, at or below the permanent snow line. This is equally as rugged as IC1a. with very steep, very rocky, deep canyons and large colluvial rock deposits. Vegetation consists of sparse, very low, moist alpine forbs and grasses with some moist alpine shrubs in the lower parts. Watershed condition is good or natural, although very high natural mass movement hazards exist.

IC1c. Rolling Mountain Highland, moist alpine meadows.

This landtype is at altitudes between 3800 and 4500 meters. It merges with the upper parts of the Transition Zone slopes and has a landform originating from glacial processes, e.g. old cirques, moraines. Fluvial processes are now reshaping the landscape. Soils are shallow to moderately deep, stony sandy loam, independent of whether they were

developed in place, in colluvium, or in morainal materials. Vegetation is a mixture of grass and forbs in moist alpine meadows with scattered alpine shrubs. The watershed condition is fair except along trails in the passes where conditions are marginal to poor due to over grazing. The upper tree line has been moved downslope in places because of over grazing.

There is considerable soil creep due to solifluction and other cryic processes, accelerated in places by heavy trampling of half frozen soil by cattle. The landtype is an important summer grazing area. The harsh environment and the heavy use of the area will make it difficult to find adequate solutions to watershed condition problems, especially along trails.

IC1d. Steep Valleys, moist alpine meadows.

Associated with IC1c, these steep valleys often form the heads of the bigger valleys belonging to land system IC2 or valleys in the Transition Zone. Fluvial process are incising a V-shaped profile in the original U-shaped glacial valleys, leaving benches of old glacial deposits at the sides of the valleys. These have steep to very steep slopes.

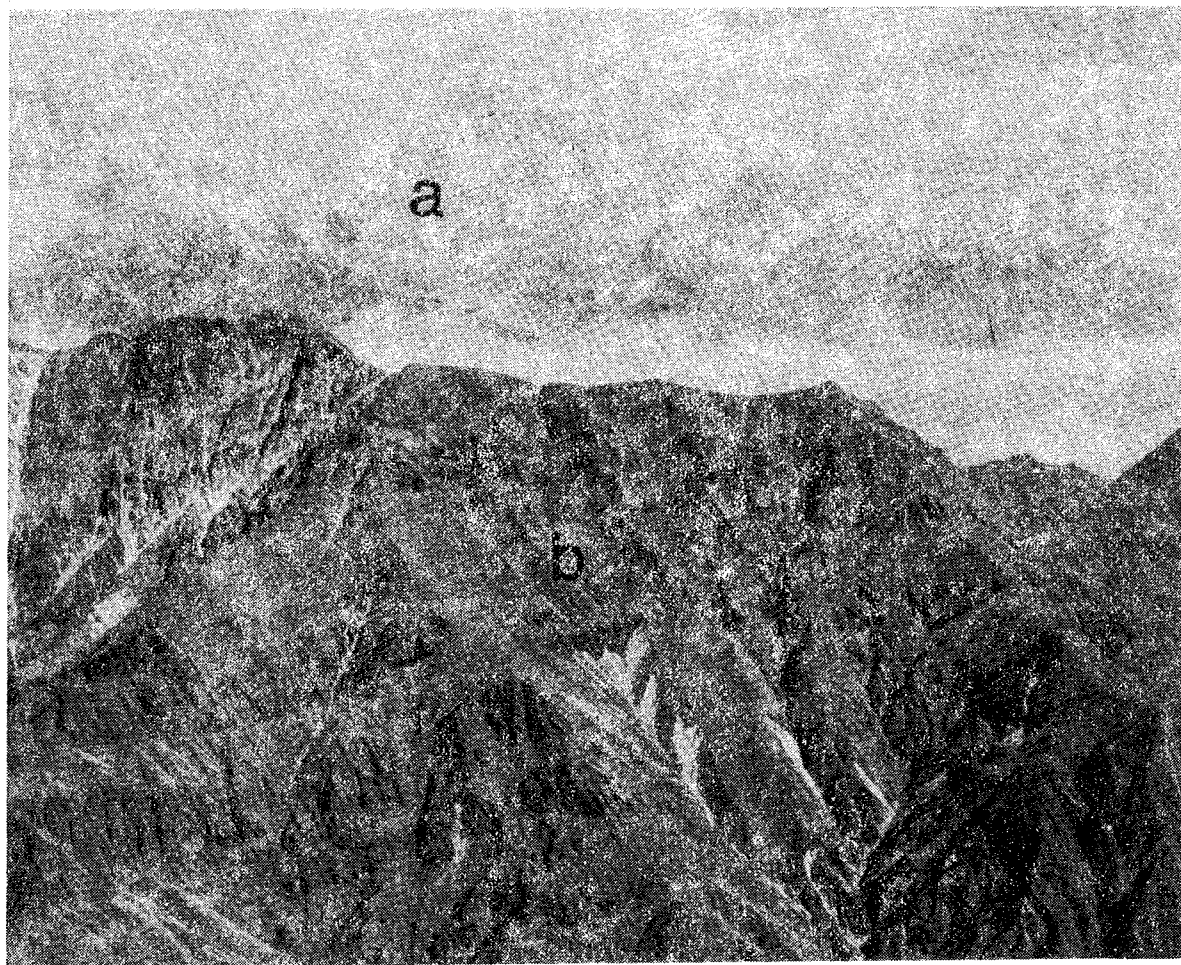
Soils here are very shallow to shallow, very stony, sandy loam. The natural vegetation is a mixture of grass and forb moist alpine meadow with scattered alpine shrubs.

The lands are overgrazed and watershed condition is fair. Rockslides, talus and soil creep here are mainly natural but are accelerated in places by sharp undercutting by streams.

IC2. Inner Valleys Land System

These are the back valleys, extensions of Transition Zone lands enclosed by the High Himalayas. They are present in the Kali Gandaki Valley between Ghasa and Jomosom, and the upper stretches of the Buri Gandaki and the Shir Khola. The largest is the Manang valley in the head of the Marsyangdi Khola catchment. Most of these are wide, U-shaped valleys that have been glaciated. Remnants of morainal and outwash terraces are on some slopes. The elevation is 2500 to 4000 meters. The principal materials are colluvium and alluvium from gneisses and sedimentary rocks. The vegetation is mainly a birch/blue pine/dry shrub group.

Most of the area is grazed but agriculture is marginal. Except in the Kali Gandaki valley which has a very dry climate, the valleys are snow covered for at least 5 months of the year.



2.16 Central High Himalayas Region with the Alpine Highlands (IC1) land system showing the rugged Upper Mountain Lands (a) and the High Ridgelands (b) landtypes. This unique area north of Dhorpatan has many natural landslides.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IC2a	50	80-150	40	-	60	low	1	5	5	5
IC2b	20	0-15	25	30	45	low	1	1	2	4
IC2c	10	70-120	-	-	100	low	3-4	5	5	5
IC2d	20	0-5	-	40	60	low	1	1	2-3 wind	2

IC2a. Steep to Very Steep Valley Slopes, birch - fir/blue pine/larch.

These steep, rocky valley slopes merge into the central Alpine Highlands at the treeline at about 4000 meters. Soils are very stony, very shallow to shallow loam. On the upper parts of north and west facing slopes there is good birch conifer forest cover. On the lower parts, and on south and east facing slopes with drier conditions, there is dry shrub or cypress/blue pine/juniper forests. Watershed condition is good or natural, there is some natural mass movement such as talus creep and rock slides. Wood is scarce so there is high pressure on these forests for fuelwood.

IC2b. Gently Sloping Old Depositional Terraces, blue pine - dry scrub.

These lands are on the irregular surface of huge and thick deposits of either glacial, or more likely ancient mass movement deposits. This surface is often about 20 m higher than the actual valley bottom. The deposits consist of graded, coarse, often chalky, weakly consolidated materials. Soils are very shallow to shallow, loamy sand to loam with 20 to 40 percent stone. The natural vegetation is dry shrub with open blue pine and juniper forest as in the Manang Valley.

These lands are used for grazing in summer. Deforestation is very high. There is some gullying but lands are mostly in good watershed condition. Irrigated fields are around villages.

IC2c. Very Steep Terrace Scarps, dry shrub.

These very steep terrace scarps have eroded to badlands in places. Soils are very shallow and extremely stony. Gullying is severe and deforestation is complete. In the Kali Gandaki Valley, where the scarps are almost vertical and the main river flows through a deep gorge between the terraces, undercutting and bank erosion is excessive. This landtype is in marginal to poor watershed condition and any earth disturbing activities should be avoided.

IC2d. Valley Bottomlands, blue pine - dry shrub.

This landtype is an association of low river terraces, alluvial fans and the valley floor. The latter is quite broad, for example the valley floor is 2500 to 3000 meters wide in the Kali Gandaki valley and 3000 to 3600 meters wide in the Manang Valley. It is almost flat and has coarse alluvial deposits with very shallow to shallow, very stony (40 percent), sandy soils. Internal drainage is poor. Accumulation of calcium carbonate and/or salt was noted. Vegetation in the Kali Gandaki, Buri Gandaki and Shiar Khola consists of a sparse, very dry shrub community. In the Manang valley, it probably was originally an open blue pine juniper forest.

Watershed condition is good or natural for the most part. There is some gullying and stream bank erosion. Wind erosion is important and effects the already poor soil fertility adversely by blowing out fine soil materials and organic matter. Restricted availability of water (mostly from snow melt), wind erosion and the short growing season are the main agricultural constraints.

ID. Eastern High Himalayas Region.

This is a series of five complex massifs in a line between Langtang and Kanchenjunga. It includes such well known peaks as Gaurishanker, Cho Oyu, Nuptse, Lhotse, Makalu and the highest, Everest. Deep river valleys separate the mountain blocks. The Arun River and the Sun Kosi have their headwaters on the Tibetan plateau, north of the Himalayas.

Summary of Region

Area 6098 sq Km

18 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Other	1	2	3	4	5
1	1	98	67	30	1	1	0
Other: Rock 30%; ice, snow 30%; meadow 30%, Shrub 8%.							

Location: The northern districts of the Bagmati, Janakpur, Sagarmatha, Koshi, and Mechi Zones. Namche Bazar is the largest town. The Region crosses the length of the Sapt Kosi river system.

Elevation/Relief: Elevation is from tree line at 4000 meters to the highest point on earth 8848 meters, the summit of Mt. Everest (Sagarmatha). Relief is 2000 to 3000 meters.

Climate: Tundra with precipitation in the 1000 mm to 1300 mm range. There is a definite rain shadow effect in the enclosed valleys of the Solu-Khumbu and Rolwaling areas. The monsoon is a time of misty clouds and light rains rather than torrential downpours. The Köppen climate classification scheme has this region in the Eternal Snow, high altitude climate (EFH) and Tundra (ETH) classes on the upper and lower slopes respectively.

Geology: As in other regions of the High Himalaya Zone, this region lies over the cores of nappes. The main rocks are gneisses. Tibetan sediments, mostly limestones and dolomite, are along the northern margin of the region.

Vegetation: The lower part of the region has birch and rhododendron forests. Above here there is a broad zone of moist alpine meadows. This gives way to mat-forming communities at about 5000 meters. Above 5300 meters bare rock, ice and snow dominate the landscape.

People: The main ethnic group is Sherpa. Lhami are in this zone in the upper Arun and Tamwa valleys. Population density is low when calculated on a total land area basis. When based on areas of crops the population density ranges from moderate (5 to 8 people per hectare) to very high (over 13 people per hectare). The Solu-Khumbu is in this latter category, probably as a result of the high proportion of people involved in tourism here.

Comments: This is a unique part of the earth that is probably going to see a steady increase in visits by outsiders. Although the traditional occupations, mainly agriculture, must be preserved, the focus of conservation efforts must be on preserving the environment in the face of this invasion of tourists. The deep canyons reaching into the region from the lower Transition Zone are particularly vulnerable to deforestation for firewood and consequent erosion. The greatest current source of erosion in the region is grazing of yaks on most of the glacial valley slopes. Here sod has been broken and soil erosion initiated. If unchecked this could cause extensive erosion on slopes where natural rehabilitation is very slow. This is part of a complex problem requiring a great deal of study before solutions can be formulated.

Divisions: Two land systems were recognized: a complex inner valley and ridge system and a Himalayan front or outer slope system. The boundary between these systems is the watershed line between slopes draining to the north toward the inner valleys and the slopes draining directly to the main Sapt Kosi river to the south. The following descriptions are based on a cursory look at the region. It is obvious that a more intensive investigation is needed.

ID1. Inner Valley Land System.

These are composed of the glaciated valleys and ridges in the interior of the Himalaya range, including the valleys north and west of Namche Bazar in Solu-Khumbu and the Rolwaling valley.

The landtypes are related to various aspects of valley glaciation.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
ID1a	30	80-160	0	0	rock 40 ice, snow 60	-	1	5	1	0
ID1b	20	10-30	0	0	rock, ice, snow 100	-	2	2	2	0
ID1c	20	5-50	0	0	ice, rock 100	-	1	5	5	0
ID1d	20	3-5 bottoms	0	5	95	low	2	5	4	1-5
ID1e	10	30-70	5	5	shrub 90	low	2,4	5	3	1-5

ID1a. Peaks and High Ridges.

These are matterhorns, aretes and cols above 5500 meters. Extremely steep rock and ice faces, hanging ice fields and ice falls are some of the features here. There is no soil or vegetation (except for lichens). The elevation is about 5500 to 8800 meters. There is no permanent human presence. The unit presents a minor hazard as a source of ice or rock-fall. Its main value is for scenery, climbing and sustained stream flow. The only watershed management needed is to determine the role of the ice and snow-fields here in relation to the valley glaciers and the streams and groundwater on lower slopes.

ID1b. High Benchlands and Ridge Slopes, cushion plants.

These are isolated shoulders, benches and mountain slopes, located mostly between the bare rock and ice of ID1a above and the glacier-cut slopes of ID1e and ID1d below. Slopes are 5 to 30 percent. The elevation is 4000 to 5500 meters. Vegetation consists of cushion plants, grasses and dwarf forbs. Soils, 10 to 40 cm deep, are thick, dark grayish brown sandy loams, neutral to medium acid. This landtype is a major component of summer yak pasture. It is in good condition in most places. There is some broken sod and shallow gullies. Attention to yak grazing is needed.

ID1c. Glacier-occupied Valleys, bare ground - ice.

These are open, rubble covered glaciers, with narrow marginal side ridges composed of boulders to sand size materials. There are ponds and meandering streams. Snow fields are in the upper reaches. There is ragged, sculpted land surface in places. Elevations are 4700 to 5500 meters. Very little vegetation is present. Soils are loose, unstable sands, gravels and cobbles. It is hazardous to cross. Sediment laden streams originate here. Landslides are common in side slopes undercut by the glacier, and by streams initiating from the glacier.

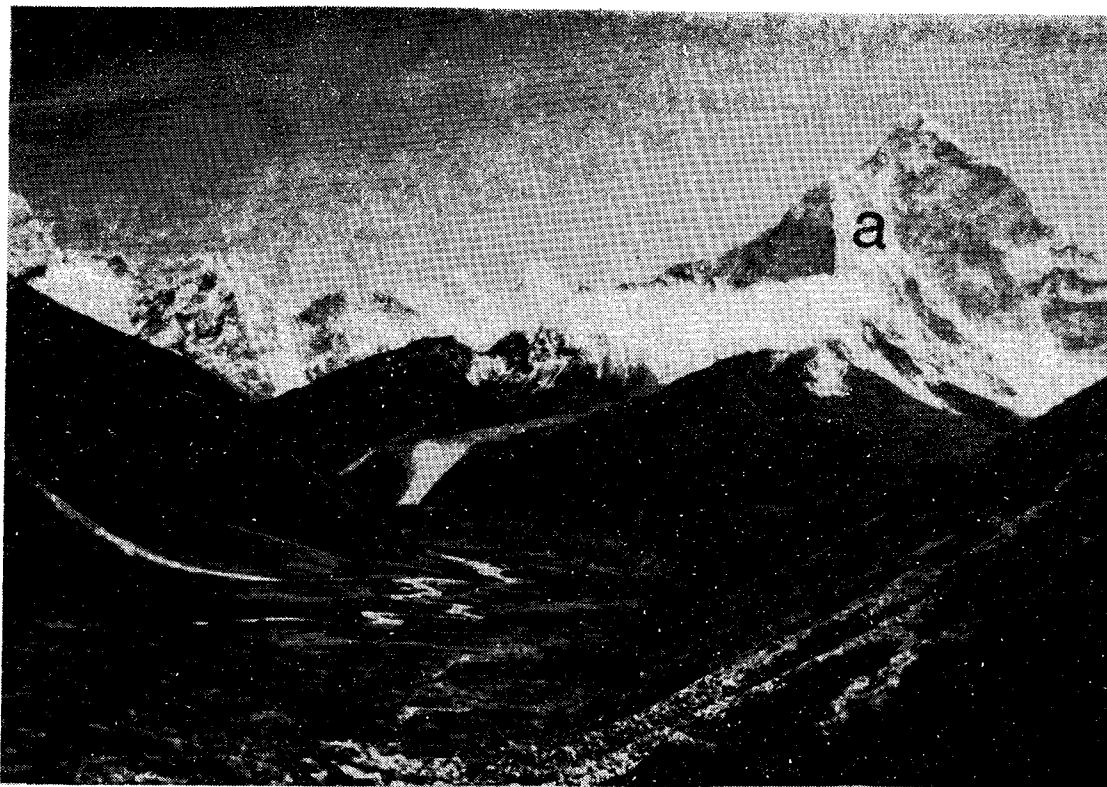
ID1d. Glaciated Valleys, wet meadow.

The landforms are broad, elongated, trough-like valleys and side slopes. This landtype was mapped below and adjacent to ID1c described above. The elevation is 4200 to 4600 meters. Materials are outwash and rubbly ground, moraine deposits. Soils are variable - mostly with a thin, black surface over sandy gravels. The pH is medium acid. Vegetation is sod grasses with junipers on elevated areas. There is a small amount of potato farming in the Dingboche area. The ID1d area is a yak grazing range. Valley bottoms are in good condition except for spots where sod is cut for building material. Lower sideslopes are eroded in places by excessive grazing, and if this continues unchecked, it could cause unravelling upslope for a considerable distance.

ID1e. Stream-cut Canyon Slopes, shrub - sod grasses.

These are the upper extension of canyons reaching into the Himalayan highlands. Slope gradients are 30 to 70 percent. The elevation is about

3900 to 4200 meters. The soil is shallow, coarse textured and very stony. The vegetation is a brush type with dwarf rhododendron, barberry and juniper most common. Birch and rhododendron are on north aspects. Benches within this unit are cultivated. These slopes are heavily grazed and are in poor condition in much of their extent. Some small landslides were noted adjacent to streams and in steeper parts. The major need is for grazing control.



2.17 The Khumbu valley above Pheriche, part of the Inner Valley land system (ID1). Landtypes: (a) Peaks and High Ridges; (b) High Benchlands and Ridge Slopes; and (c) Glaciated Valleys, are shown.

ID2. Front Slope Land System.

This land system is on the southerly aspects of high mountain massifs in eastern Nepal. It is more exposed than the enclosed land system ID1. It is also simpler and does not have the great glacial troughs nor the number of glaciers that are in the ID1 land system.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
ID2a	40	50-100 +	0	0	100	0	1	4	-	-
ID2b	30	30-70	0	0	100	0	1	2	2	-
ID2c	30	60-100 +	10	0	90	0	1	5	3	-

ID2a. Peaks and High Ridges, no vegetation.

This is the southern aspect of the same ridge crest unit as that described in ID1. There are very high ice and snow covered aretes and matterhorns. The elevation is 5500 to 8000 meters. It is a lifeless area. Its major asset is its spectacular appearance. However these ridges are important hydrologically. They are responsible for sustained stream flow and for impeding, and to some extent, drying moisture laden air masses.

ID2b. Upland Basins and Benches, sod grass meadows.

These are low relief, undulating, broken surfaces which appear to form a narrow platform at the base of the rocky high ridges. Their elevation is 5000 to 5500 meters. The slope gradients are 10 to 40 percent. The soils are moderately deep, gravelly, sandy loams. The vegetation is dominantly a wet meadow with low shrubs. These areas are grazed by yak.

ID2c. Narrow Ridgeland.

These are rocky, sharp ridges extending from the Peaks and High Ridges and the upland basin and benches landtypes. On their lower slopes they are in contact with the eastern parts of the Transition Zone. The elevation of these ridges is 4000 to 5600 meters. Slopes are vertical to about 70 percent. In many places the slopes are very long. The vegetation changes with elevation from no vegetation on massive rock surfaces, to sod and cushion plants, and then to low shrub which merges with birch and rhododendron covered slopes of the next lower landtype. The boundary between the High Himalaya Zone and the Transition Zone is very irregular. Soils are generally fine, gravelly, sandy loams, shallow to moderately deep. Rock outcrop accounts for up to 40 percent of the surface on individual slopes. Some yak grazing is probable here. The watershed condition appears to be excellent.

II. Transition Zone

As implied by the name, the Transition Zone is the land between the heavily used hills of the Middle Mountains and the sparsely populated High Himalayas. It can be described as the foot slopes of the High Himalayas. The zone has approximately 25000 sq Km or about 18 percent of the country.

Its upper boundary is the forest line at approximately 4000 meters. The lower boundary is the somewhat diffuse line that separates extensive agriculture development from scattered, isolated development. On ridge crests the elevation is 2300 to 3000 meters. In valleys it can be as low as 1000 meters.

Stainton (1972) speaks of much of the Transition Zone as the "Upper slopes" and says that during monsoon these slopes are "almost perpetually covered with drizzling mist and cloud". It is this monsoon cloud line that marks the upper limit of most cultivation.

The dominant aspect here is one of steep, long slopes. This zone typically consists of forested slopes of the valleys and ridges on the southern margins of the High Himalayan massifs and the Tibetan plateau. Steep slopes, heavy forest cover and climate only marginally suited to crops, has restricted the extent of agricultural development to the open south facing slopes, valley bottoms and benches. The most extensive forest lands north of the Siwaliks are in this zone. Some of these slopes such as in the Dudh Kosi and Arun Valleys, have been stripped of their forest cover.

These slopes are important watersheds. They receive large amounts of precipitation because their position and structure make them the sites of many orographic storms. Some of the most intensive rain storms in Nepal occur here.

The slopes of the Transition Zone are above the valleys of the Middle Mountain Zone. The runoff and the sediment production here directly affects land use in the midlands. The Transition Zone slopes, being long, straight and steep, are thus sensitive to erosion and give high sediment delivery rates. Because of this the Transition Zone is important hydrologically. The narrow canyon bottoms, and short, steep, side drainages mean that most detached materials are apt to end up in the major rivers rather quickly.

Much attention has been given to the receding forests of the Terai and to the afforestation efforts in the Middle Mountains. However the forests of the Transition Zone still offer considerable opportunity for management. One reason for separating this zone is to call attention to the critical land use problems which could develop here if efforts are not made to protect these landscapes.

The zone is mapped in five regions. Four form elongated belts running the length of the country at the foot of and between blocks of the high mountains. The fifth region is the Humla-Jumla area in western Nepal.

IIA. Far Western Transition Region

This is a comparatively small region in far western Nepal. Like other Transition Zone regions, it shows sharp contrast in land use and watershed conditions between land systems identified in the region.

Summary of Region

Area 2422 sq Km

10 percent of the Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Other	1	2	3	4	5
51	11	38	64	12	24	0	0
Other: 25% brush, 13% grass.							

Location: Between the Karnali and the Mahakali. It includes parts of the Darchula, Bajhang, Bajura districts of the Mahakali Zone and the Kalikot district of the Karnali Zone. Some of the towns here are Bajura, Chainpur, Talkot and Chaubishê. The region forms part of the Mahakali and Seti watersheds.

Elevation/Relief: 1500 to 4000 meters. Relief is dominantly in the moderate class: 500 to 2000 meters.

Climate: Temperate Monsoon. Mean annual precipitation is 1000 to 1500 mm.

The climate in this region has been classified under the Köppen scheme as a warm temperate rainy upland - sub tropical monsoon (Cwa/Csb.).

Geology: The materials are mostly gneisses. Dolomite, marble, sandstone and limestone are in the western portion of the region. The structure was described by Hagen (1969) as a series of nappes. The unit occupies the flanks of an anticline.

Vegetation: Oak communities dominate this region. Q.semecarpifolia with rhododendron on upper slopes, Q.incana and Q.lanata on mid and lower slopes. Above these main communities there is a belt of oak mixed with fir, then birch and mat-shrub types leading to the alpine meadows of the Western High Himalayas Region. A chir pine community is below the belt of oaks. Blue pine is in the upper Seti Valley.

People: The people are dominantly Chhetris. Brahmins and occupational castes are minorities. The population density is moderate. Based on area of crops, the population density is in high to very high classes. Bajhang district, one of the 13 districts in the very high density class, has 14 people per hectare of crops.

Comments: The sparsity of forest cover below 2500 meters is an indicator of a long period of settlement. We saw very little of this region during our field work. More detailed investigation is definitely needed before firm recommendations on conservation practices can be made. Afforestation, improved irrigation channels and grazing control, are universal needs which apply here however.

Subdivisions: Two land systems were identified primarily on the basis of elevation as reflected in land use.

IIA1. Upland Ridges and Valleys Land System.

This land system is a complex network of ridges and valleys lying between 1800 meters and the upper forest line. It is restricted to the higher parts of the main valleys and ridges. There are no permanent settlements. Time limitations did not permit visiting the area on the ground. The following descriptions are based on viewing the area from the air, from thematic inventories, and from satellite imagery interpretation. For description purposes the type has been divided into two landtypes.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIA1a	70	50-70	80	0	20	low	1	4	3	-
IIA1b	30	1800-3000	70	T	30	low	1	4	3	-

IIA1a. High Ridges, fir - oak.

These are the highest ridge slopes in this region. The elevation is 2800 to 4000 meters. The slope gradients are 50 to 70 percent. The vegetation is a fir-oak type (Abies spectabilis, Q.semecarpifolia) with birch and rhododendron.

As with most forested slopes, these are in good hydrologic condition.

IIA1b. Valley Slopes, fir - oak.

These are the upper valleys of the major drainages. The elevation is 1800 to 3000 meters. The valleys range from a broad U-shape in their upper reaches to a near vertical walled gorge for short segments. The vegetation is Q.semecarpifolia and A.spectabilis. Blue pine, Q.lanata and chir pine are on the lower slopes of the valley. Birch and rhododendron are patches at higher elevations.

Condition estimated to be good to excellent because of the low population.

IIA2. Lower Ridges and Valleys Land System.

This is the populated portion of the zone. It reaches from the bottomlands of the major drainages to the forested slopes of the upland ridges and valley land system. The elevation is 1500 to 2800 meters. The impression of these lands is one of intensive land use. This land system has two distinct sets of landforms: those associated with the major drainageways and those in the uplands. Three landtypes, one in the bottomlands and two for the valley side slopes, were used to describe this land system.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIA2a	30		10	10	80	mod.	2	3	2	2-4
IIA2b	60	30-70	15	25	60	mod.	2-4	3	3	2-4
IIA2c	10	< 5	T	90	10	mod.	1	1	1	1-2

IIA2a. Upper Slopes, oak.

These are a combination of steep ridges and open basins reaching up to land system IIA1. Many of these basins are funnel shaped leading to a narrow canyon at their base. They are crossed by a series of shallowly-incised, converging drainageways. Their elevation is 2400 to 3000 meters. The aspect is dominantly south. The geology is a mixture of schists, dolomite and limestone. There is less than 1 percent rock outcrop. The soils are deep gravelly loams over clay loams. Stone to gravel size material makes up 20 to 60 percent of the profile. The vegetation is an oak type, *Q. lanata*. Much of it assumes a shrub-like growth pattern because of heavy lopping.

The basin slopes, shoulders and benches are cultivated. Steeper and higher slopes are grazed. The oak are heavily lopped. Small landslides and soil erosion are common on the steeper slopes. The cultivated lands moreover are in good condition with brush and grass on the risers between the terraces. The steep lands adjacent to the drainageways have given way in a few places to small landflows.

Grazing control, afforestation and structures at key points in the drainageways are needed.

IIA2b. Mid and Lower Slopes, oak.

These slopes reach from the valley floor to a continuous brush vegetation cover or to the oak forested upper slopes of IIA2a. They are convex to straight. The slope gradients are 30 to 70 percent. The rock

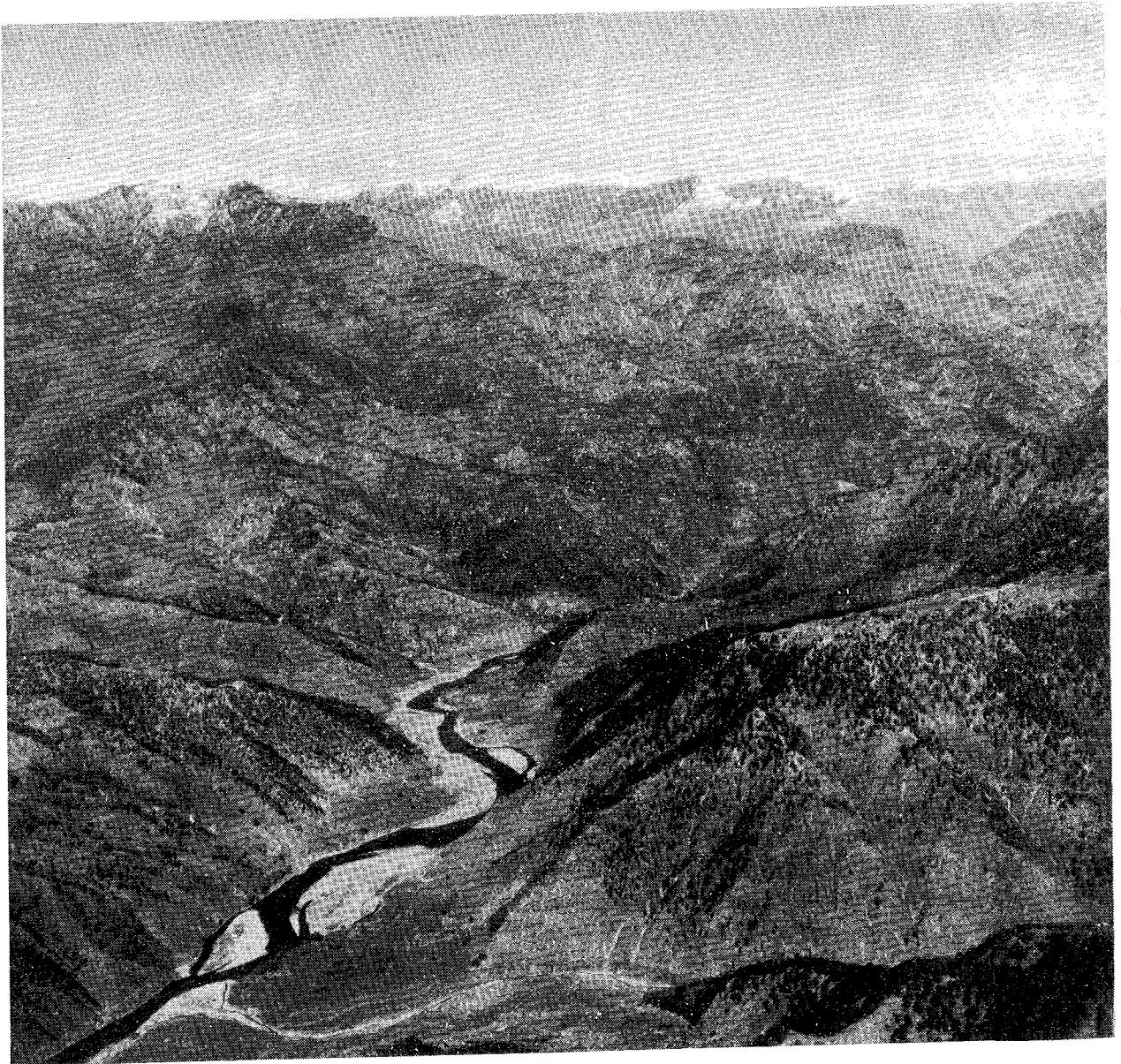
material is gneiss. The soils here are deep, gravelly loams over clay loams. The vegetation on south aspects is an open chir pine stand. On north aspects is oak and brush.

This is a rather complex landtype. There are at least three kinds of slopes, each with a different use. On the west and south sides of valleys the lower slope which contacts the bottomland is very steep. These slopes are heavily grazed and farmed. They are in poor hydrologic condition. Above these lower slopes the gradient is less steep. These slopes are terraced for the most part and are in fair to good condition. Some large landslides start in this section of the unit, crossing the lower slopes to deposit their loads on the valley floor. As the valleys become narrower, the side slopes become steeper and straighter. Land use on these steeper slopes decreases and the hydrologic condition improves. North facing slopes and slopes undercut by streams are straight, steep and generally in good hydrologic condition even though deforested.

IIA2c. Bottomlands, cultivated.

This landtype is composed of multi-level, natural terraces with deeply entrenched stream channels. The flood plain, where the channels broaden, is a rubble field with raw embankments. Land flow materials from the side slopes cover the terrace surface in places. Slope gradients are usually less than 5 percent. The inter-terrace slope, and the gorge slopes enclosing the stream may be vertical. Some remnant terraces are as high as 100 meters above the present river level. The soils are deep, gravelly loams. Except for the steep slopes, the unit is almost entirely cultivated.

Because of the low relief and the intensive, terraced cultivation practised, the landtype is in excellent condition. The biggest impact arises from deposition from the side slopes and, in secondary drainages, stream bank erosion.



2.18 The Far Western Transition Region (IIA) in the vicinity of the Seti River.

IIB. Humla-Jumla Region.

This large region covers much of the Karnali River basin. It consists of mountain ridges and valleys. Deep canyons in the upper Humla and Mugu drainages are cut into the main block of the High Himalayas. Isolated ridges and peaks of the Western High Himalayas Region are scattered throughout the region. The entire Humla-Jumla region occupies a gap in the alignment of the Himalayan range. Although this is a rugged, mountainous area, it is surrounded by higher mountains: the main Himalayas across the north with elevations over 6100 meters and the Thakurji-Chakhure Lekh system across the south with elevations up to 5200 meters. The barrier effect of these southern ridges creates a rain shadow for the Humla-Jumla Region. This is one of the region's distinguishing characteristics.

Summary of Region

Area 6098 sq Km

23 percent of the Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Other	1	2	3	4	5
54	12	34	56	44	0	0	0
Other: 24% brush, 10% grass							

Location: Karnali Zone, all districts but Dolpa. Jumla, Simikot and Gum are the main towns.

Elevation/Relief: From 1500 to 6200 meters. Relief is mostly in the moderate class: 500 to 2000 meters.

Climate: This has been classified as Humid Continental with severe, dry winter and warm summer (Dwb). Bishop (1976) describes the climate as having a three season monsoon pattern: "a cold dry period from October through March, a hot dry period from April to June, and a warm summer monsoon from July through September during which 75% of the rainfall occurs." The higher parts of Humla and Mugu have a cool, semi-arid montane steppe climate. The lower lands of the Sinja and Tila basin have a warm temperate montane climate. High, isolated segments of the High Himalaya Zone in this region have an alpine or Nival climate.

Geology: Zones of rocks are oriented in a northwest-southeast pattern with quartzitic schists in two belts separated by biotite garnet schists between. Wide bands of dolomite and limestone are in the central part of the region. The main central thrust also passes through the middle of the region. Structurally, this area is a series of folds with a northwest-southeast trend. Locally most rocks here appear to be in layers dipping steeply to the northeast.

Vegetation: The vegetation communities in the Humla-Jumla Region are three complex groups which are closely tied to elevation zones.

These are:

1. Western Highland group - ranging from cushion plants, through steppe shrubs to birch and rhododendron. A large grass-dominated community is common here. The elevation of this group is between 3000 and 5700 meters.
2. Pine - Fir - Oak group has fir (A. spectabilis) and oak (Q. semecarpifolia) at its higher elevations and blue pine (P. wallichiana) at its lower extent. Also in this group are other oak species, walnut, alder, maple and laurel. Trees with small distributions include juniper, cypress and cedar. The elevation range is about 2300 to 4000 meters.
3. Chir pine/hardwood group has oaks (Q. incana and Q. lanata) mixed with chir pine on the south facing slopes. At lower elevations of the Karnali river there is an extensive Euphorbia steppe. In cooler, narrow canyon bottoms there are walnut, chestnut and poplar. Lower elevation canyon bottoms have khair (Acacia catechu) and sissoo (Dalbergia sissoo) forests.

People: The people are mostly Bhotia across the northern part of the region and Hindu caste groups across the south. Population density is very low. The Jumla district is the most heavily populated. Based on area of crops, most of the region is in the moderate class. The Jumla district however, is in the very high class, with 22 people per hectare of crops, the third highest in Nepal.

Comment: From a hydrologic view point, this region is probably in the best overall condition of any region in the country. This is because it is forested in most of its extent and the people are concentrated in a relatively narrow strip along the rivers because irrigation is required. We noted areas of rapid degradation of forest lands where agricultural expansion is occurring. The exceptions to this generally favourable picture are the dry, southfacing slopes near villages, e.g. near Simikot and Jumla. Both areas are excessively grazed.

Forest management opportunities exist and must be taken advantage of soon to prevent the destruction of some very attractive riveraine forest communities, especially stands of walnut, maple and chestnut.

This large region presents a wide range of challenges and opportunities. The lands between cultivated plots on south facing slopes are the biggest problem areas. The north facing slopes, though sensitive, are in the best condition hydrologically. The major problems from a soil erosion standpoint are excessive grazing on lands next to cultivated areas, expansion of fields on to unstable, heavily forested slopes, and forest fires. The entire region should be classified in detail as a guide to forest management planning.

Divisions: The region was divided into two land systems on the basis of physiographic characteristics: relief, degree of dissection and width of canyons.

IIB1. Humla - Mugu Khola Land System.

This is in the north part of the region and consists of the deep canyons of the Humla Karnali and Mugu Karnali and their many side canyons. This is a rugged area with much of it still in forest. Five rather complex ecological landtypes were recognized on the basis of slope position in relation to the canyons.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIB1a	25	60-100	20	10	70	mod.	1	3-4	3	2-5
IIB1b	25	70-110	90	T	10	low	1	4-5	2	5
IIB1c	35	40-80	70	20	10	mod.	1-2	3	3	2-4
IIB1d	10	50-70	80	0	20	low	1	3	3	4
IIB1e	5	2-10	10	80	10	low	1	1	1	1

IIB1a. South Aspect Slopes, mixed vegetation cover.

These are long, fluted slopes with distinctive zonation. The elevation is 2000 to 4000 meters. The local relief of 1500 meters is in the moderate class. The geologic materials are mostly gneisses. These tend to be in scarp slopes with the northward dip of the bedrock exceeding 100 percent. The soils here are strongly colluvial, moderately deep, gravelly, sandy loams and loamy sands. Vegetation is an open chir pine-bunchgrass type with blue pine on the upper part of the slopes. Oak (*Q. incana*) is present on some upper slopes.

Benches and saddles here are cultivated and are the sites of villages. The crops are rain fed and the fields are very steep in places. The unit is in good to excellent hydrologic condition. The exceptions are on overgrazed benches and a few upper slopes next to villages. A few slopes are obviously too steep for cultivation as indicated by a widening zone of exposed sub-strata material across the tops of the fields.

The upper reaches of these canyons have cobbly, loose soils that are easily eroded by excess grazing. The area near Simikot is an example.

IIB1b. North Aspect Canyon Slopes, blue pine/fir.

These long, straight, steep slopes are the other half of the major canyons in the northern part of the region. The elevational and relief range is the same as for the south slopes. The planes of the layers of rock are generally parallel to the slope. The soils are stony, sandy loams. Most show signs of strong colluvial action. There are three vegetation types: a narrow chir pine zone near the bottom of the slope, a wide blue pine forest with spruce and fir covering most of the unit, and a fringe of birch and rhododendron at the top of the unit.

Agriculture is a minor activity on most of these slopes although the benches of the upper canyons are cultivated. Much of this landtype is forested, with excellent watershed condition.

There are isolated but extremely sensitive slopes. Road cuts here would have a very large impact. The forests generally have uniform age classes suggesting a major role of fire. Protection against fire is needed. These slopes could be a major wood supplier with careful management. The sensitivity of these slopes indicate that watershed protection may be the best land use, as at present.

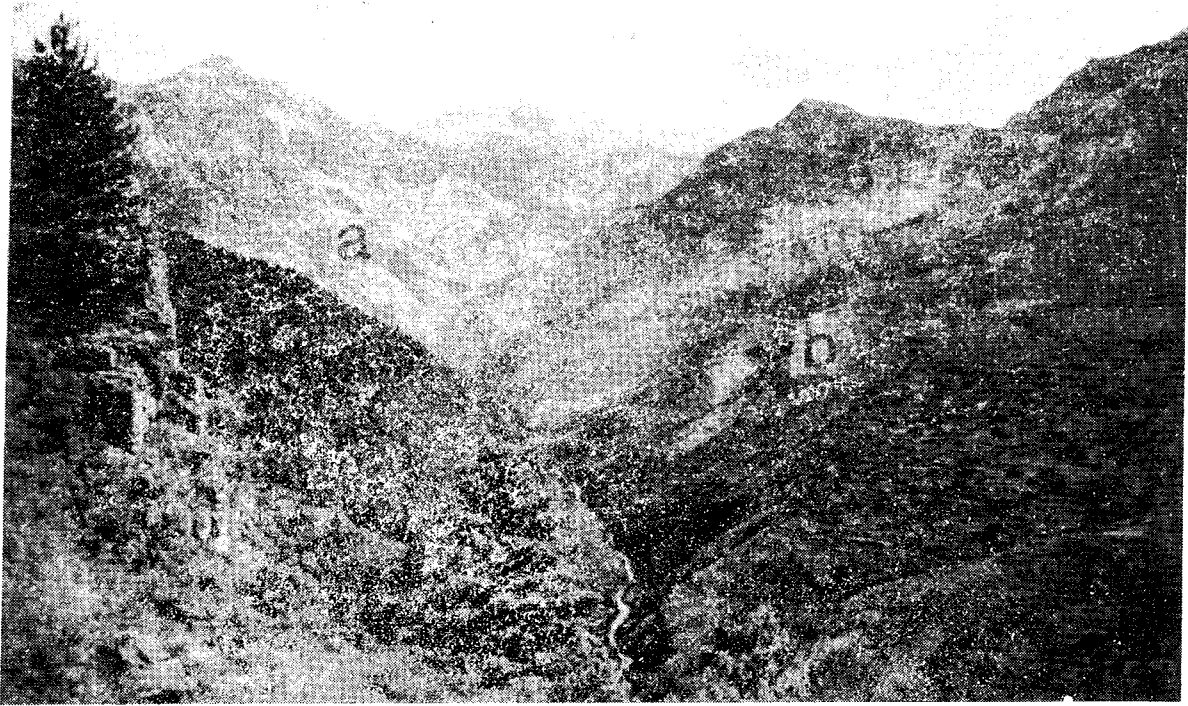
IIB1c. Back Valleys, blue pine - hardwoods.

Tributary valleys to the major canyons form a complex set of land units which are grouped under this one heading. The influence of aspect is less strongly expressed here than it is in the main canyons. These valleys can be divided into valley bottoms, often with the stream enclosed in a gorge, and side slopes. Side slopes have 10 to 100 percent slope gradients. Large, stabilized, land flows were noted in two of these side valleys. The soils are deep, gravelly and sandy loams. The vegetation is mainly blue pine or oak but some of the oldest, best preserved riveraine hardwood stands consisting of maple, poplar, chestnut, hemlock, spruce and fir are also present.

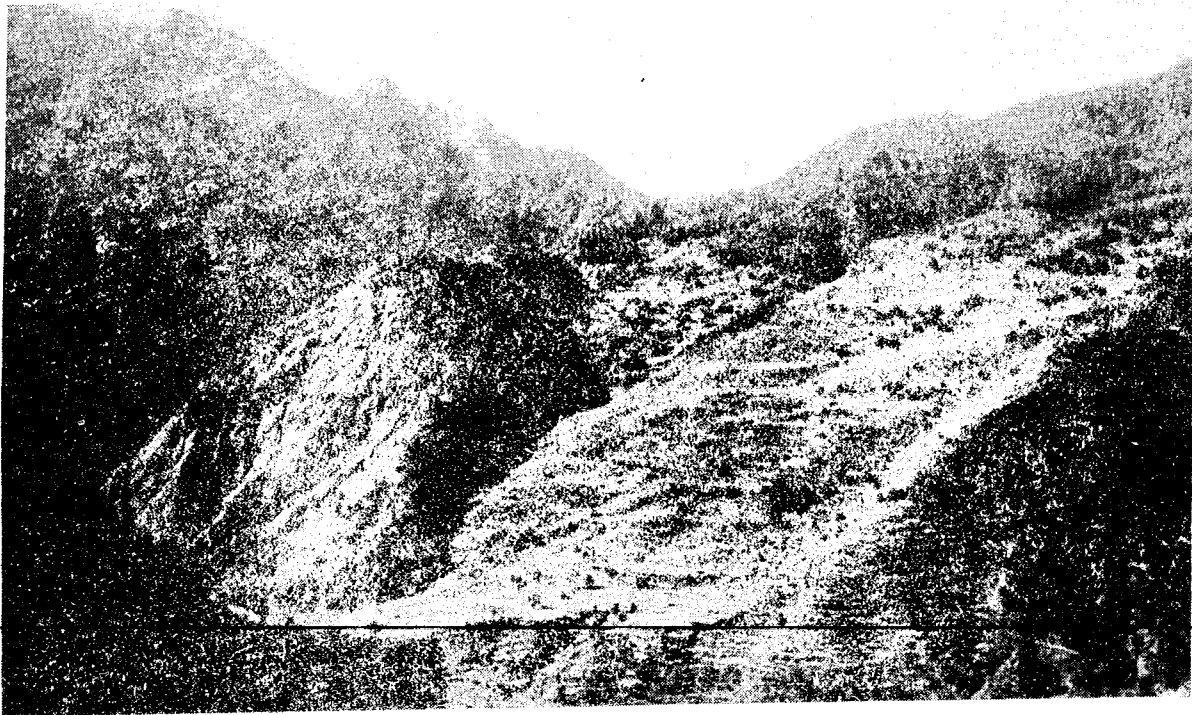
The old landflows here have been cultivated for a long time. These support some of the highest elevation paddy in the world near Rimi. The fact that these are landflows means a supply of irrigation water, gentle slopes and deep soils. Except for minor streambank erosion, these lands are now stable. Shoulders and benches on mid and upper slopes are also cultivated. Some debris slides were noted on steeper slopes. Agriculture is expanding rapidly on to benches in this unit, with the loss of much forest land. Detailed studies are needed to allocate most beneficial land use.

IIB1d. Bottomland of Main Canyons, chir pine.

This landtype is composed of the slopes, benches, and a central gorge in the bottoms of the major canyons. It is not continuous, being pinched out where the canyon narrows. Relief is low. The toe slopes are deep stabilized colluvium; the benches are covered with cobbles and gravel. The soils are shallow to moderately deep, gravelly, loamy sands. The vegetation is an open chir pine cover with walnut, maple and chestnut.



2.19 The Upper Humla Karnali showing South Aspect Slopes (a) and North Aspect Canyon Slopes (b) above Simikot in the Humla-Mugu Khola Land System (IIB1).



2.20 A stabilized landflow in Back Valley Landtype of the Humla-Mugu Khola Land System (IIB1).

Most of the bench surfaces are cultivated, much being irrigated by water from side streams. The main trails occupy this unit.

No management improvement needs were noted in this small landtype.

IIB1e. Upper Slopes, oak (*Q. semecarpifolia*).

These long straight slopes at elevations of 3300 to 4000 meters are in contact with the open steppe brush type of the High Himalaya inclusions in this system. The general aspect is south. The slope gradients are from 60 per cent to over 100 percent. The soils are moderately deep, loams over silt and clay loams on the ridge crests. On side slopes they are gravelly sandy loams. The unit is characterized by an open stand of tall oak trees and dry grass-forb ground cover. The stands are more dense at lower elevations. Blue pine takes over with decrease in elevation.

This area is grazed. The watershed condition, except on heavily used trail areas on ridge crests, is fair to good. Some streams which start in snow fields in the higher zone have high, raw channel banks.

The development of a scientific grazing plan is needed here.

IIB2. Tile-Sinja-Karnali Mountain Lands Land System.

This complex land system covers the southern two-thirds of the Humla-Jumla region. It reaches from 600 meters where the Sinha Khola meets the Karnali to about 4000 meters where the High Himalaya Zone begins. It consists of canyons of various dimensions, forested uplands and mountain slopes. Jumla is the principal town here. Six landtypes were recognized on the basis of landform.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIB2a	35	70-110	50	0	50	low	1	4	2	5
IIB2b	25	30-50	50	20	30	low	2	3	2	2-4
IIB2c	15	70-110 sides 5-30 benches/ bottoms	60	10	30	low	1	4	3	2-4
IIB2d	10	40-70 sides 2-20 bottom	20	30	50	mod.	3upper 2lower	2-3	4	4sides 1bottom
IIB2e	15	80-100	60	10	30	low	2	4	4	3-4

IIB2a. Upper Mountain Slopes, birch/rhododendron - blue pine/fir - grassland.

These are straight to slightly concave slopes of V-shaped valleys that incise the High Himalaya lands in the southern edge of the region. The elevation is 2500 to 4000 meters. The relief is moderate. There is a strong aspect relationship to vegetation, with grasslands on many south facing slopes and pine-fir-birch on the north facing slopes. Slope gradients are from 70 percent to over 100 percent. The rocks, mainly schists, are exposed in rugged outcropping in the western extension of this landtype. The soils are moderately deep, silt loams, loams and clay loams. Angular stone is 5 to 30 percent. The vegetation is notable for density of the stands of trees on north facing slopes and the abruptness of the stands' edges. The south aspects are generally grasslands. In places, this landtype is a narrow, horizontal belt between croplands on lower ridges and barren upland ridge crests.

Some grazing takes place in the grass lands but otherwise this landtype is unused. A few valley bottoms had severe erosion problems in trail areas. Avalanche paths are common in the birch forests on upper slopes.

This landtype is mostly removed from populated areas, which probably accounts for its excellent watersted condition. Fire could be a problem here. Efforts should be made to educate the local people in fire prevention.

IIB2b. Basin Hill Land, blue pine.

This landtype consists of hill slopes and broad upland surfaces between the main valleys and inclusions of IALc.

The elevation is 2100 to 3000 meters and slope gradients are 30 to 50 percent on upland surfaces but 70 to 90 percent on valley side slopes. The rocks are schists. The soils are deep loams and sandy loams, mostly stone-free. The vegetation is an open blue pine type with a grass groundcover. Some long slopes in secondary valleys have complete grass cover with only scattered blue pine.

The benches, shoulders and gentle slopes in this unit are cultivated. Except where very steep, the unit has been heavily grazed and grass is cut by hand on many of the very steep slopes. Heavy trailing, broken sod and small debris slides are common near villages. Excessive deforestation by both cutting and fire is a serious problem. In most places the fields are walled and have brush on the margins, but terracing is very rudimentary. This results in down slope soil movement. The upper parts of fields are into the subsoil and regolith. The lower parts generally have thick accumulations of surface soil.

This is an important and generally productive landscape. Several villages are located here. The conservation needs are for a reforestation program and improved grazing practices. Some benefit would be gained by demonstration of gully check dams. It would be informative to close a small block of this land to grazing and see what the recovery and herbaceous production rates are.

IIB2c. Upper River Valleys, oak/fir/hemlock/blue pine - hardwood.

This unit is composed of straight, steep canyon slopes; high, deeply incised toe slope benches; step-like, partially stabilized landflows, and open basins. Most of the canyons are asymmetrical with the north and east facing slopes steeper and less benchy than the south and west slopes. The elevation is 2500 to 3800 meters. The rocks are gneisses. Rock outcrop is up to 25 percent on south facing slopes. The soils, as suggested by the number of landforms, are variable. They are moderately deep to deep, with sandy loam to clay loam textures. The vegetation is mostly blue pine and oak (*Q. semecarpifolia*) on south aspects and birch, fir and blue pine on north aspects. Bamboo is a common understory component. Walnut, chestnut, maple and grass lands are on the lower slopes and in the bottoms. Juniper was noted on a few lower slopes.

The elevation and ruggedness of the topography here confine cultivation to a few south facing benches and some open bottomlands. Except in the vicinity of villages, the unit is in good hydrologic condition. Forest fires are a serious problem which should be dealt with through an education program. Firewood is readily available. Training in soil fertility improvement methods such as mulching would be beneficial. Destruction of crops by wildlife was mentioned by the people here.

IIB2d. Mid-drainage Valleys, grassland - blue pine - cedar.

These are the broad, open valleys typified by the Jumla area. They have straight to convex side slopes; benchy, fan-covered toe slopes, and bottomland flats. Some small side valleys are present.

The elevation is 2200 to 3100 meters. Local relief is up to 700 meters. The slopes are 1 to 10 percent in the bottoms and 40 to 70 percent on the side slopes. The aspects are north and south. The rocks are schists with deep alluvial deposits in the bottoms. The soils are shallow to moderately deep, gravelly, sandy loams and sandy loam. The vegetation is a grass type with scattered blue pine on south aspects and closed blue pine with fir forests on north aspects. The valley bottoms and low benches are almost completely cultivated. A few pockets of cedar (*Cedrus deodara*) are on north facing toe slopes.

These are heavily used landscapes. The bottomlands are irrigated terraces, the sideslopes have sloping, unirrigated fields. Most villages are located on the toe slopes rather than in the valley bottoms. The hydrologic condition on slopes near villages is poor. This is indicated by heavy trailing, sheet erosion and rilling. The cause is excessive grazing. Convex slopes are especially hard hit. The forest edge on north facing slopes is in poor condition also. Tree planting on lower north facing slopes would help. Grass fires should be discouraged.

IIB2e. Lower Valleys, chir pine/euphorbia steppe - khair/sissoo.

These are the main valleys of the Karnali and its major tributaries. The landform has long valley side slopes with benches and shoulders. In places it tightens into a steep walled canyon. The elevation is

700 to 2500 meters. The relief is 1500 meters on individual sections of the valley. The slope gradients are in the 80 to 100 percent range. The geologic materials are schists. The vegetation is mostly a chir pine cover. On strong south aspects, the chir pine forms an open stand with bunch grass ground cover.

Most cultivated land here is unirrigated land on mid slope benches. Excessive grazing has caused some erosion. Fires have had an important impact. Large natural landslides were noted here. As with other landtypes, fire must be controlled.

This landtype was viewed on aerial reconnaissance flights and on aerial photographs but was not visited on the ground.



2.21 Landtypes: (a) Upper Mountain Slopes, and (b) Basin Hill
Land of the Tila-Sinja-Karnali Mountain Land System
(IIB2).

IIC. Western Transitional Mountain Region.

This is a rugged, deeply dissected mountainous region extending along the Himalayan front from the Karnali to the Dhorpatan area. It extends through and behind the main Himalayan range in the Thulo Bheri drainage. The rectangular pattern of major drainage is a notable feature. The region is heavily forested on most north aspects but has open, dry, commonly heavily grazed south facing slopes.

Area 4504 sq Km Summary of Region 17 percent of the Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Other	1	2	3	4	5
35	17	48	35	42	23	0	0
Other: 38% brush, 9% grass, 1% rock							

Location: The zones and districts are as follows:

Karnali Zone: Dolpo district; Bheri Zone: Dailekh and Jajarkot districts; Rapti Zone: Rukum district, and Dhaulagiri Zone: Baglung district.

Towns here include Tibrikot, Dhorpatan, and Rukumkot. Some major streams are the Thulo Bheri, the Bari Gad, the Thala Khola. The region is in the Karnali and the Kali Gandaki drainage systems.

Elevation/Relief: Elevation is 900 to 3200 meters. The relief is moderate to moderately high.

Climate: Temperate monsoon with 1000 to 2000 mm of precipitation on the front portion of this region and about 500 mm in the Tibrikot valley. Köppen classification is Warm Temperate Rainy Upland climate (Cwb), with subtropical monsoon (Cwa) on the lower slopes. Rukumkot is an exceptionally wet area with nearly 3000 mm of mean annual precipitation.

Geology This unit lies in a transition area between the central and western metasediment zones. The local structures are a series of faulted anticlines and synclines. The regional structure is a series of nappes. The rock types are quartzite, phyllite, schists and limestones.

People: Main groups are Magar, Brahmin, Chhetri, Thakuri and occupational castes. Population density is low to moderate. Based on cropland area, these districts are mainly in the moderately low population density class at 8 people per hectare.

Division: The region is mapped in four land systems separated on differences in the drainage pattern and location with respect to the axis of the Himalayan Range.

Comments: This is a complex region from land capability and land use view points. Although most of the region is in fair watershed condition, specific spots are in poor condition. The major challenges here are to upgrade the quality of agricultural practices, develop a grazing program, and make a plan for forest utilization.

IIC1. Western Ridges Land System.

This is a series of steep, parallel ridges and deep, narrow valleys in the western part of the region. The altitude range is from 1200 to 3800 meters. The relief within the landtypes is up to 2500 meters. The materials are garnet-biotite schist and phyllite with layers of quartzite and limestone.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Brush Grass					
IIC1a	55	60-110	55	5	15B 25G	low	1-2	3-4	4	5
IIC1b	10	0-20	20	10	20B 50G	low	1	2	2	2
IIC1c	15	60-100	15	35	35B 15G	mod.	2-3	3-4	4	4
IIC1d	10	80-150	30	5	20B 45G	low	2	4	4	5
IIC1e	10	0-5	20	50	15B 15G	low to mod.	2	1	2	2

IIC1a. Steep Dissected Upper Mountain Slopes, fir/hemlock - oak.

The well forested, north aspect slopes here have dominantly fir and hemlock forests and the south aspect slopes have oak forests. Most of these lands are above 2200 meters. There is little agriculture. Soils are shallow, sandy loam to loamy sand, 15-20% stones and 5% rock outcrop.

Watershed condition is good to excellent, since these are little used lands, but this indicates that some protective measures are needed. Most lands should be left under forest and grazing should be controlled.

IIC1b. Gently Sloping to Moderately Steep Uplands, fir/hemlock - oak.

These lands include draws and crestlands which are found in a complex pattern with IIC1a. They mostly have a grass cover and are used for grazing. Soils are moderately deep to deep loams. They are in good condition, except along trails. This landtype is best suited for grazing.

IIC1c. Steep Lower Mountain Slopes, oak - sal - chir pine.

These steep slopes are near the valley bottoms and lower parts of the region. The soils are shallow to moderately deep, sandy loams to clay loam. Much of the original forest cover has been replaced by brush. There is agriculture on noses and benches below 2200 meters. Many small slumps and landslides were noted. The watershed condition is fair on the lowest slopes and good above.

Upgrading of agricultural practices would lead to improved watershed condition. Better control of surface water is especially needed.

IIC1d. Very Steep Canyon Slopes, oak - chir pine.

These very steep, canyon slopes have shallow, sandy, loam soils with 30 to 40 percent stones and 10 to 20 percent rock outcrop.

Quercus semecarpifolia is on the upper slopes; Q. incana and Q. lanuginosa are on lower slopes. The forests are open with a bunch-grass ground cover.

Much of the area is grazed, and in spite of its ruggedness, is in good watershed condition. Grazing resources must be examined as a start toward grazing management.

IIC1e. River Bottomlands, alder - bamboo - acacia.

These narrow river bottoms are filled with aggraded fluvial deposits. The soils are deep, stony and have sandy textures. The vegetation is a jungle in narrow sections of the canyons opening to khair and sal forest in more open sections. A few fans and blocks of terrace lands are farmed. Strong bank protection measures are needed.



- 2.22 Western Ridges Land System (IIC1) between Dialek and Jumla.
Landtypes: (a) Steep Dissected Upper Mountain Slopes dominate this scene, with (b) smaller areas of Gently Sloping to Moderately Steep Uplands, and (c) Steep Lower Mountain Slopes present.

IIC2. East-West Ridges Land System.

This is a very rugged mountainous area, dissected by deep, narrow valleys. The valley orientation here is east-west rather than the normal north-south direction common to most of the Transition zone. The elevation is 1800 to 3800 meters. The relief is over 2000 meters. The rocks are phyllites, quartzites and limestone.

IIC2a. Steep North Aspect Mountain Slopes, fir - blue pine - maple.

These steep north facing slopes are mostly above 2500 meters. The soils are shallow to moderately deep, gravelly, sandy loam to loam (10-20% stones, 2-5% rock outcrop). They are almost completely forested with fir, with birch on the upper slopes. Hemlock is on the south side of Dhaulagiri Himal. Blue pine and deciduous forest with maple, walnut and horse chestnut are on lower slopes. Oaks, (Q. incana, Q. lanuginosa) and chir pine are in the southern part of the land system below 2200 meters.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br./Gr./Waste					
IIC2a	25	60-120	85	-	15B/G	low	1	4	4	5
IIC2b	25	60-120	60	5	10B/G 25G	low	1-2	4	4	5
IIC2c	10	40-80	25	40	10B 25G	mod.	3	3	3-4	3-4
IIC2d	20	80	20	-	30B 50G/W	low	1-3	3-4	4	5
IIC2e	10	9-15	-	70	30W	low	1	1	2	3
IIC2f	10	(For details, see subdivisions f1, f2 and f3, below.)								
f1	(5)	50-100	60	-	40G	mod.	1	3	4-5	4-5
f2	(3)	5-20	5	40	55B/G	mod.	1-2	1	1-2	1
f3	(2)	0-1	-	-	95G 5W	low	1	1	2	1

There is little agriculture here. The few landslides and avalanche paths are natural and the land type is in excellent condition. No changes in land management are required under current land use.

IIC2b. Steep South Aspect Mountain Slopes, oak - blue pine.

These slopes are less forested than their north aspect counterparts. The soils are shallow to moderately deep, gravelly, sandy loam to loam. Open oak (*Quercus semecarpifolia*) forests with a grass undercover reach to the treeline on the upper slopes. Blue pine replaces oak on the lower slopes. Dry oaks and chir pine are in the southern part of the land system below 2200 meters.

These slopes are used mostly for grazing with heavy trailing, slips and landslides resulting. Trail areas especially are damaged. Watershed condition is good to excellent. No specific management is needed except for the very difficult trail protection problem.

IIC2c. Moderately Steep to Steep Mountain Slopes, including "flow" and "bench" Lands, oak/pine.

This landtype is a mixture of landforms. South of Dhaulagiri Himal (excluding Pelma Khuda area) there are bench lands, noses and gentle mountainside slopes. Soils are moderately deep to deep, sandy loam to loam (10-20% stones, 1% rock outcrop). Above 2500 meters where it is too cold and foggy for agriculture, there is an oak/pine forest. Below 2500 meters agriculture is intensively practised.

The heavy use of these lands for agriculture increases the susceptibility of the land to erosion. Watershed condition is fair but gully erosion and landslides, especially near main drainageways, need attention.

IIC2d. Very Steep Rocky Mountain and Canyon Slopes, oak - blue pine - chir pine.

These are very rocky slopes. Vertical canyon walls are included here. Soils are very shallow, loamy sand to loam with 30 to 50% stones and 10 to 25% rock outcrop. Forests open in the southern part of the landtype where chir pine and oaks (Q. lanuginosa, Q. incana) are dominant. The steep lower slopes just above the valley bottom have probably never been under forest cover.

Watershed condition is from excellent to fair. There are steep, stable, canyon slopes in good condition, but also very abused overgrazed areas with abundant rockslides, shoestring slides, soil creep, trailing and gullying. The landtype needs afforestation. Even grass cutting should be curtailed in abused areas until these areas have recovered.

IIC2e. River Bottomlands, maple - walnut.

The land forms here are remnants of river terraces and alluvial fans. The vegetation is open forest with many scattered maple, walnut, horse chestnut, poplar and willows. Agriculture is predominant and the watershed condition is good. There is some streambank and gully erosion. Irrigation needs to be improved or introduced.

IIC2f. Subsystem of Dhorpatan Valley.

This is a complex area that has been divided into three smaller land units for description purposes.

f1. Rounded Mountain Slopes, blue pine - juniper.

These slopes are completely forested with blue pine and juniper. Open forests or grassland cover other parts. There is no cultivated land. Soils are shallow to moderately deep loam with 20% stone, 2% rock outcrop. Watershed condition is excellent and no management measures are required.

f2. Alluvial Fans, blue pine - juniper.

These lands are cultivated and grazed. Soils are moderately deep to deep, gravelly loam with 20% stone, no rock outcrop. The watershed condition is fair to good. Small patches of gully development are related to seepage lines which surface at the edges of valley plains. These areas need protection. There needs to be a general improvement in agriculture through the use of organic fertilizers and better field construction.

f3. Valley Plain, grass.

Situated at an altitude of 2800 meters, this swampy, very poorly drained, wide valley plain is covered by forbs and grasses. Soils are shallow to moderately deep, gravelly sands with a high content of organic matter. It is in excellent hydrologic condition.

The river is meandering but causes little stream bank erosion.

The valley is traditionally used for grazing cattle, sheep and horses being herded between Dolpa and the southern areas of Nepal (Dhor = cattle, patan = plain). Trials for fast growing plantations of poplar and willows are recommended.

IIC3. Lower Thulo Bheri Valley Land System.

This land system includes the valleys of Thulo Bheri and Sano Bheri Rivers. It extends in canyons through and behind the main Himalayan ridge in the area between Herikot and the Thulo Bheri. It has long, steep slopes with relatively open valleys containing river terraces. The drainage pattern is coarse textured and has rectangular shape in the southern part of the system. The elevation is 900 to 2700 meters. The relief is up to 1500 meters. The materials are quartzites and phyllites with interbedded limestones.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br./ Gr./ Waste					
IIC3a	25	65	10	10	40B/G 40G	mod. low	3	3	4	5
IIC3b	45	45	15	25	60	mod.	2	4	5	5
IIC3c	10	15-45	-	40	60	mod.	2	2	2	2
IIC3d	5	150	10	-	90 W + gr- azing	low	1	1	5	5
IIC3e	15	1-2	-	100	-	mod. high	2	1	2	2

IIC3a. Dry Steep South Aspect Mountain Slopes, oak - chir pine - sal.

These mountain slopes have very shallow to shallow sandy loam soils with 10 to 25 percent stones and 2 to 10 percent rock outcrop. They are overgrazed and only patches of oak, chir pine and sal forest are left. Watershed condition is fair and little water is available for agriculture. Restrictions on grazing are necessary to reverse the already negative trend in vegetation and soil condition.

IIC3b. Other Mountain Slopes, oak - chir pine - sal.

These slopes, on all but south aspects, have a heavy brush cover giving a more forested impression than IIC3a. Oak (Q. incana, Q. lanuginosa), chir pine and sal forests are present in elevation-related zones. Soils are shallow to moderately deep, loamy sands to sandy loams with 5 to 20 percent stones and less than 2 percent rock outcrop.

Agriculture is practised. Although land is heavily grazed, there are few disturbances. The watershed condition is good. Brushland can be used for fuelwood production and eventually converted to forest land if properly designed management practices are applied.

IIC3c. Gently Sloping Ridge Crests and Noses, oak - chir pine - sal.

These gently sloping ridge crests and noses have shallow to moderately deep soils, loamy sands to sandy loams with 5 to 20 percent stones and less than 2 percent rock outcrop. The natural vegetation is oak, chir pine and sal forests according to elevation. Part of the landtype is cultivated.

IIC3d. Canyonland, chir pine - sal.

These very rocky, extremely steep, canyon lands are a small unit confined to lower parts of the mountain slopes. Soils are very shallow sand to loam with 10 percent stones and 10 to 30 percent rock outcrop. A little grass cutting is about the only use made of these lands, and they are in excellent hydrologic condition.

IIC3e. River Terraces and Bottomlands, sal - acacia.

The main valleys in the land system are those of the Thulo Bheri and Sano Bheri. Four levels of extensive river terraces have been recognized. Soils are moderately deep to deep loam with 20 to 30 percent stones and 2 to 5 percent of the surface covered with big rocks and boulders.

The landtype is almost entirely used for agriculture. If irrigation were made available, these lands would be among the better agricultural lands in Nepal.

Watershed condition is good, but there is considerable bank erosion at the terrace sides. Gully development also tends to be increasing. Erosion must be checked to protect the farm land.

The river bottomlands are very stony wasteland, mostly unsuitable for agriculture or grazing.

IIC4. Thulo Bheri Inner Valley Land System.

This valley lies between the Dhaulagiri-Himalchuli Patan Himal on the south and the lekhs of the Kanjiroba Himal on the north. It is in a rain shadow of the high lands to the south, this being the feature which distinguishes it from other systems in this region. Total relief here is over 2000 meters. The system includes the lower sections of the Tarap Khola, Suli Gad and Ghata Khola canyons. Tarakot and Tibrikot are the principal villages here. Two landtypes are used to describe this system.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIC4a	30	10-100 +	50	T	50	low	1	4	3	4-5
IIC4b	70	5-10 60-100 +	30	20	50	mod.	2-3	4	4	1-4

IIC4a. Upland Ridges and Canyon Slopes, blue pine - fir - oak.

This landtype forms a belt on the upper slopes of the Thulo Bheri valley. It follows down the steep, straight, northerly slopes of secondary canyons to river level. Most of it consists of straight ridge and canyon slopes, but benches are in the lower part of the type. The elevation is 2700 to 4600 meters. It joins the High Himalaya Zone on its upper margin. Slope gradients are mostly 60 percent but range to over 100 percent. Cliffs and rock outcrops account for up to 10 percent of this unit in the Sali Gad canyon.

The benches have 10 to 50 percent slopes. Rock outcrop here is up to 3 percent. The soils are moderately deep loam, sandy loam and loamy sands. On north facing slopes the highest vegetation type is a birch-fir type, with fir type (Abies spectabilis) stands below. On south facing slopes, there is an oak type (Quercus semecarpifolia). The lowest zones are dominated by blue pine.

The landtype is lightly used in most of its extent. The lower south facing benches have been deforested and are now cultivated. It is in good watershed condition.

IIC4b. Lower Valley Slopes and Benches, bunch grass - chir pine.

These lower slopes are the facets of truncated spur ridges. They are convex to straight, fluted, and sparsely dissected by long, shallow

drainageways. They form gorges in much of their lower extent. A few flat benches were noted in the lower part of this unit near Tibrikot. The elevation is 1800 to 3900 meters. The rocks are coarse textured gneisses. The soils are shallow to moderately deep stony sands and loamy sands. The vegetation is an Artemesia sp type with scattered chir pine on the lowest slopes and cedar and cypress in remnant stands around temples. Cedar (Cedrus deodara) forms extensive stands on the slopes west of Ruma. Reproduction in these stands was conspicuously absent. Cypress (Cupressus torulosa) is the most common tree on the warmer slopes in the Suli Gad canyon.

The bottomlands and lower slopes of the Suli Gad canyon have a wide variety of tree species including maple, wild peach, poplar, walnut, elm and Syringa.

In the main valleys, most slopes with less than 40 percent gradients and some with slopes up to 70 percent are cultivated. The secondary canyon slopes in this unit are mostly over 70 percent and are not cultivated.

Where irrigation water is available crops do quite well. The dry land fields on these steep slopes with coarse textures require well timed rainfall for successful cropping. Droughts are common here. The fields on north facing slopes appear more productive than those on south facing slopes. Severe soil erosion was noted in some steep fields due to improper field layout and irrigation practices. Steep (40%+), non-irrigated fields are weakly benched rather than terraced. Maintaining soil fertility is a major problem because of the soil creep and coarse textures.

There is need here for training in layout of fields and in the use of mulches as soil stabilizers and sources of nutrients. Using fire as a grass growth stimulant should be discouraged because of the damage this practice does to soils.

Terracettes caused by livestock are very common here. There is erosion (caused by excessive grazing) near villages. The biggest watershed impact however is from poor farming practices. With the development of a National Park in the Ringmo area, the Suli Gad canyon will receive very heavy use. Care should be taken to protect camping sites and to prevent damage by fuelwood collection.



2.23 Tibrikot in the Lower Valley Slopes and Benches landtype (IIC4b) of the Thulo Bheri Inner Valley Land System (IIC4).

IID. Central Transitional Mountain Region.

This region occupies the flanks of a series of mountain blocks between Dhaulagiri and Langtang.

Summary of Region

Area 5075 sq Km

20 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Other	1	2	3	4	5
46	28	26	54	46	0	0	0
Other: 22% brush, 3% grass/meadow, 1% rock.							

Location: Dhaulagiri Zone: Myagdi district; Gandaki Zone: Kaski, Morang, Lamjung and Gurkha districts; Bagmati Zone: Dhading, Rasuwa, and Nuwakot districts. There are no towns of any size in the region. It is drained by the Trisuli - Marsyangdi drainage system in its eastern part and the Kali Gandaki in the west.

Elevation/Relief: the elevation is 750 - 3200 meters. The relief is high, over 2000 meters.

Climate: Temperate monsoon with 1500 to 2000 mm precipitation, reaching over 3000 mm on the slopes at the foot of the Annapurna Himal. Köppen's classification is warm temperate rainy upland (Cwb) with subtropical monsoon (Cwa) on the lower slopes.

Geology: The rocks here are quartzites, phyllites, schists, sandstone and limestone. There is a general homoclinal structure. It is in the tectonic zone of the main central thrust, which separates the northern gneissic zone of rocks from the southern schistose zone.

Vegetation: The upper slopes, above 3000 meters support a fir-birch-rhododendron type. High oaks, Q. lanuginosa and Q. lamellosa form a zone between 2300 and 3000 meters. The lower slopes and valley bottoms are in a chilaune-chestnut type.^{1/}

People: Across the front of this region, there are Gurungs in the west and Tamang in the east, along with Brahmin, Chhetri and occupational castes. Gurungs are in the upper Marsyangdi valley; Larke are in the Buri Gandaki; Shar are in Shar Khola valley, and Tamangs and Sherpas are in the upper Trisuli Nadi areas. The population density is low to moderate. Based on ~~crop area it is moderate to high.~~

^{1/} Chilaune = Schima wallichii, chestnut (Nep. Katus) Castanopsis sp.

Comments: Most of the region is in good watershed condition. Natural earth disturbances, landslides, rockfalls and floods and stream erosion are common. These are very sensitive lands that will not support heavy populations. Steep, deforested areas have large landslides.

Division: The region has been divided into two land systems: the main canyons and the upper valleys of the canyons.

IID1. Central Transitional Mountain Land System.

This land system is composed of a parallel series of north-south oriented, very steep, high relief, mountain ridges and narrow V-shaped valleys.

It makes up about 70 percent of the region. The elevation is 750 to 3200 meters. The relief is moderate to high. The rocks are phyllite and sandstones along the southern edge of the unit and gneiss in the north and western parts.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IID1a	25	50-120	85	-	15	low	1	5	5	5
IID1b	25	30-65	25	70	5	mod. high	2	4	4	3-4
IID1c	30	60-120	20	50	30	low-mod. high	2	5	5	5
IID1d	10	120	30	5	65	low	2	5	5	5
IID1e	5	0-5	-	80	20	mod. high	1	1	1	2
IID1f	5	0-15	-	25	75	low	1	1	2	2

IID1a. Crestlands and Steep Upper Slopes, fir - oak - rhododendron.

These ridge crests are above 2500 meters. They have shallow to moderately deep loam soils with 10 to 20 percent stone and up to 5 percent rock outcrop. The vegetation is a mixture of fir (*Abies spectabilis*), and oak (*Quercus semecarpifolia*) with rhododendron and some broadleaf species.

This area is dominantly under forest with little access and no significant erosion.

IIDlb. Moderately Steep to Steep Dip Slopes, oak - rhododendron.

These are north facing slopes below 2700 meters. The soils are shallow to moderately deep loam with 10 percent stone and up to 2 percent rock outcrop. The vegetation is oak (Q. semecarpifolia) - rhododendron above 2500 meters. Other oaks, below 2500 meters, are Quercus lamellosa in the western part and Q. lanuginosa in the eastern parts.

These lands are the agricultural areas within the land system. Agriculture is possible because slopes are not very steep but there are many landslides here. Much attention needs to be given to improvement of terracing techniques and proper water management. Diversion of excess water to well vegetated natural drainageways is needed.

IIDlc. Steep Middle Slopes, oak - rhododendron - chilaune.

These slopes are below 2500 meters. They have very shallow to shallow loam soils with 15 to 30 percent gravel and up to 5 percent rock outcrop. The vegetation is oak-rhododendron with Q. lamellosa in the west and Q. lanuginosa in the eastern part. Sal, chilaune and with chestnut forests are below 1800 meters.

Slopes are generally steeper here than in IIDlb. Landslide and erosion hazards are high. Agriculture and grazing should be restricted to slopes of less than 65 percent gradients. Forests should be planted and protected against grazing to control erosion. The forest would be a source for fuelwood with easier access than IIDla.

IIDld. Very Steep Lower Slopes and Cliffs, chilaune - chir pine.

These very steep lower slopes and cliffs are below 1500 meters. They have shallow, sandy loam soils with 20 to 40 percent stones and 10 to 15 percent rock outcrop.

Parts of this landtype consist of vertical cliffs where rockfall is a high hazard. Many of these slopes are seriously affected by landslides, with rehabilitation impeded by too heavy grazing. Grazing therefore should be restricted as much as possible.

IIDle. River Terraces and Scarps, chilaune - chir pine.

These are high river terraces and scarps at 750 meters to 1300 meters and narrow remnants of terraces on steep slopes. The soils are shallow to moderately deep, sandy loam with 20 to 40 percent gravel and little rock outcrop. The vegetation is chir pine on drier sites, and sal, chilaune and chestnut in more temperate positions.

These terraces form an important agricultural area. The terrace scarps need protection from undercutting by rivers.

IIDlf. Valley Bottomlands, sal - chilaune - chir pine.

These lands are at 750 meters to 1300 meters and consist of colluvial, coalescing toeslopes and flood plains. They have shallow, loamy sand

soils and gravels with up to 50 percent gravels and 5 percent rock outcrop. Natural vegetation is sal, chir pine and chilaune. Rough surfaces, extremely stony soils and high flood hazard, make these lands unsuitable for agriculture.

IID2. Upper Valley Land System.

This system occupies the upper valleys of the Marsyangdi, Buri Gandaki, and the Trisuli Nadi Rivers and part of the Kali Gandaki drainage between Dhana and Ghasa. The landforms are narrow, deep canyons, mountain slopes and upland basins. The elevation is 1300 to 3200 meters. Relief is about 1500 meters. The materials are coarse grained gneisses.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IID2a	50	50-120	85	-	15	low	1	5	5	5
IID2b	10	50-80	70	20	10	mod.	1	4	4	4
IID2c	30	120	40	-	60 Br./ Waste	low	1	5	5	5
IID2d	5	0-20	85	15	-	low	1	2	3	4
IID2e	5	0-10	-	20	80 Br./ Waste	low	1	1	3	4

IID2a. Upper Mountain Slopes, fir - hemlock - blue pine - oak - rhododendron.

The slopes are above 2500 meters. They have very shallow to moderately deep loam soils with 10 to 20 percent gravel and up to 5 percent rock outcrop. The slopes are densely forested. There are no significant erosion problems due to the little land use and difficult access.

IID2b. Steep Dip Slopes, oak - rhododendron.

These steep north facing slopes are below 3000 meters. They have shallow to moderately deep loam soils with 10 to 20 percent gravels and up to 10 percent rock outcrop. The vegetation is a mixture of rhododendron and oak (Q. semecarpifolia, Q. lamellosa, Q. lanuginosa).

Agriculture is marginal, not sufficient even for a subsistence level. Lands are very sensitive to mass movement due to the steeply dipping rock structures.

IID2c. Canyonlands, mixed oak forest.

These very steep, long canyon slopes, including bare cliffs, are below 2500 meters. They have very shallow, sandy loam soils with 20 to 40 percent stones and up to 30 percent rock outcrop. The vegetation is oak and lower temperate mixed broadleaf forests in Marsyangdi Khola and Kali Gandaki area. Oak and chir pine forests are in Buri Gandaki and Trisuli Nadi areas.

A very high natural hazard for debris slides and rockfall make these lands unsuitable for agriculture.

IID2d. River Terrace, mixed conifer forest.

These are eroded remnants of river terraces above 2300 meters. The soils are shallow to moderately deep loamy sand with 40 to 60 percent stones and gravel.

The vegetation is a mixture of temperate mixed broadleaf forests, oak and chir pine.

Agriculture is marginal. Undercutting by rivers is a high natural hazard.

IID2e. Valley Bottomlands.

These rough, narrow bottomlands are at altitudes from 1300 meters to 2500 meters. The soils are shallow to moderately deep loamy sand with 40 to 60 percent stones and up to 10 percent rock outcrop. Above 2300 meters there are blue pine, spruce and hemlock stands; lower down are temperate mixed broadleaf forests in the Marsyangdi Khola and Kali Gandaki areas, and chir pine forests in the Buri Gandaki and Trisuli Nadi areas.

Rough land, extremely stony soils and high flood hazards make these lands unsuitable for agriculture. In some places, as in the Marsyangdi Khola, small lakes have formed as a result of landslides which partly blocked the river valley. In flat lands fine sediments have been deposited making agriculture possible.



2.64 A view of the Eastern Terai Region (VC) with the Sapt Kosi in the foreground.

IIE. Eastern Transitional Mountain Region.

These are the canyons, rugged ridges and forested upland surfaces that are between the Middle Mountain and the High Himalaya Zones in eastern Nepal.

Summary of Region

Area 7075 sq Km

30 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Other	1	2	3	4	5
52	21	27	53	47	0	0	0
Other: 20% brush, 7% grass.							

Location: The region is between the Langtang Himal and the eastern border. It is in nine northern districts of the Bagmati, Janakpur, Sagarmatha, Koshi and Mechi zones. All of the major streams of the Sapt Kosi drainage cross through this region. Few towns are located here.

Elevation/Relief: 1300 to 4000 meters. Relief is 500 to 2400 meters, moderate to high.

Climate: Temperate monsoon with 2000 to 3000 mm of precipitation. Köppen's classification here is warm temperate rainy uplands (Cwb).

Geology: Mostly gneisses in layers dipping toward the northeast.

Vegetation: Fir (Abies spectabilis) and oak (Q. semecarpifolia) cover most of the higher slopes. Birch, rhododendron and meadows are on the upper margins. Blue pine is common throughout the zone. Chilaune-chestnut and sal communities are at lower elevations in the Arun - Tamur valleys. Chir pine with the chilaune-chestnut stands are on low elevation slopes west of the Arun valley.

People: Sherpa is the most widespread ethnic group. Population density is low with less than 10 people per square kilometer of land. Based on crop areas, the density is moderate to very high at 5 (Rasuwa) to 16 (Dolkha) people per hectare.

Comments: This is a rugged area of long canyon slopes. Some of the canyons extend into China. The region is in excellent to good watershed condition. The biggest problems are large debris avalanches in the Arun, Tamur and Dudh Kosi valleys. Most of these are in deforested areas. Size and remoteness of these landslides place them beyond direct stabilization measures. They should be studied however to see how they can be controlled and how future slides can be prevented.

Divisions: Two land systems were recognized here on the basis of position and landform: canyon and uplands.

IIEl. Canyonlands Land System.

This system includes the landtypes in the main and secondary canyons in this region. Six landtypes were recognized.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIEl a	5	10-30	20	30	50	mod.	1	2	2	1-4
IIEl b	20	50-80	60	0	40	low	1	4	3	5
IIEl c	10	50-80+	70	0	30	low	1	3-5	3	5
IIEl d	35	40-90	50	0	50	low	1	3-4	3	5
IIEl e	25	40-80	60	5	35	low	2	4	3	3-4
IIEl f	5	10-20	60	20	20	mod.	1	1-4	1-4	1-5

IIEl a. Highland Benches, juniper - fir - rhododendron - sod grass.

These are shoulders and benches noted mainly in the lower Khumbu area. Namche, Syangboche, Phortse, Pangpoche and Tengboche occupy this landtype. Its elevation is 3400 to 4000 meters. The benches have flat to undulating surfaces. Slope gradients are less than 20 percent. The soils are deep, very dark grayish brown sandy loam. They generally are stone-free but boulders from higher slopes may cover up to 10 percent of the surface. The vegetation here suggests a rainshadow effect by the surrounding ridges. It consists of sod grasses with juniper, rhododendron and fir. A high percent of this landtype is cultivated. Soil erosion is not a problem but soil fertility may be. This landtype has some of the highest, permanently inhabited lands in Nepal.

IIEl b. Headland Canyon Slopes, blue pine - grasses - shrubs.

These are the walls of great canyons cutting into the Himalayan highlands. They are mostly straight but the upper parts are benchy and the lower parts are rocky gorges in places. The elevation is 2800 to 4000 meters. Slope gradients are 30 to 80 percent. The gorge walls are nearly vertical. The soils are mostly deep, very dark brown, stony, fine sandy loams. Boulders are common. The forest cover reflects the dominant slope aspects. North faces have a heavy birch-fir-rhododendron

cover. South facing slopes have sod grass, juniper, various shrub species, and open blue pine/rhododendron stands.

This landtype has very little agriculture. An estimated 30 percent of it is grazed by yak. It is a source of firewood for settlements in landtype IIA1a above. Although in good hydrologic condition for the most part, serious landslides in very hard to stabilize rubble deposits adjacent to streams are a problem. A few landslides on higher slopes appear to be natural and will be stabilized by vegetation with time.

IIElc. Upper Ridge Slopes, birch - rhododendron.

These are straight, fluted slopes and ridge crests which blend into slopes of the High Himalaya landtype ID2b. The elevation is 3200 to 4000 meters. Slope gradients are 50 to 80 percent. Rock outcrop is about 5 percent. The soils are gravelly, sandy loams, usually less than one half meter deep. The vegetation is a birch-rhododendron-fir community. Juniper (J. indica) is common in dryer segments. The unit provides limited yak pasturage. There is no cultivation here.

Soil erosion is rare here. It is within a snow avalanche zone. Some small landslides are natural and will heal themselves.

IIEd. Mid-slope Canyons, fir - oak.

This is an extensive landtype. It consists of straight side slopes of the upper canyons. Slope gradients are 40 to 90 percent. The soils are deep, cobbly, sandy loams. The fir and blue pine are in the upper part of the system and oaks, Q. semecarpifolia and Q. lamellosa, are on the lower slopes. Rhododendron is common throughout. Some open grasslands with scattered, old growth fir are in this unit also.

The unit has little erosion. Unpalatable shrubs, (Berberis spp, Mahonia spp) seem to be increasing in heavy grazed areas. Fires are very destructive to the forest here although they have not had any long term effect on the watershed condition.

This unit is primarily watershed land and should be protected. Remoteness and steep slopes would make commercial forestry very expensive. Fires should be controlled. Grazing, by both yak and cattle, is excessive on some lower ridge crests.

IIEle. Lower Canyon Slopes, chilaune - chestnut.

This landtype consists of long, straight to slightly benchy slopes. The elevation is from about 800 to 2400 meters. Slope gradients are 40 to 80 percent dominantly but slopes in excess of 100 percent are common. Rock outcrop reaches 5 percent on a few slopes. The soils are deep gravelly sandy loams. The vegetation is mostly a chilaune-chestnut type. Chir pine is common in the central and western segments of landtype. Oaks (Q. lamellosa and Q. semecarpifolia) are on upper margins. Castanopsis tribuloides is in the Tamur basin. Lagerstroemia parviflora is mixed with chilaune in the western canyons.

Much of this landtype has been deforested by fire and either lacks trees or has very open stands. Most of the slopes are heavily grazed. About 5 percent has been terraced for agriculture.

Landslides are common here. Some, particularly in the Arun Valley, reach from the top of the unit to the river. There is a definite need for afforestation and fire prevention.

This landtype and landtype IIElf make up the canyons of the major rivers as they cut through the lower part of the Transition Zone and enter the broad valleys of the Middle Mountains. The most conspicuous feature here is the long, usually treeless slope. These landtypes are some of the most critical land units from a watershed management standpoint in eastern Nepal.

IIElf. Toe Slopes and Benches, chilaune - chestnut.

This landtype is at the base of landtype IIEle above. It is made up of fir covered benches, terraces, and the gorge walls of the main river and side streams. The unit is not continuous. Boulders, river cobble and avalanche accumulations are present. The elevation is 800 to 1200 meters. Slopes are dominantly 10 to 20 percent on the toe slopes, flat on bench surfaces and nearly vertical in the gorges. The soils are gravelly sandy loams, usually deep. They may also be sandy or cobbly. The vegetation is a chilaune-chestnut type. The upper extension of sal forest reaches into this unit. Many of the benches are cultivated. This unit has the best road locations in the region.

Extreme care is needed to avoid causing landslides here because of the unconsolidated alluvial and colluvial materials. Wet areas are especially hazardous. Grazing is excessive on the gorge slopes, causing shallow debris avalanches.

IIE2. Lower Main Ridge Land System.

This land system is in finger-like extensions reaching to the south along the main ridge crests into the Middle Mountain Zone. This land system was separated from higher land systems because (1) it is oriented along a series of single main ridges rather than being a set of ridge and valley systems, (2) it is surrounded to a large extent by cultivated, populated lands, and (3) it is somewhat warmer than the higher IIE1 system's landtypes.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIE2a	40	10-100	60	10	30	low	1-2	2	2-3	1-5
IIE2b	60	30-70	70	10	20	low	1	2	3	4

IIE2a. Ridge Crest Complex, oak - rhododendron.

This landtype consists of ridge crests, and associated upper ridge slopes and headlands of lateral drainages. The elevation is 2000 to 2600 meters. Slope gradients are 10 to 30 percent in uplands, 50 to 100 percent on side slopes. The relief is moderate and low. The soils are sandy loams and loams. They are deep with black to dark grayish brown colors. This is mostly an oak (Q. semecarpifolia and Q. lamellosa) - rhododendron type. Most of the area is grazed. Agriculture is encouraging on the sides of the landtype in lower elevations.

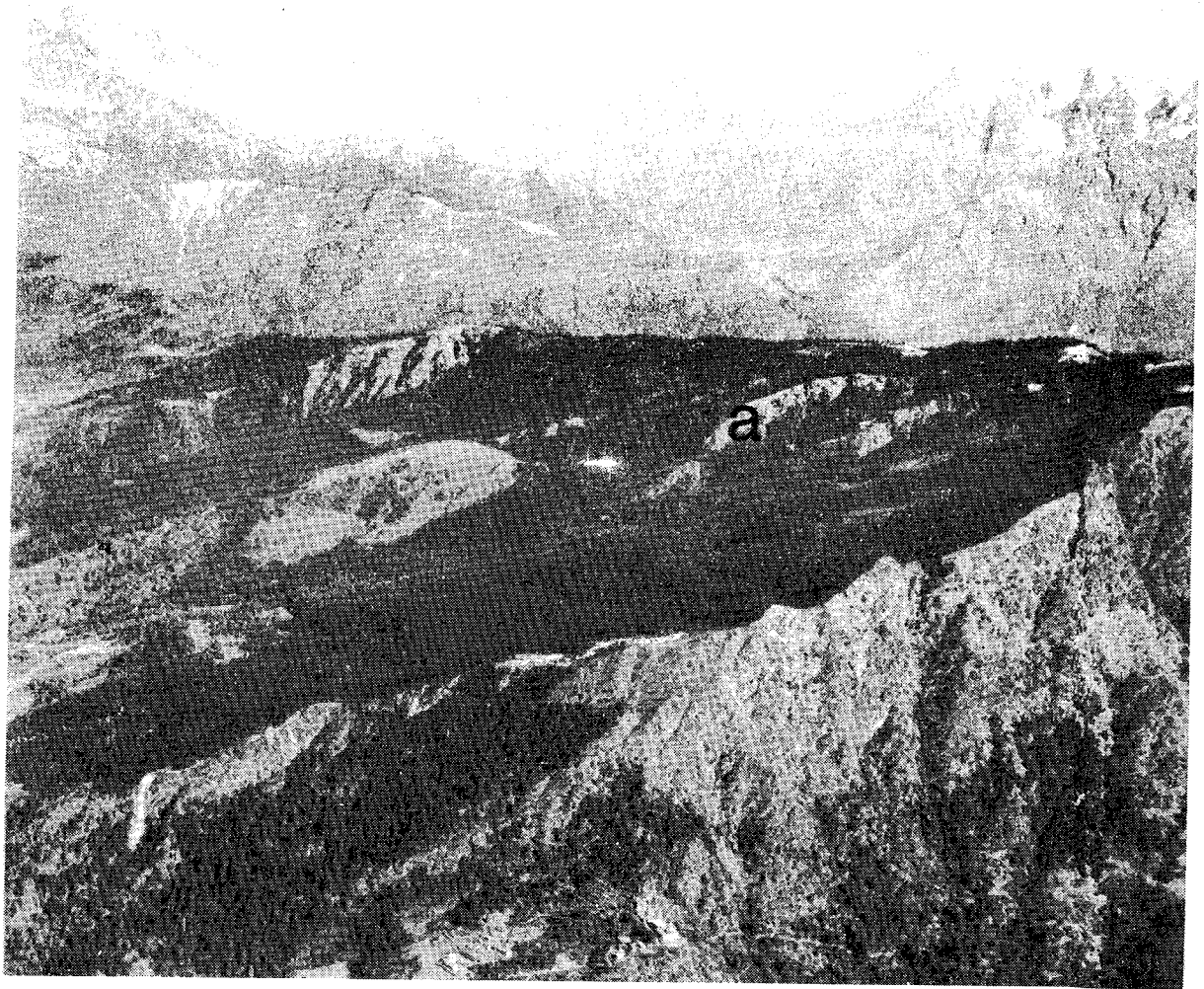
Long debris avalanches are present on some of the very steep slopes. Excessive grazing on some upland surfaces have broken the sod and caused erosion.

These are critical watersheds because snow tends to accumulate here, and they form the headlands of many of the east west, lateral drainages. The needs are for grazing control and protection of forests. Structures in gullies in the lower relief uplands would be beneficial.

Little can be done to arrest the erosion of very steep headland positions, except to introduce protection measures.

IIE2b. Upland Side Slopes, oak.

This type is on the ridge slopes adjacent to the ridge crests which form the IIE2a landtype above. The elevation is 1800 to 2600 meters. Slopes are 30 to 70 percent. The soils are deep sandy loams. The vegetation is mostly an oak type (same species as IIE2a). Mixed broadleaf and deciduous mixed broadleaf forests are in segments of this landtype in the east. Although encroached upon in places, this landtype contains extensive forest lands that could be managed commercially.



- 2.25 The Ridge crest complex (a) of the Lower Main Ridge Land System (IIE2) near Phaphlu dominates the foreground. Landtypes of the Canyonland System (IIE1) of the Eastern Transitional Mountains Region in the upper Dudh Kosi Valley are in the background.

III. Middle Mountain Zone.

This zone is the great central belt of Nepal where the country's origins and character are most deeply rooted. It is also called the midlands, the middle hills or just "the hills". This is the largest of the five zones we recognized in Nepal with about 42,000 sq Km, making up 30 percent of the Kingdom. It is bounded by the northern slopes of the Siwaliks on the south, and the forest covered slopes of the Transition Zone to the north. Two-thirds of the population, about one third of the agricultural production and many major cities, including Kathmandu are located in this zone. The Middle Mountain Zone is inhabited by Tibeto-Burman and Indo-Aryan groups. It has been the meeting ground for people long established in Nepal and groups coming in from the north and the south.

The Middle Mountain Zone is composed almost exclusively of a network of ridges and valleys. Less than 5 percent of the zone is flat land. With the exception of the Mari and Bagmati watersheds, it is drained by three international river systems: the Mahakali-Karnali in the west, the Narayani in Central Nepal, and the Sapt Kosi in the east. The lowest part of the zone is the river bottomlands in the east at about 200 meters and the highest points are on ridges extending from the Transition Zone at about 3000 meters. The climate is temperate monsoon with cool, dry winters and wet, warm summers. Mean annual precipitation ranges from about 3500 mm near Pokhara to less than 1000 mm in the western valleys. The rocks are mostly metamorphics with schists predominating. Phyllites, gneisses and metasediments of sandstone, limestone and dolomite origins are common. Granites form the core of the southern ridges. The vegetation ranges from sal forests in the lower canyon slopes to oak-rhododendron forests on the upper ridge crests. Chilaune-chestnut forests are probably the most extensive type. Originally the zone was nearly entirely forested. Forest cover has been reduced to about 25 percent by conversion to agriculture and deforestation for fuel and grazing.

Twelve ecological regions were separated in the zone based mainly on east-west climatic differences, geological structure, and pattern and density of the drainage systems.

Long, intensive use of the lands in this mountainous zone is indicated by the intricate, extensive terrace systems, and inevitably, by a large number of landslide scars, eroded soil areas and loss of forest land. The landslides here, particularly conspicuous near population centers, were one factor in prompting this inventory.

Population pressures require people to cultivate land of marginal suitability to agriculture or to migrate to the Terai. Many development projects have been aimed at improving living conditions here. As forests have diminished, firewood has become harder to get. In response to this problem, a major afforestation program is underway. Watershed conditions are expected to improve as a by-product of this effort.

IIIA. Baitadi Middle Mountain Region.

This small region is in the extreme far western part of Nepal. It contains Baitadi and Dandeldhura, hill towns now linked by a roughed out road. It has a complex pattern of landscapes characterised by multiple stages and forms of geologic erosion. The extensive limestone beds here makes the region somewhat unique in Nepal. The lands present an interesting combination of ruggedness and gentleness. The result is a mixture of deforested ridges and large blocks of mostly undisturbed forest land. The landscapes here were notable for their small number of gullies and landslides in comparison with similarly used lands to the east. The credit for this goes to the limestone bedrock.

Summary of Region

Area 2635 sq Km

6 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Other	1	2	3	4	5
33	15	52	0	88	12	0	0

Location: Mostly Baitadi district of the Mahakali Zone but also parts of the Dharchula and Dandeldhura districts. It is drained by the Mahakali via the Suna Gad and Chamliya Rivers. The eastern part drains to the Seti River.

Elevation/Relief: 600 to 2600 meters; maximum relief is about 1200 meters (moderate).

Climate: Temperate monsoon with 1000 to 2000 mm of precipitation. According to Köppen's classification, it is a subtropical monsoon climate with maximum temperature before the rainy season (Cwag). As with other parts of western Nepal, there is a weak, winter rainy period.

Geology: Quartzose-muscovite-biotite-garnet schist with thick beds of Ordovician limestone and some narrow belts of quartzite and granite. The structure, like most of the Middle Mountain Zone is a series of imbricate, northward dipping layers.

Vegetation: Dominantly chir pine with oak (*Quercus incana*). On the highest ridges it is oak (*Q. semecarpifolia* and *Q. dilatata*) with fir and hemlock. Tropical hill sal communities are on the lower slopes. Much of the forest has been converted to brush.

People: Mostly Chhetri and Brahmin along with the occupational castes. Population density is moderate for the region as a whole. Based on people per hectare of crop, it is moderate and very high (13 people/ha for Baitadi, 8 and 9 respectively for Dandeldhura and Darchula districts).

Comments: The major need in this region is afforestation. The soils are quite stable as indicated by the comparatively little erosion in spite of the near total deforestation in most of the region. We saw the most erosion, both rill and gully type, in the "Hilly" landtype (IIIA2d) west of Patan. There are spots here where protection, plantings and furrowing would be very helpful.

Division: Three land systems were mapped on the basis of intensity of dissection and combination of landtypes.

We were handicapped here by not having an opportunity to visit the Darchula district. From the high ridges on the north side of the Baitadi district and a flight over the Chamlia river, there appears to be much erosion in this unvisited area.

IIIA1. Mahakali Riverbank Land System, brush.

This is a series of parallel, east-west canyons and ridges forming a broad belt on the east side of the Mahakali River, Nepal's western border. It is notable for the density of dissection and its long, straight slopes.

Baitadi is the major town here. Agriculture, and therefore settlements, are confined to a few broad ridges.

Land System Summary

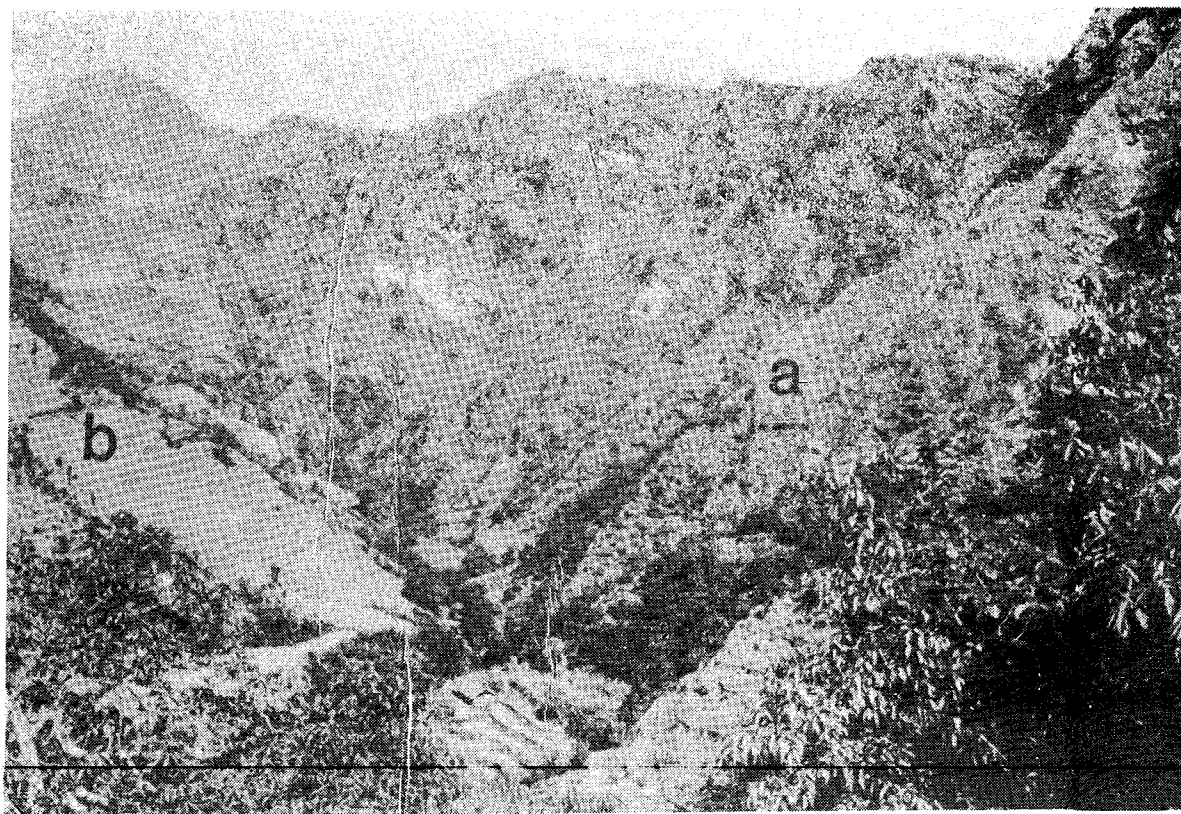
Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIA1a	85	70-100 +	10	5	85	low	2	4	3	4
IIIA1b	15	15-50	5	30	65	low	2-3	3	3	2-4

IIIA1a. Canyon Slopes, oak - chir pine.

These are long, straight slopes reaching from the ridge crests to the river bottoms. The elevation is 600 to 1800 meter. The slope gradients are 70 to over 100 percent. The geologic materials are limestone and schists. Rock outcrop is rare. The soils are dark, yellowish brown (10 YR 4/4) gravelly, clay loam. The vegetation is brush with scattered chir pine and oak. On the highest, steepest slopes, oak (Quercus incana) forms dense stands. Sal is on the lower slopes. These slopes have probably been deforested by fire. They are grazed in part but there is little opportunity for cultivation. The Mahakali and its tributaries contacting this unit have very little bottomland. A roughed out road to Baitadi has caused a few slumps in the back slope but due to its high ridge location, it is remarkably stable. The needs here are to keep agriculture from moving onto the steep side slopes, fire protection, tree planting and strict limitation on road building.



2.26 Canyon Slopes landtype (IIIA1a) of the Mahakali River Breaklands Land System (IIIA1).



2.27 Upland Ridge and Basin Land System (IIIA2) of the Baitadi Middle Mountain Region (IIIA). South-facing Upper Slopes (IIIA2a), and North-facing Ridge Slopes (IIIA2b) landtypes are shown.

IIIA1b. Upland Benches and Shoulders, oak - chir pine.

Some of the ridges in this system have benches and shoulders near their crests. The Baitadi area is an example of this. The elevation is 400 to 1600 meters. Slope gradients are 15 to 50 percent. These slopes break off to the very steep landscapes of the IIIA1a landtype. The soils noted here are deep, reddish loams over clay loams. The vegetation is brush with scattered oak.

This is a small landtype but important because it has most of the cultivated land in this land system. Firewood shortages appear to be a problem. A few landslides, caused by the heavy land use, were observed.

Training in terrace construction may be helpful. Firewood plantations would serve a long term need. Some slopes here are in poor condition because of excessive trampling by goats and sheep.

IIIA2. Upland Ridge and Basin Land System.

This is a complex ridge system with basins, hills and broad valley lands. It shows a lack of integration of the drainage network and multiple shifts in base level. More detailed mapping would divide this land system into two or three simpler systems. The lands here are above the V-shaped canyons lying closer to the major rivers. They have not been as intensively eroded geologically as the lower parts of the drainage, hence colluvial and alluvial deposits form benches and terraces on the valley slopes and in the bottomlands.

Land System Summary

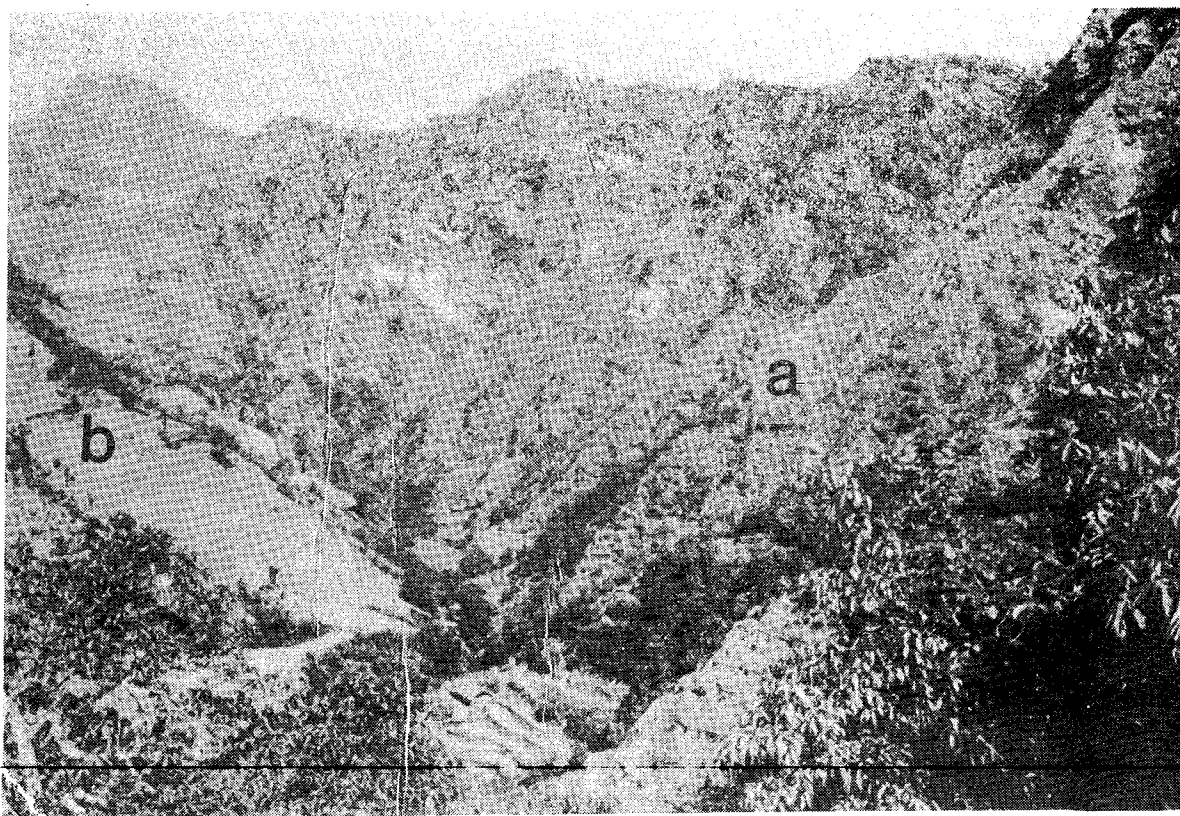
Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIA2a	30	50-100	20	10	70	low	2	4	3	4
IIIA2b	30	30-80	35	15	50	mod.	2	4	2	2-4
IIIA2c	20	5-40	10	50	40	high	1-3	1-4	1-4	1-3
IIIA2d	20	60-80	30	25	45	mod.	3-4	2-4	2-4	2-5

IIIA2a. South-facing Upper Slopes, oak - pine.

These are straight to convex slopes forming the northern rims of valleys, and upper parts of ridges. Slope gradients are 50 to 100 percent. The rocks are limestones and schists. Limestone forms conspicuously massive scarp slopes along the drainageways. It appears that most loose material has slipped off these faces to the convex toe



2.26 Canyon Slopes landtype (IIIA1a) of the Mahakali River Breaklands Land System (IIIA1).



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Some of the ridges in this system have benches and shoulders near their crests. The Baitadi area is an example of this. The elevation is 400 to 1600 meters. Slope gradients are 15 to 50 percent. These slopes break off to the very steep landscapes of the IIIA1a landtype. The soils noted here are deep, reddish loams over clay loams. The vegetation is brush with scattered oak.

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Training in terrace construction may be helpful. Firewood plantations would serve a long term need. Some slopes here are in poor condition because of excessive trampling by goats and sheep.

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Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIA2a	30	50-100	20	10	70	low	2	4	3	4
IIIA2b	30	30-80	35	15	50	mod.	2	4	2	2-4
IIIA2c	20	5-40	10	50	40	high	1-3	1-4	1-4	1-3
IIIA2d	20	60-80	30	25	45	mod.	3-4	2-4	2-4	2-5

IIIA2a. South-facing Upper Slopes, oak - pine.

These are straight to convex slopes forming the northern rims of valleys, and upper parts of ridges. Slope gradients are 50 to 100 percent. The rocks are limestones and schists. Limestone forms conspicuously massive scarp slopes along the drainageways. It appears that most loose material has slipped off these faces to the convex toe

slopes below. The soils are shallow to moderately deep, gravelly loams. The vegetation is an open oak (Quercus incana) - chir pine type.

Some slopes are grazed (indicated by heavy trailing) and provide firewood but many are relatively untouched. The trees have been cut from other slopes, converting them to a bunchgrass type crossed by shoe-string debris avalanches. These slopes are critical watersheds.

Protection against excessive grazing and deforestation is needed throughout. Afforestation is needed in many places.

IIIA2b. North-facing Ridge Slopes, oak - pine.

These are the counterparts of the IIIA2a landtype. They differ in having heavier natural forest cover, more benches, and thicker accumulations of soil and rock. Slope gradients are 30 to 80 percent. These slopes appear to be on dip slopes of northward dipping schist and limestone layers. The soils are deep, sandy loams over sandy, clay loams. The vegetation is oak (Quercus semecarpifolia) on higher ridges, Q. incana on lower ridges with other broadleaf trees and rhododendron. The canopy is closed where undisturbed along the ridge crests.

Mass movement processes seem to dominate these slopes. Much land here has been converted to agricultural terraces. Some disastrous landslides were noted in this kind of land in the Chamlia river system. Encroachment onto unsuitable slopes is occurring. The deep soils, relatively gentle slopes, springs, and freedom from intensive sunlight make this a valuable agricultural and horticultural site.

Care is needed to prevent cultivation of unstable slopes.

IIIA2c. Basins and Bottomlands, oak - pine.

This landtype was observed along the upper Surna Gad and Parchuni Khola. It consists of two to four levels of terraces which are cut through by an entrenched stream channel. The landtype forms a bench nearly a kilometer wide at Patan. Further upstream it has a U-shape cross section with weakly developed shoulders and toe slopes.

It is discontinuous where the river passes through a canyon. The geologic materials are mostly cobbly, alluvial deposits from limestone and schists. The stream bottom is rubbly but does not suggest high flooding levels. The stream in this landtype in the Chamlia drainage appears on aerial photograph to be flood prone. The soils are loams and silt loams over clay loams, moderately deep to deep. At lower elevations the soils are reddish. The landtype is largely cultivated but remnant forests at temple sites show a wide variety of hardwood and chir pine.

This landtype is the best agricultural land in the land system and is the location of important trails. The slopes appear to be in good

condition. Water supply on some of the larger terraces may be a problem. The slopes adjacent to the terraces (IIIA2a/b) show signs of degradation.

An evaluation of the irrigation practices here may identify opportunities for improvement. Tree planting on adjacent toe slopes is needed.

IIIA2d. Hilly Land, oak - chir pine.

This is a network of rounded ridges and deep canyons west of Patan. The uplands here are rounded ridges. The landtype has an elevation range from 600 to 2200 meters. Slope gradients are 60 to 80 percent with gradients over 100 percent in the gorges. The rocks are limestone and schist. The vegetation is a chir pine - oak type. The soils are dark brown(7.5YR 4/4,5/4)gravelly loams and sandy loams, shallow to moderately deep.

It is heavily used for agriculture and grazing. Forest land is limited to remnant stands on the steepest slopes. Although landslides occur, they are not as common as the apparent intensity of land use would suggest they should be. The limestone rock type is credited with being a stabilizing factor. Erosion is extensive, even under forest cover. Tree planting, improved water supply and irrigation, and grazing management are needed to restore these landscapes.

IIIA3. Dandeldhura Ridge Land System.

This is a complex set of landscapes in the southern part of the Baitadi Middle Mountain Region. The northern part of the land system is a compact set of ridges and valleys. The highest of these is Pilkot Danda at 2300 meters. The southern part is a broad valley landscape with long, prominent secondary ridges and a deep, inner valley gorge. This land system is undoubtedly in the best condition of the three delineated in this region.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIA3a	60	50-70	90	5	5	low	1-2	3	2-3	3-5
IIIA3b	30	30-60	20	30	50	high	2			
IIIA3c	10	40-100 +	15	10	75	mod.	2	5	4	4

IIIA3a. Ridges and Valleys, chir pine - oak.

This is a group of V-shaped ridges and narrow valleys in the headwaters of tributaries to both the Seti and the Mahakali Rivers. Slopes gradients are 50 to 70 percent. The materials are a mixture of schist and limestone with coarse textured quartzite on the higher ridges. The soils are moderately deep to deep gravelly loams. Soils in lower areas are reddish. The vegetation is a chir pine type with a grass ground cover on the lower slopes, a chir pine/oak (Quercus incana) on mid-slopes and an oak type (Quercus semecarpifolia) with rhododendron on upper slopes and ridge crests. The zonation pattern is conspicuous.

There is very little bottomland. Some slopes are cultivated with the more gentle, north aspects being favoured. The main ridges here are almost completely forested. The chir pine stands are heavily grazed. There is no shortage of firewood or other forest products here. Soil erosion was noted along the main trails under a closed forest canopy. Few landslides were seen.

There is an opportunity for community forest management land in mature forests. One of the first tasks would be to prevent extension of cultivation on the excessively steep slopes.

IIIA3b. Basin Ridges, oak - chir pine.

The large valleys here show multiple stages of downcutting. One such stage created broad open basins that were subsequently incised by a deep, dendritic secondary drainage system. This landtype is composed of the high secondary and main ridges left after the more recent downcutting. The slopes are 30 to 60 percent. The elevation is 600 to 1500 meters. The materials are almost exclusively phyllite and granitic schists. The soils have fine sandy loam and loam over clay loam textures. The original vegetation of oak (Q. incana) and chir pine has given way to brush and cultivated lands.

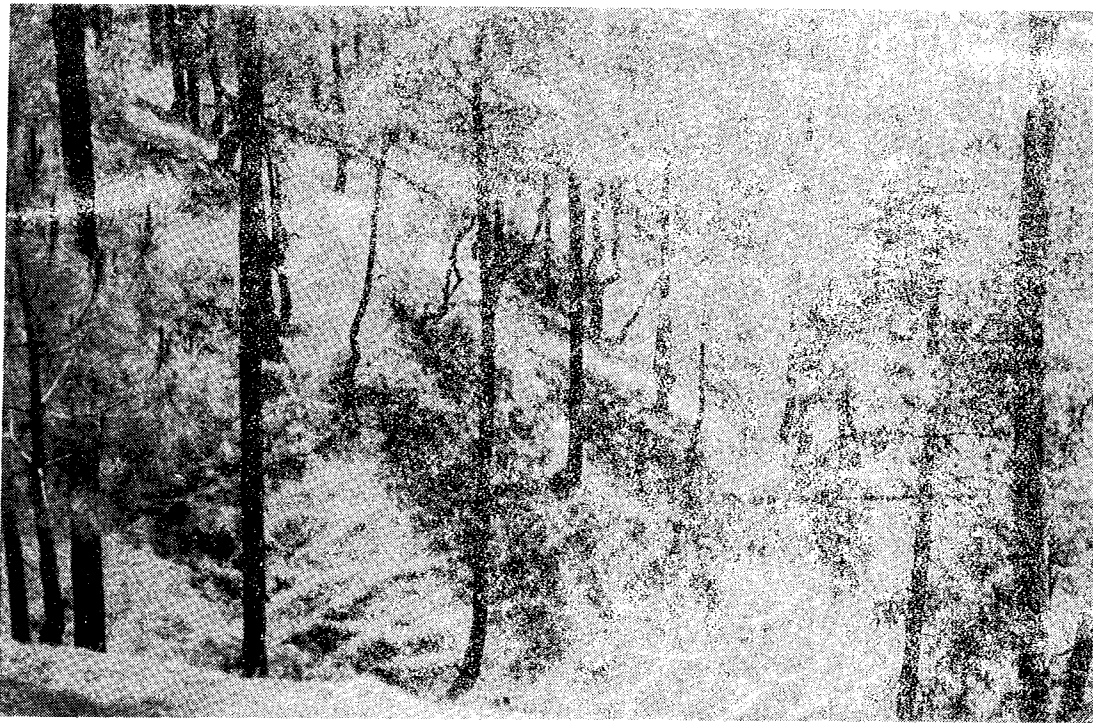
Dandeldhura is located here. The landtype is heavily cultivated. The exceptions are the main ridge crests and the sides of drainageways reaching into these lands from the main rivers. Both are too steep to be cultivated. The forest has been largely destroyed, leaving solid stands only on the very steep slopes. In spite of the apparent heavy use, there are few gullies or landslides. A roughed out road here caused little impact. The first priority for action here should be afforestation.

IIIA3c. Canyons, pine - sal.

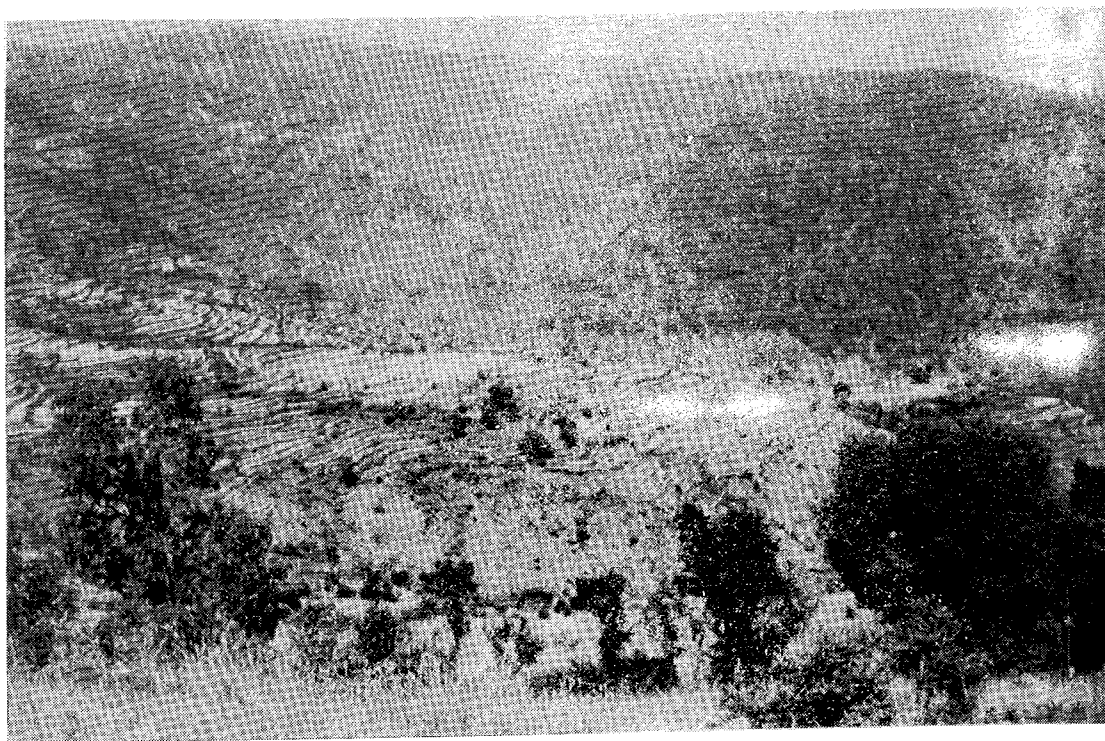
These are the steep slopes of the inner valley of the basins described in IIIA3b. They are narrow with very little bottomland. They form meandering gorges in the Chawandi Gad drainage. The elevational range is from 600 to 1100 meters. The slopes are 40 to 100 percent. The soils are shallow and moderately deep loams and sandy loams. The vegetation which is now mostly a brush-grass type, was originally chir pine and sal.

Some benches here are cultivated. There are landslides on steeper canyon slopes and some originating on the less steep lands of land-type IIIA2b.

There is a need for protection from grazing and cultivation. These slopes should be planted with trees. Farmers should be trained to dispose of excess water without damage to slopes below.



2.28 Chir pine in the Ridge and Valleys landtype (IIIA3a) of the Dandeldhura Ridge Land System (IIIA3).



2.29 Basin Ridges (IIIA3b) of the Dandeldhura Ridge Land System.

IIIB. Dailekh Middle Mountain Region.

This is the large, complex region in the Middle Mountain Zone reaching from Jajarkot at its eastern end almost to Dandeldhura in the west. The common land feature is the dominance on the landscape of major river valleys - the Thulo Bheri, the Karnali and the Seti. The region occupies a relatively narrow belt between the foot of the Transition Zone and the Middle Mountain regions of the Mahabharat Lekh.

Summary of Region

Area 4079 sq Km

10 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Other	1	2	3	4	5
22	37	41	8	64	28	0	0

Location: Dailekh and Jajarkot districts of the Bheri Zone and the Doti and Achham districts of the Seti Zone. The major towns are Silgarhi, Doti and Dailekh.

Elevation/Relief: From 600 meters on the Karnali to 3000 meters on the ridges north of Dailekh and Silgarhi-Doti. Maximum relief is about 800 meters within a single drainage. Moderate class.

Geology: The most widespread rock material is muscovite-biotite-garnet schist. Marble and limestone were noted in the western part of the region. This is a belt of imbricate, northeasterly dipping layers. The percent dip is 10 to 30 percent.

Climate: Temperate monsoon. Precipitation is 1000 to 1500 mm. According to Köppen's classification, it is warm temperate rainy upland/subtropical monsoon. (Cwa/Cwb).

Vegetation: Mostly an oak type dominated by Quercus dilatata and Q. incana on upper slopes. Chir pine and sal are on lower slopes. A khair-sissoo (Acacia catechu - Dalbergia sissoo) riverine community is in lower valleys.

People: The major groups are Magar, Chhetri, Brahmin and the occupational castes. The population density is moderate in the Doti and Jajarkot districts and high in the Achham and Dailekh districts. Based on area of crop, the population density is moderate to high. Dailekh has the highest at 14 people per hectare of crops.

Comments: This is a complex region which does not lend itself to clear land unit distinction. Additional work would undoubtedly result in significant revisions. The most important need is for afforestation work.

Subdivisions: Two land systems were recognized on the basis of physiography. The larger system is a series of mostly north-south ridges and valleys. A smaller land system was identified in the eastern and western extremes of the region because there are extensive, thick alluvial deposits in the major river valleys and a series of secondary valleys with deep alluvial deposits.

IIIB1. Ridge and Valley Land System.

This land system comprises about 85 percent of the region. It is a group of roughly parallel ridges and valleys draining toward the south. They vary considerably in their relief, steepness of side slope and general ruggedness. Describing the lands here in terms of their basic slope components, focuses on their common features and the land units most closely tied to watershed condition. In places, any one of the slope facets represented as landtypes may be absent or much smaller, or larger than the figure shown for its extent in the land system in the table below.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIB1a	20	40-70	50	10	40	low	2	3	4	2-4
IIIB1b	40	40-60	10	30	60	high	2	4	2	2-4
IIIB1c	30	60-110	20	60	20	mod.	3	3	3	3-4
IIIB1d	10	2-10	10	80	10	mod.	2	1	2	1-3

IIIB1a. Upland Slopes and Ridge Crests, oak.

These are the upper slopes of main ridges and heads of valleys. These slopes are benchy in their lower extent and sparsely dissected. The elevation is 2000 to 3000 meters. The slope gradient is mostly between 40 and 70 percent. The soils are moderately deep, loams and sandy loams. Coarse material is 15 to 30 percent. The vegetation is dominantly a *Q. semecarpifolia* community. Where the aspect is northerly, fir and rhododendron are present with oak. The trees in the lower part of the landtype are heavily lopped for fodder. Agriculture is confined to benches. Nearly all the area is heavily grazed and firewood is collected here. There is considerable bare ground. Small debris avalanches are common on steeper slopes. Tree planting and controlled use of forest is needed. The local people, most of whom live on slopes below here, should understand the importance of these upper slopes to the maintenance of their water supply.

IIIBlb. Midslopes, oak - chir pine.

This landtype consists of shoulders and benches that contour the central part of the valley slopes. The elevation is approximately 300 to 2000 meters. Slope gradients are 40 to 60 percent. The soils are deep loams and sandy loams. The vegetation is an oak type (*Q. incana*, *Q. lanuginosa*). Chir pine is common on lower slopes. Much of the forest has been converted to brush.

A third to one-half of the landtype has been terraced. The upper part of this landtype is heavily grazed and picked over for firewood. Although the terraces are stable, the slopes below are commonly crossed by gullies and small avalanche paths caused by uncontrolled water or excessive grazing. The most obvious need here is for instruction in irrigation water management. Most of the people in this land system live in this landtype. Instruction in erosion control methods and conservation in general must take place here.

IIIBlc. Lower Slopes, sal - chir pine.

This landtype reaches between the midslopes and the bottomlands. The slopes are generally convex, becoming very steep (60-110 percent) in the toe slope. Straight concave slopes with 30 to 50 percent gradients make up about 25 percent of the unit. The soils are shallow to moderately deep loam and sandy loam over clay loams. Coarse fraction is 10-40 percent. The vegetation is a sal - chir pine type. The sal trees form extensive pure stands on slopes too steep for cultivation. In places, the forest is replaced by brush cover.

The less steep slopes have been terraced. The forested areas are grazed. In spots this has removed all ground cover and has resulted in soil erosion. Many trees are lopped for fodder. The landtype is in fair hydrologic condition with some parts in poor condition.

As in other parts of the Middle Mountain Zone which are supporting sal, research is needed to develop management practices for sal forests. At a minimum, closures should be made to demonstrate the potential productivity of undisturbed lands.

IIIBld. Bottomlands, sal - khair - sissoo.

This is composed of two or three levels of narrow terraces and a rubbly stream channel. Fans of debris from side drainages cover the terraces in places. This type is more extensive in the larger river valleys. It pinches out in the smaller drainages. Slope gradients are 2 to 10 percent. Interterrace slopes may be nearly vertical. The soils is deep, sandy loam to loam. Some are brownish (7.5 YR 4/4). The vegetation is sal and riveraine trees such as khair and sissoo. ~~Most of the landtype is irrigated, terrace land.~~ The stream channels are rubbly and broad suggesting high runoff level. There is a need for training in stream bank stabilization.



2.30 Ridge and Valley Land System (IIIB1) in the Dailekh Middle Mountain Region (IIIB). Upland Slopes and Ridge Crests (a), Midslopes (b), Lower Slopes (c), and Bottomlands (d) are landtypes shown.

IIIB2. Open Valley Land System.

This complex land system was delineated at the eastern and western ends of the region. It consists of broad river valleys with multiple terrace levels; low but generally steep, forested side slopes; a group of secondary valleys with long, very steep slopes; and deep alluvial fill. This unit more than most expresses recent geological rejuvenation.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIB2a	30	70-100 +	30	10	60	low	1-2	3-4	3	4
IIIB2b	20	5-10 (bottom)/ 50-70 (sides)	20	40	40	mod.	1-3	1-3	2-3	1-4
IIIB2c	30	60-80	30	10	60	mod.	2-3	2-4	4	3
IIIB2d	20	0-5 (bottom)/ 80 (sides)	10	70	20	high	2-3	1-3	1-4	1-4

IIIB2a. Long Valley Slopes, oak - chir pine.

These are smooth, long upper ridge slopes above the secondary and main valleys. The elevation is 1500 to 2200 meters. Slope gradients are 70 to 100 percent. Relief is up to 500 meters. The geologic materials are schists with limestone, dolomite and marble in the western part. The soils are loams and sandy loams over clay loams and sandy clay loams. The coarse fraction is 10 to 40 percent. The vegetation is a chir pine and oak type (*Q. incana*) in the central part of the landtype and *Q. semecarpifolia* in the higher part. The south facing slopes have open stands or have been converted to brush types. Some of the north aspects have closed stands. There is a chir pine - sal mixture where this landtype reaches nearly to the main canyon floor. The long, steep slopes and narrow ridges make this a harsh site for agriculture but benches, ridge crests and upper ridge slopes are cultivated. In places, excessively steep slopes have been brought under cultivation, resulting in soil erosion. Many of the oak have been heavily cut for fodder. The area is grazed. Irrigation, with narrow ditches winding across steep slopes, is attempted in places. Parts of the type have cliffs and very steep slopes. There are usually sod grasses under an open forest cover. Many steep slopes are

so obviously hazardous that no attempt has been made to cultivate them.

The people need assistance in irrigation development and field layout. Tree planting should be done.

IIIB2b. High Basins, oak - chir pine.

These are confined to the Seti drainage near its great bend between Bajhang and Silghari-Doti. The basins occupy back valleys draining to the main Seti. These are mostly broad valleys with terraces formed in deep (20-100 meters) alluvial accumulations. They are incised by vertical-walled, headward cutting drainageways. A narrow canyon connects these upland basins with the main Seti Canyon. Examples of such valleys are at Thularakot, Sikhiel, and Gortheli.

The elevation is about 1000 to 1500 meters. The slope gradients are 5 to 10 percent on the valley floors. Side slopes are 50 to 70 percent. The rocks in the side slopes and the sources of alluvium are schists, limestone and marble. The soils in the valley floor are deep, sandy loams and loams over loamy sands, or sandy gravels, but in a few places, sandy clay loams. The vegetation is mostly chir pine or oak (Q. incana).

These are important agricultural lands with the basin floors almost entirely cultivated. The side slopes are heavily grazed. The trees are in poor condition and in most places have been replaced by brush or grass. Small landslides are especially abundant on the flanks of dissected terraces. The walls of the gorges enclosing the stream channels have many land slips. The channels are unvegetated rubble suggesting high runoff levels. The side slopes have much bare ground. The terraces are generally in good condition and present no obvious erosion control problem.

The people need instruction in stream channel stabilization, irrigation system design and construction, afforestation and grazing control. The grazing pressure must be taken off the interterrace slopes. The direct relationship between deterioration of basin side slopes and the cultivated bottomlands must be shown to the people.

IIIB2c. Lower Ridge Slopes, sal - chir pine.

These are convex to straight slopes, usually above the flat bottomlands. Side canyons cut through this unit. Benches are in some of the lower part of this landtype. The slopes are usually 50 to 70 percent. The relief is up to 300 meters. The materials are schists which outcrop on some of the steeper slopes. The slopes are covered with colluvial, and in a few places, alluvial deposits. The soils are loam, deep and usually brown (7.5 YR 5/4). When wet, they are quite slick.

Sal or chir pine are the main vegetation type. Most stands forms a complete canopy cover.

This is a forested landtype. Cultivation is minor. It is grazed, in places excessively, causing rill erosion under the sal forest cover. The sal is lopped for fodder.

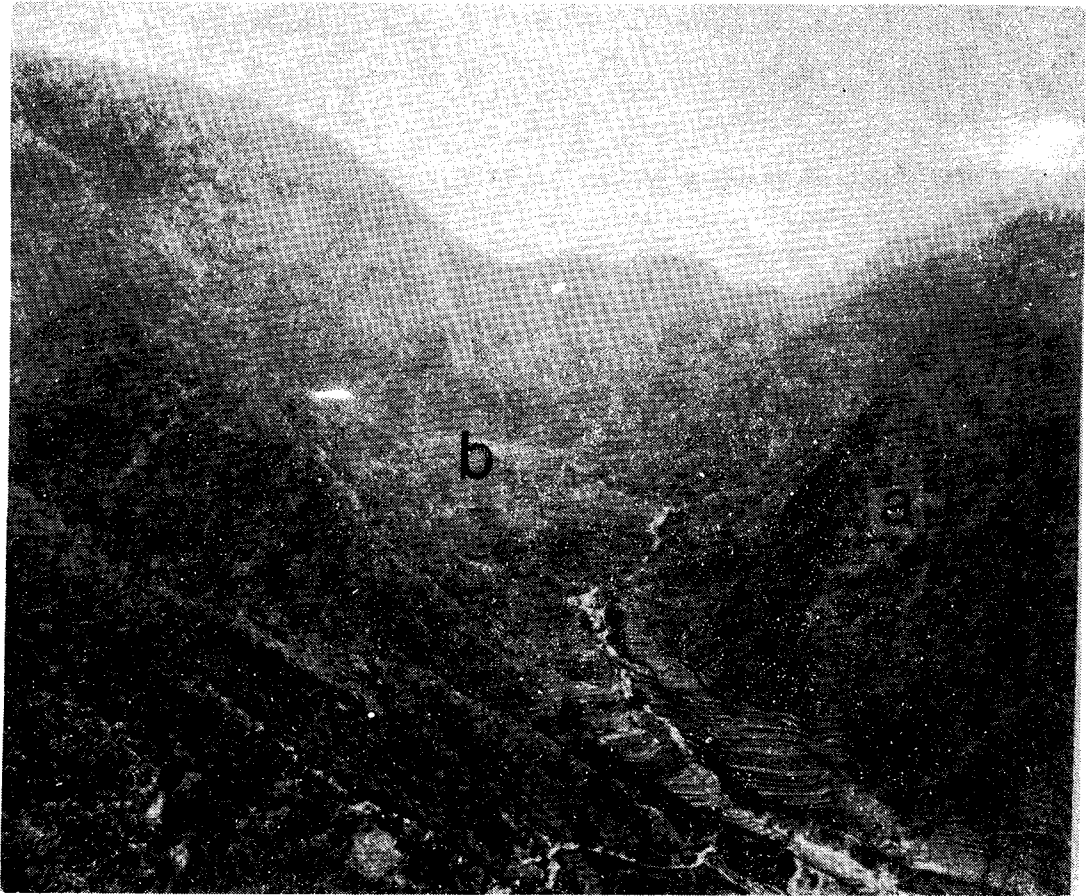
Heavily used parts of the unit have numerous small landslides. Some have a brush cover. Trails here become deeply rutted by erosion. These slopes should be protected from excessive grazing and fire. They occupy a critical position in the watershed.

IIIB2d. Bottomland, sal - khair - sissoo.

These are represented by extensive remnants of terraces along the Seti and Thulo Bheri. Broad, gently sloping fans cover the surface in places. There are three or four levels which reach up to 100 meters above the rivers. The elevation is 600 to 800 meters. The slopes are usually less than 5 percent with interterrace slopes to 80 percent. The materials are alluviums from schists. In places, there is a covering of rounded cobble. The soils are deep on the terrace surfaces, silt loam, loam and silty clay loam. The inter-terrace slopes have shallow to moderately deep soils. The vegetation is dominantly a sal forest type.

These are agriculture lands. Less than 20 percent is still in forest.

The inter-terraces have been heavily grazed and are in poor condition. The materials here are soft and highly erodible. Deep, headward cutting gullies slice through these terraces in places. Streams crossing the terraces are meandering causing serious undercutting of terrace land. The need is for training in gully control methods, and seeding or tree planting on inter-terrace slopes.



2.31 Long Valley Slopes (a) and High Basins (b) landtypes of the Open Valley Land System (IIIB2).



2.32 Open Valley Land System (IIIB2) in the Seti Valley. The Siligari-Doti landing field is visible. Landtypes here include (a) Long Valley Slopes, (c) Lower Ridge Slopes, and (d) Bottomland.

IIIC. Piuthan Dry Rounded Ridges Region.

This region is composed of an intricate pattern of low relief ridges and valleys in the southwestern part of the Middle Mountain Zone. High drainage density, heavy populations, and poor watershed conditions are conspicuous features of this region.

Summary of Region

Area 3612 sq Km

9 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Other	1	2	3	4	5
21	33	46	16	55	12	17	0

Location: Rapti Zone - Sallyan, Piuthan and Rolpa districts. Lumbini Zone - Arghakhanchi and Gulmi districts.

The principal towns are Piuthan in the east and Sallyan in the west. It is drained by the Sarda Khola, a tributary to the Babai Nadi; and the Mari Khola, a tributary to the Rapti.

Elevation/Relief: 600 to 2400 meters elevation. The relief is low to moderate.

Climate: Temperate monsoon with 1000 to 3000 millimeters of precipitation. According to Köppen, the climate is a subtropical monsoon with dry winters and hot summers.

Geology: The region is blocked in by faults. The layers of rock are folded with the entire region a series of synclines and anticlines. The materials are phyllites, schists, quartzite and limestone.

Vegetation: Mainly a mixture of oak (Quercus incana), chir pine and sal. Chilaune-chestnut with sal is in the eastern part of the region.

People: The major ethnic groups are Magar, Brahmin, Chhetri and the occupational castes, with Newars in the bazaars. Density is moderately high to high, based on total area and moderate to very high based on cropland with 8 to 24 people per hectare of cropland for the districts here.

Comments: This is a heavily populated area with a high percent of land in poor watershed condition. Enlarged and improved irrigation systems and better grazing practices are needed. Overall, the watershed condition is poorer here than in any other Middle Mountain Zone region. A broad-spectrum integrated program is needed to halt the downward trend in watershed condition.

Divisions: Four land systems were differentiated on the basis of relief, degree of dissection and drainage pattern.

IIICl. Gulmi Convex Ridge Land System.

This is an area of low, rounded, symmetrical ridges separated by narrow valleys. The elevation is dominantly less than 1500 meters. Isolated ridges in the northern part reach to 2300 meters. The materials are phyllites and schists.

This land system includes some seriously eroded lands.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIICla	20	120-150	30	0	70	low	1-2	4	5	5
IIIClb	15	5-15	10	80	10	very high	1	1	2	2
IIIClc	30	40-100	5	80	15	high	2	3-4	3-5	3-4
IIICld	25	50-100	5	30	65	high	4	3-4		4-5
IIICle	5	3-8	0	80	20	very high	1	2		1
IIIClf	5	0-2	0	60	40	mod.	1	1		1

IIICla. Gulmi Convex Ridge System Uplands, chilaune - oak.

These steep to very steep, rugged and rocky mountain uplands rise up to 1500 meters. They have shallow loam soils with 10 to 20 percent gravels and 2 to 4 percent rock outcrop. The vegetation above 1200 meters on north facing slopes and crestlands is Schima wallichii, with Castanopsis sp. Oak and rhododendron are on the higher slopes. These lands are unsuitable for agriculture. Slopes over 60 percent gradient should be retained in forest to sustain firewood production.

IIIClb. Ridge Crestlands, chilaune - chestnut.

These smooth, rounded ridge-crestlands have moderately deep to deep, clay loam soils with 5 to 10 percent stone. Chilaune - chestnut forest, now present in remnant patches, is the natural vegetation.

This landtype is in excellent condition. However, mismanagement of water in the future may cause gully development on the lower adjacent slopes. Agriculture production can be raised by improvement of soil fertility, additional use of manure and diversification of crops. Water for crops is scarce. Rice cultivation shows promise but more water is needed.

IIIClc. North Aspect Ridge Slopes, chir pine - sal.

These steep, convex north facing slopes have moderately deep to deep clay loam soils with 10 to 20 percent stone. The vegetation on upper slopes is chilaune and chir pine forest with sal forests on the lower slopes. The watershed condition here is aggravated by use of sloping rather than terraced fields. Significant rill erosion exists. It is recommended that terracing techniques should be improved on these lands and crop production intensified. Irrigation can be hazardous on these slopes as it might increase landslides and gullies.

IIICld. South Aspect Ridge Slopes, chir pine - sal.

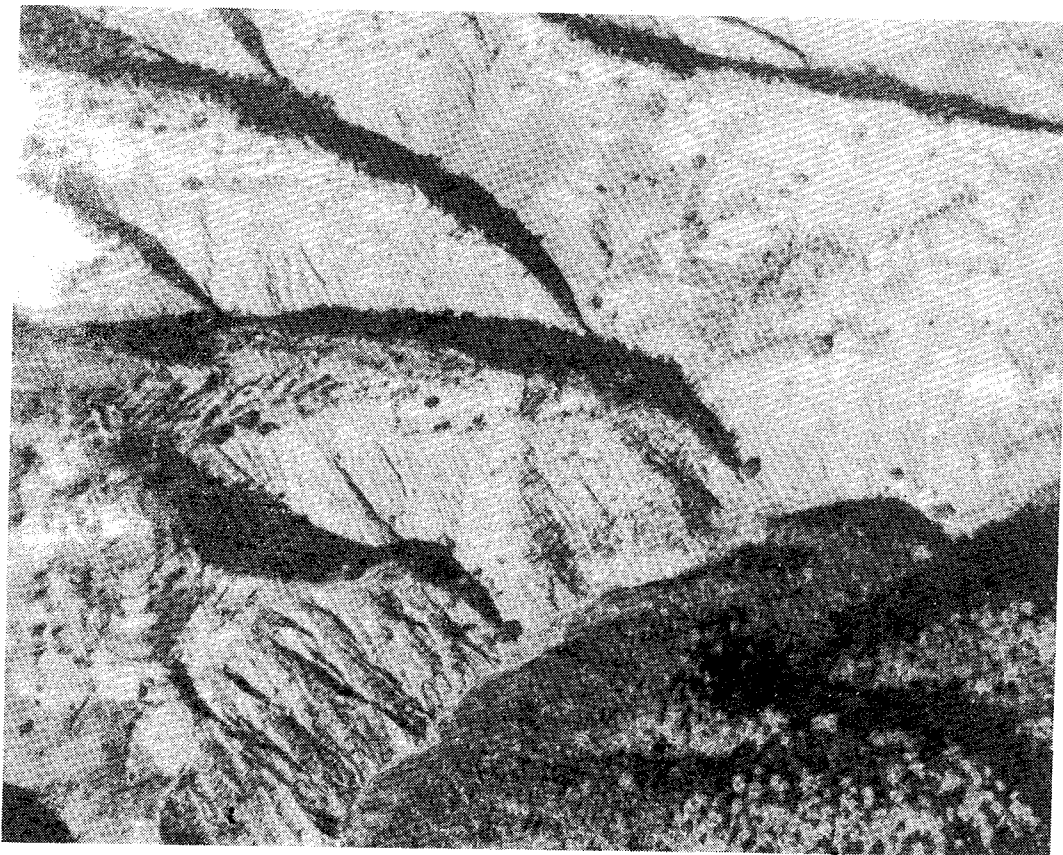
These steep, south facing ridge slopes have shallow to moderately deep loam to clay loam soils with up to 40 percent gravels and 2 percent rock outcrop. The vegetation is chir pine on upper slopes with sal and sub-tropical deciduous hill forest on lower slopes. Lands are dominantly used for grazing and are in poor condition (class 4) due to severe overgrazing. The steeper parts (over 60 percent gradient) need to be forested. The less steep parts can be used for grassland if grass is harvested by hand cutting or if strict rotation grazing schemes are applied. The poor condition lands can be rehabilitated by restricting grazing, thus permitting natural rehabilitation processes to operate.

IIICle. River Terraces, sal.

This landtype includes colluvial toe slopes and river terraces along the Buri Gad and Riri Kholas. The soils are moderately deep to deep loam or clay loam with 5 to 20 percent stones and no rock outcrop. Sal forests are the natural vegetation. These lands have great potential for agricultural production, especially if irrigation makes rice cultivation and intensifying crop production possible.

IIIClf. Valley Floors, khair/sissoo.

These valley floors are young alluvial deposits with moderately deep sand to loam soils with 20 to 50 percent gravels and no rock outcrop. The vegetation is a mixture of Acacia catechu and Dalbergia sissoo forest. This is dominantly agricultural land. The production potential is great if irrigation and intensified crop production measures are taken.



2.33 Erosion in the South Aspect Landtype of the Gulmi Convex Ridge Land System (IIIC1).

IIIC2. Gulmi Structurally Controlled Ridge Land System.

This is an intricately dissected network of ridges which have a north-south trend. The northward dipping bedrock seems to have a major influence on the shape of the slopes here. The valleys are open and contain remnants of river terraces. The Buri Gad valley however, has well developed, extensive river terraces. The elevation is 600 to 1500 meters. The materials are schists. The watershed condition is one of the poorest in central Nepal. The area is densely populated and there is high grazing and wood collecting pressure on lands marginal to the cultivated lands. The watershed problems are caused mostly by overgrazing. The problem is widespread. This area should be investigated as a target area for an integrated development project.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIC2a	5	30-60	0	80	20	very high	1	3	4	3-4
IIIC2b	20	40-80	10	60	30	very high	1-2	3-4	4	3-4
IIIC2c	40	80-150	30	10	60*	mod.	2-3	5	5	5
IIIC2d	25	80-150	50	10	40	low	3-5	5	5	5
IIIC2e	5	5-10	0	90	10	high	1	1	1	1
IIIC2f	5	0-2	0	60	40 stream bed	mod.	1	1	1	1

* includes 10% wasteland.

IIIC2a. Crestlands, chilaune/chestnut.

This landtype is in segments at altitudes from 600 to 1500 meters. It has moderately deep clay loam soils with 10 percent gravels and 2 percent rock outcrop. The vegetation is a remnant stand of chilaune-chestnut (Schima-Castanopsis) on crests, and north facing slopes. Agriculture is the dominant land use. Improved terracing and crop production are needed. Serious splash and rill erosion was noted on cropland.

IIIC2b. Dip Slopes, chir pine.

These moderately steep to steep dip slopes have shallow to moderately deep loam to clay loam soils with 15 percent stone. The vegetation is mainly chir pine forest but Schima-Castanopsis stands are on upper, north facing sites. The sloping fields are intensively used for agriculture. Crop production can be raised while erosion can be reduced by introducing improved methods of terracing. Water sources are scarce and there is a need to survey for additional sources of drinking water and irrigation water.

IIIC2c. Upper and Middle Slopes, chir pine.

These very steep slopes have very shallow to shallow sandy loam soils with 20 to 50 percent stone and up to 15 percent rock outcrop. The

vegetation is dominantly open chir pine forest. Lands are severely overgrazed and in poor watershed condition in many places. Grazing should be restricted to slopes of less than 60 percent and even here rotation schemes or grass cutting practices introduced. Steeper lands should be unused or planted to forest.

IIIC2d. Dissected Lower Slopes, sal.

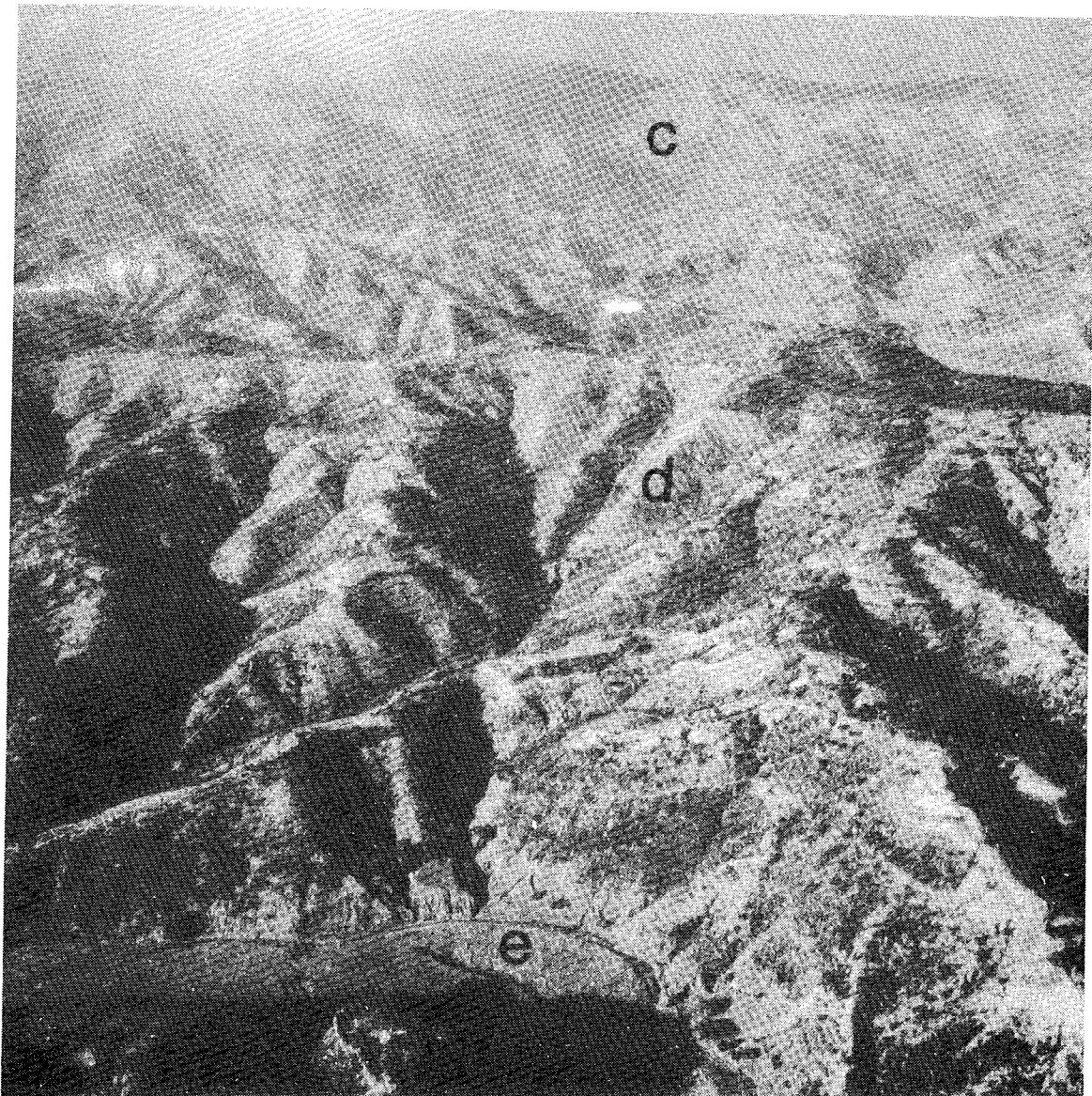
These intricately dissected lower slopes have very shallow to shallow sandy loam soils with 20 to 25 percent stone and 2 to 5 percent rock outcrop. The natural vegetation is sal forest. These lands are inherently highly erodible. This problem is further aggravated by stream undercutting. These lands can be best kept under forest for wood production for local use.

IIIC2e. River Terraces and Toe Slopes, sal.

These alluvial river terraces and colluvial toe slopes have moderately deep, clay loam soils with 5 percent stone. Sal forest is the dominant vegetation. Lands are used for agriculture. Emphasis should be given to improved crop production. Except for some bank erosion by rivers, no significant erosion problems exist here.

IIIC2f. Valley Floors, khair.

These young alluvial deposits have moderately deep gravel to sandy loam soils with 20 percent stone. The vegetation consists of strips of river bank catchment forest. These lands are mainly used for agriculture and measures for improving crop production are needed.



2.34 Gulmi Structurally Controlled Ridges Land System (IIIC2), with Upper and Middle Slopes (c), Dissected Lower Slopes (d), and River Terraces and Toe Slopes (e) landtypes.

IIIC3. Mari Dry Hills Land System.

This system has a landscape of mountain ridges with steep straight slopes and smooth, rounded ridge crests. The Mari Khola valley, which has well developed river terraces, is in the middle of the land system. The elevation is 1500 to 2400 meters. Relief is moderate. The materials are phyllites. The system is in fair condition with some spots of poor condition caused by excessive grazing. Lack of surface water is a problem in parts of the land.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIC3a	20	20-100	10	20	30G 40B/G	mod.	2	3-4	3-5	2-3
IIIC3b	10	40-100	10	40	20G 30B/G	very high	2	3-4	3-5	3-4
IIIC3c	60	75-120	30	10	30G 30B	low to mod.	2-3	5	5	5
IIIC3d	5	0-2	0	95	5	very high	1	1	1	1
IIIC3e	5	0-15	0	80	20 stream bed	mod.	1-2	1	1-2	1

IIIC3a. Crestlands, oak - chir pine.

This landtype consists of smooth, rounded, ridge tops and moderately steep to steep upper slopes. Maximum elevation is 2400 meters. The soils are shallow to moderately deep loam to clay loam with 10 percent stone. Above 1600 meters on crests and north facing slopes the vegetation is oak (*Q. incana*, *Q. lanuginosa*) forest, and chir pine (*P. roxburghii*) with extensive grasslands are below. This landtype includes many abandoned fields which were cropped more than 75 years ago and are now left for grazing, causing significant erosion problems. Trees should be planted here.

IIIC3b. Upland Basins and Noses, chir pine.

These concave positions, with ridge noses and other moderately steep parts on upper and middle slopes, have shallow to moderately deep loam

to clay loam soils with 10 percent gravel. Chir pine (P. roxburghii) is the natural vegetation. This landtype is mainly used for agriculture. Investigation for improving water availability should be made especially for the lands in concave positions. Small scale irrigation schemes and introduction of terracing techniques can improve agricultural production. Proper water channel designs to restrict landslide hazard are needed. Terracing on lands steeper than 65 percent should be avoided.

IIIC3c. Middle and Lower Slopes, chir pine - sal.

These steep to very steep slopes have very shallow to moderately deep sandy loam to clay loam soils with 10 to 20 percent stone and 2 to 4 percent rock outcrop. The vegetation is chir pine (P. roxburghii) forest on north and south facing slopes. Sal with subtropical semi-deciduous hill forest are on south facing slopes up to 1200 meters. The steep slopes of this landtype should be kept under forest and grazing of these lands should be restricted, and transferred to the less steep parts of IIIC3a.

IIIC3d. River Terraces, sal.

These flat terraces have moderately deep to deep, loam to clay loam soils with 15 percent stone. Sal is the natural vegetation. These lands are dominantly used for agricultural production. No significant erosion problems occur here.

IIIC3e. Valley Floors, Khair.

These valley floors have moderately deep, loamy sand to loam soils with 10 to 20 percent gravel. The vegetation is Acacia catechu forest along the river bank. This landtype is used for agriculture and improvement of agricultural production is needed. No significant erosion problems occur here.

IIIC4. Sallyan Ridge Land System.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIC4a	70	40-100	10	30	25B 35G	mod.	2	2	3-4	3-4
IIIC4b	10	20-70	0	85	15	high	1	3	3-4	2-4
IIIC4c	15	5-30	0	75	25G	high	2	2	2	2
IIIC4d	5	0-5	0	90	10 river bed	mod.	1	1	2	1

IIIC4a. Crestlands and Ridge Slopes, chir pine.

These ridge crests and moderately steep to steep, parallel, dissected convex slopes have shallow to moderately deep, loam soils with 10 to 20 percent stone and 5 to 15 percent rock outcrop. The vegetation is chir pine. These lands are mainly intensively used for grazing, and this heavy use has completely cleared both the grasslands and open park forest of chir pine. Serious rill and gully erosion have also resulted due to heavy grazing. The chir pine forests do not have much undergrowth while the grass burning often escapes into the forests, which impedes the otherwise good natural regeneration of the chir pine. However, with rotational grazing, grass cutting by hand, introduction of better grasses and other fodder species these lands would be restored. The opening of the Pokhara - Surkhet road, which will pass through the south of this land system could give a favourable impact on timber production as slopes are not very steep and could be safely logged with modern logging techniques, though care must be given to soil conservation requirements. High potential for resin production from chir pine exists.

IIIC4b. North Aspect Dip Slopes, chir pine.

These moderately steep dip slopes have moderately deep loam soils with 10 to 20 percent stone. The vegetation is chir pine. Although a

small part of the landscape, it is very intensively terraced and cultivated. Due to the dip slopes, there are sufficient water sources to make rice cultivation possible. With adequate care there are no significant erosion problems here. Attention should be given to improving terracing and other agricultural practices.

IIIC4c. Foot Slopes, chir pine.

The gently dissected foot slopes and bench terraces have moderately deep loam to clay loam soils with 10 to 20 percent gravels. Chir pine is the natural vegetation. Lands are used for agriculture or grassland, overgrazing has caused some rill and gully erosion. No other significant problems occur.

IIIC4d. Valley Floors, chir pine - hardwood forests.

The broad, meandering valley floors have shallow to moderately deep sand to loam soils with 10 to 20 percent stone. The vegetation here is a mixture of chir pine with alder and chestnut forests in shady sites. The land type is mainly used for agriculture and there are no significant erosion problems.

IIID. Baglung Middle Mountain Region.

This is perhaps the most rugged region in the Middle Mountain Zone. It is an area of high, sharp ridges with long, steep slopes. Flat lands are a minor part of the region's landscape.

Summary of Region

Area 4101 sq Km

10 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush	1	2	3	4	5
33	27	40	27	70	3	0	0

Location: Rapti Zone: mainly Rolpa district. Dhaulagiri Zone: mainly Baglung district. The principal towns are: Baglung, Musikot, Kusma and Libanggaon. The area is in the Kali Gandaki and Rapti basins, drained by the Bari Gad, the Modi Khola, the Myagdi Khola, and the Mari Khola.

Elevation/Relief: 1200-3600 meters elevation, moderate internal relief.

Climate: Temperate monsoon with 1500 to 3000 mm of precipitation. Classified according to Köppen as subtropical monsoon with the maximum temperature before the rainy season (Cwag) grading to warm temperate rainy upland climate (Cwb).

Geology: Schuppen structure with quartzite and phyllitic schist materials. Inclusions are layers of marble, dolomite and chloritic schist. The area is crossed transversely by a series of parallel faults.

Vegetation: A mixture of fir - oak - chir pine in the north central part; oak - chir pine with chilaune and sal in the eastern part.

People: The main groups are Magar, Brahmin, Chhetri and occupational castes, with Newars and Thakali in the bazars. The population density is moderate to high based on total land area. Based on area of crops, the density is moderate with 6-8 persons per hectare.

Comments: This region has many steep, rocky slopes that should remain in forest and be protected from excessive grazing. The agriculture land has the usual need for increased productivity through better utilization of organic fertilizers and improved irrigation systems. Improper grazing practices were repeatedly noted as the single most damaging land use.

Division: The area is mapped in three land systems separated on the basis of relief and drainage pattern.

IIID1. Tin Bainhi Mountain Land System.

These are rugged, parallel ridges in the northwest part of the region. The ridge crests are flat, the side slopes are structurally controlled and the drainageways are steep and narrow. The altitude range is 750 to 2500 meters in the area west of the Thabang Khola watershed, and 1500 to 3500 meters in the eastern part of the system. Relief is moderate and high. The materials are schists with limestone and quartzites.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIID1a	15	70-120	50	10	40	low	1	3	4	5
IIID1b	5	5-20	0	100	0	high	1	1	2	2
IIID1c	35	60-120	25	30	45	mod.	2	3	4	4-5
IIID1d	35	50-120	10	30	60	mod.	2-3	3	4	4-5
IIID1e	5	0-2	0	80	20	very high	2	1	1	1
IIID1f	5	0-5	0	60	40	low	2	1	2	3

IIID1a. Steep Mountain Uplands, fir - oak - blue pine forests.

These steep mountain uplands are above 2500 meters. They have shallow to moderately deep loam soils with 10 to 20 percent gravel and up to 5 percent rock outcrop. The vegetation is a mixture of fir, oak and blue pine forests (*A. spectabilis*, *Q. semecarpifolia*, *P. wallichiana*). This landtype is almost entirely above the upper limit of cultivation. According to Stainton (1972) heavy cloud and mist during monsoons impedes ripening of crops above 2500 meters. The land is in good to natural condition and no watershed management is needed. In the future, pressure on forest lands for fuelwood will increase.

IIID1b. Flat Crestlands, oak - chir pine forests.

These flat crestlands at 1600 to 2000 meters have moderately deep loam soils. The vegetation is a mixture of oak and chir pine (*Q. lanuginosa*, *Q. incana*, *P. roxburghii*) forests. Although small in area the landtype is of great importance for agricultural production in the higher elevations of the land system. By improving water supply and soil fertility and eliminating crop diseases, agricultural production will increase. No special soil conservation measures are needed.

IIIDlc. Steep North Aspect Slopes, oak - chir pine - sal forests.

These are generally dip slopes. They have shallow to moderately deep loam soils with 10 to 20 percent gravels and up to 5 percent rock outcrop. The vegetation on the upper and middle slopes is oak and chir pine (Q. incana, Q. lanuginosa, P. roxburghii) forests. Brush forests and sal are on the lower slopes.

This is a complex unit with irregular but dominantly steep slopes. It is unsuitable for agriculture, except on benches and in concave positions. Food production here is often insufficient for local needs. There are however good prospects for horticulture (apple, peach, mango, walnut, banana), especially when the Pokhara-Surkhet road (1 day's walk to the south) is opened.

Watershed management practices should include protection of forest lands, conversion of brush to forest and introduction of a rotational grazing system and grass cutting practice. The latter may have a good chance as most grazing lands here are privately owned.

IIIDld. Steep South Aspect Slopes, oak - chir pine - sal forests.

These steep, dry, south facing slopes have very shallow to moderately deep, sandy loam to loam soils with 10 to 30 percent stone and 2 to 5 percent rock outcrop. The vegetation on the upper and middle slopes is sal, chir pine and oak (Q. incana, Q. lanuginosa) forests. Sal and brush grasslands are on the lower slopes. The land use problems are similar to IIIDlc. Gully erosion is more severe here due to drier conditions. Grazing should be completely stopped on the abused lands.

IIIDle. River Terraces, sal forest.

These flatlands have deep to moderately deep, loam soils with 10 percent gravels. The vegetation is sal forest. These lands have great potential for increasing agricultural production with improved irrigation and additional use of manure. Bank erosion along the river terrace edges needs attention.

IIIDlf. Valley Floors.

These rough stream bottoms have very shallow to moderately deep coarse sand to sandy loam soils with 50 percent gravel to stone size material and up to 5 percent rock outcrop. This landtype has marginal agricultural value due to shallow, stony, sandy soils and flooding after rainstorms. Farmers need guidance in embankment construction.

IIID2. Central Mountain Land System.

This is a very large land system, reaching from the Kali Gandaki to the Sarda drainage of the Rapti. It consists of a continuous block of high ridges separated by V-shaped canyons. It is drained by the Bari Gad in its eastern half, and tributaries to the Mari Khola in the west. The Gurlung-Sheulabang-Panchase ridge splits the system into these two major drainages. The

elevation is between 800 and 3500 meters, increasing from the south to north. The materials are limestone and phyllitic schists.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIID2a	30	60-100 deep slopes / 80 scarps	55	5	15B 25G	low	1	4	5	5
IIID2b	8	20-50	30	45	25B/G	high	1-2	2-3	2-3	2-3
IIID2c	30	80-120	30	25	35B 10G south asp.	mod.	1-2	4	5	5
IIID2d	25	100-150	45	15	25B/G 15 rocky waste	low	2	5	5	5
IIID2e	7	0-10 30-65 coll. toe slopes	0	90	10 river beds	mod. to high	1-2	1 3 toe slopes	1 3-4 toe slopes	1 2-3 toe slopes

IIID2a. Steep Rugged Uplands, oak - rhododendron.

These moderately steep to very steep lands above 2400 meters are dip slopes on the northern parts and scarp slopes on the southern parts. They have very shallow to moderately deep sandy loam to loam soils with 10 to 30 percent stones and 2 to 10 percent rock outcrop. The vegetation is a mixture of fir, oak, hemlock and rhododendron (*A. spectabilis*, *Q. semecarpifolia*, *Tsuga dumosa* and *Rhododendron* spp). These lands are above normal cropping altitudes and are densely forested. Some parts can be used for grazing but they need to be managed.

IIID2b. Crestlands on Lower Ridges and Noses, oak - rhododendron - chilaune chestnut.

These gentle to moderately steep lands below 2400 meters include different levels of benches. They have shallow to moderately deep loam to clay loam soils with 5 to 10 percent gravel. The vegetation

is a mixture of oak, rhododendron and Schima-Castanopsis. These and the valley bottoms are the cropping areas in the land system. With improved terracing and agricultural practices (such as additional use of manure, protection against diseases and insects), increased production will permit reduced use of unsuitable lands.

IIID2c. Moderately Steep to Steep Middle and Lower Slopes, oak - rhododendron - chilaune - chestnut.

These steep lands are below 2400 meters. They have shallow to moderately deep loam soils with 5 to 20 percent stone and up to 4 percent rock outcrop. The vegetation is oak (Q. lanuginosa) and rhododendron on higher slopes, chilaune-chestnut with patches of chir pine on lower south-facing slopes. About one fourth of the lands is farmed.

Watershed condition is mostly in the "good" class. Forest and grass-land use is recommended.

IIID2d. Canyonlands, Very Steep Middle and Lower Slopes, oak - rhododendron - chilaune - chestnut.

These rough, rocky and densely forested canyonlands are below 1800 meters. They have with 10 to 30 percent stone and 5 to 10 percent rock outcrop. With minor exceptions, the vegetation is a mixture of oak, rhododendron, chilaune-chestnut and shrub. These lands are too steep and rough for any use other than forest or brush.

IIID2e. Valley Bottomlands, sal - subtropical semi-evergreen hill forests.

These colluvial toe slopes, river terraces and streambeds at 750 to 1500 meters have moderately deep, sandy loam to loam soils with 5 to 35 percent stone and gravels. The vegetation is a mixture of sal and subtropical semi-evergreen hill forests (Alnus nepalensis, Cedrela toona, Albizia julibrissin).^{1/} These are important agricultural areas within the land system. Emphasis on agricultural production is needed. Small scale irrigation on the river terraces and valley floors is possible. On the steeper colluvial toe slopes, intensive irrigation might cause landslides. Stream banks need protection.

IIID3. Baglung Broad Open Mountain Land System.

This system is in the eastern end of the region and consists of steep, broad, open mountain lands with sharp, rugged ridge crests and long, dissected side slopes. The upper slopes are less steep than the lower slopes. There are high, entrenched river terraces along the Kali Gandaki. The elevation is 750 to 2700 meters. The relief is moderate (500 to 2000 meters). The materials are phyllitic schists with thick layers of quartzite. Marble, dolomite and chloritic schist are present in smaller areas.

^{1/} (Syn. A. mollis).

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIID3a	10	100	80 north aspect 40 south aspect	-	20 n. asp / 40W, 20B s. asp	low	1	5	5	5
IIID3b	15	40-70	5	65	30B/G	high	2	3-4	3-4	3
IIID3c	15	50-80	5	35	60B/G	mod. to high	3	3-4	4	3-4
IIID3d	40	60-100	15	30	25B 30G	mod.	2	5	5	5
IIID3e	5	120	40	-	60B/G	low	2	4	5	5
IIID3f	10	0-5	-	70	30G	very high	1	1	1	1
IIID3g	5	5-40	-	90	10B/G	high	1-2	2-3	3	2

IIID3a. Rugged Crestlands, oak - rhododendron.

These rugged ridge tops and upper slopes are mostly above 2400 meters and have very shallow to moderately deep loam soils with 10 percent gravels and 2 to 4 percent rock outcrop. The vegetation is oak (Quercus semecarpifolia) and rhododendron. It is dominantly forested on north aspects and has brush-grass vegetation on south aspects. Most of the landtype is in fair to good watershed condition. The steep north aspects need protection from deforestation by fuelwood cutting and fire. Scarps and rocky, overgrazed south-facing slopes require attention to grazing management.

IIID3b. Dissected Upper Slopes, oak - rhododendron - chilaune - chestnut.

These are moderately steep, sprawling lands with northerly aspects. Benchlands are on lower slope positions. The soils are moderately deep loams with 5 to 15 percent stone and 2 to 4 percent rock outcrop. The vegetation is oak (Q. lanuginosa) and rhododendron on the higher parts with chilaune-chestnut (Schima-Castanopsis) below. The landtype

is an important area for agriculture and is intensively terraced. Emphasis should be on improvement of terracing techniques and diversion of run-off water to natural drainageways, efficient use of labour and manure, protection against diseases and insects. The higher parts of the landtype are often used for grazing. Rotation grazing schemes should be introduced. Although many gullies are now well vegetated, care should be given to restricting further gully development by vegetative means.

IIID3c. Middle Slopes, oak - rhododendron - chilaune - chestnut.

These are south-facing moderately steep, ridgeland with shallow to moderately deep loam soils. The vegetation is oak (*Q. lanuginosa*), rhododendron and chilaune-chestnut. Watershed condition is fair, and in places, poor. The land is used heavily for grazing. The main forms of erosion are gully and land slips. In many places agriculture would be possible if water was available. Much care has to be given to grazing management.

IIID3d. Lower Slopes, chilaune - chestnut - chir pine - sal.

These steep slopes have very shallow to moderately deep, loam soils with 10 to 20 percent gravels. The vegetation is mostly chilaune-chestnut forest on north aspects and pine and sal on south aspects. Brush and grassland cover parts of the south facing slopes.

The land should be left in brush and forest as far as possible. The good watershed condition could be maintained or improved. These lands could be planted to provide fuel wood.

IIID3e. Canyonlands and River Terrace Scarps, chir pine - sal.

This very steep, rugged, rocky land unit has very shallow to shallow loam soils with 5 percent stone and up to 20 percent rock outcrop. The vegetation consists of sal and chir pine, with chilaune and alder in shady sites. Part of the landtype is very rocky, inaccessible land. These areas should be left completely under brush or forest. Existing mass movements are mostly due to natural factors such as undercutting by streams. River terrace scarps are very sensitive to gully and landslide erosion because they are too steep for agriculture or grazing. These activities should be restricted here. The edges of the flat terrace surface need vegetation protection.

IIID3f. River Terraces, sal.

These flat lands have moderately deep to deep loam to clay loam soils with 5 to 10 percent gravel and no rock outcrop. The vegetation is sal. These are important agricultural lands. Emphasis on increase of agricultural production is needed. Drainage of surface water has to be regulated to avoid further gully development along the edges of the river terraces. Erosion along the edges of these river terraces is a serious threat to these scarce, highly valuable agricultural lands.

IIID3g. Colluvial Foothslopes, Alluvial Fans, Valley Floors, sub-tropical semi-evergreen hill forest.

These lands have shallow to moderately deep, sandy loam to loam soils with 10 to 20 percent gravels. Boulders make up about 2 percent of the surface. The vegetation consists of semi-evergreen hill forest (Alnus nepalensis, Cedrela toona, Albizia julibrissin (syn. A. mollis)). Most of these lands (except the flood plain) are used intensively for agriculture. They are very sensitive to gully erosion and mass movement, due to weak consolidation of materials and often high concentration of subsurface water. Parts of these landtypes are in fact old landslide surfaces. Permanent structures such as irrigation channels and roads should be kept to a minimum here. Better terracing and manuring can improve crop production. More detailed data is needed to locate and design structures to avoid damage by mass earth movements.



2.35 Baglung Broad Open Mountain Land System (IIID3), with Rugged Crestlands (a), and Dissected Upper Slopes (b) landtypes shown.

IIIE. Central Middle Mountain Region.

This region is a belt of moderate relief ridges between the Trisuli drainage and the Kali Gandaki. It has the Mahabharat Lekh as its southern border and the Transition Zone along its northern edge. Most of the ridges are assymetrical with a gradual south slope and an abrupt north-facing, scarp slope. The drainageways have broad terraces with entrenched meandering streams. This appears to be the most fertile and productive region in the Middle Mountain Zone.

Summary of Region

Area 4334 sq Km

10 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush	1	2	3	4	5
22	50	28	31	62	7	0	0

Location: Gandaki Zone: Kaski, Syangja, Lamjung, Gorkha and Tanahu districts; Bagmati Zone: Dhading district; Gandaki Zone: Parbat district. The region reaches from the Kali Gandaki to the Buri Gandaki. The major town here is Pokhara. Most of the region is drained by tributaries to the Narayani River, including the Madi, Seti and Marsyangdi Kholas. The Andhi Khola is an important drainage in the southern part of the region. The western edge of the region is in the Kali Gandaki valley.

Elevation/Relief: Elevation is 450-2000 meters; relief is low to moderate.

Climate: Temperate monsoon with precipitation ranging from 2000 to over 3000 mm near Pokhara. Köppen classification is subtropical monsoon (Cwa) with spots of excessive rainfall (Cwar).

Geology: The major kind of rock is phyllitic schist with inclusions of coarser textured, garnet-biotite-muscovite schists. These are in layers dipping to the north in the northern part of the region and to the south in the south and western part of the region.

Vegetation: The bulk of the region is a chilaune-chestnut (Schima/Castanopsis) community with chir pine (P. roxburghii). Tropical sal (Shorea robusta) forest is in valleys and on lower slopes. A river forest lines the streams with Alnus, Cedrela, and Albizia as the major genera. Some of the southern ridges reach into the oak zone with Q. lamellosa, Q. lanuginosa as the main trees.

People: The main groups are Gurung across the northern part, Magars in the south and Tamangs in the east. Brahmin, Chhetris and occupational castes are scattered throughout. Newars are in most of the bazaars. The population density is mostly high. Based on population in relation to

area of crops it is moderately to extremely high. Dhading district has a calculated 30 people per hectare of crops, the highest density in Nepal.

Comments: This is a complex region containing some of the most valuable agricultural lands in the Middle Mountain Zone (IIIIElf) and some spots of land in the poorest condition (IIIIE3a). The need is for maintenance of present forest cover (which is diminishing rapidly) and cutting back of grazing pressure on landtypes with low suitability for agriculture. Many needs were noted to improve land use practices related to watershed condition:- stall feeding of livestock should be encouraged; lopping of trees should be curbed collection, preparation and use of organic fertilizers need to be improved; water systems must be developed, including building ponds; crops need to be diversified, and natural and man-made terraces need to be protected from streambank erosion.

Divisions: The region was divided into six land systems on the basis of intensity of dissection, depositional history, relief and geologic structure.

IIIIE1. Marsyangdi Assymetrical Ridge Land System.

This land system lies between Pokhara and the Trisuli and consists of structurally controlled ridges with broad intervalleys. The ridges have an east-west orientation giving the drainage area a weak lattice pattern. The south aspects are comparatively gentle dip slopes. The north slopes are abrupt scarp slopes. The elevation is dominantly 600 to 1200 meters with some ridges in the west up to 2000 meters. The relief is low. The materials are mostly schists. The major terraces (tars) here are inclusions under subsystem IIIIE6.

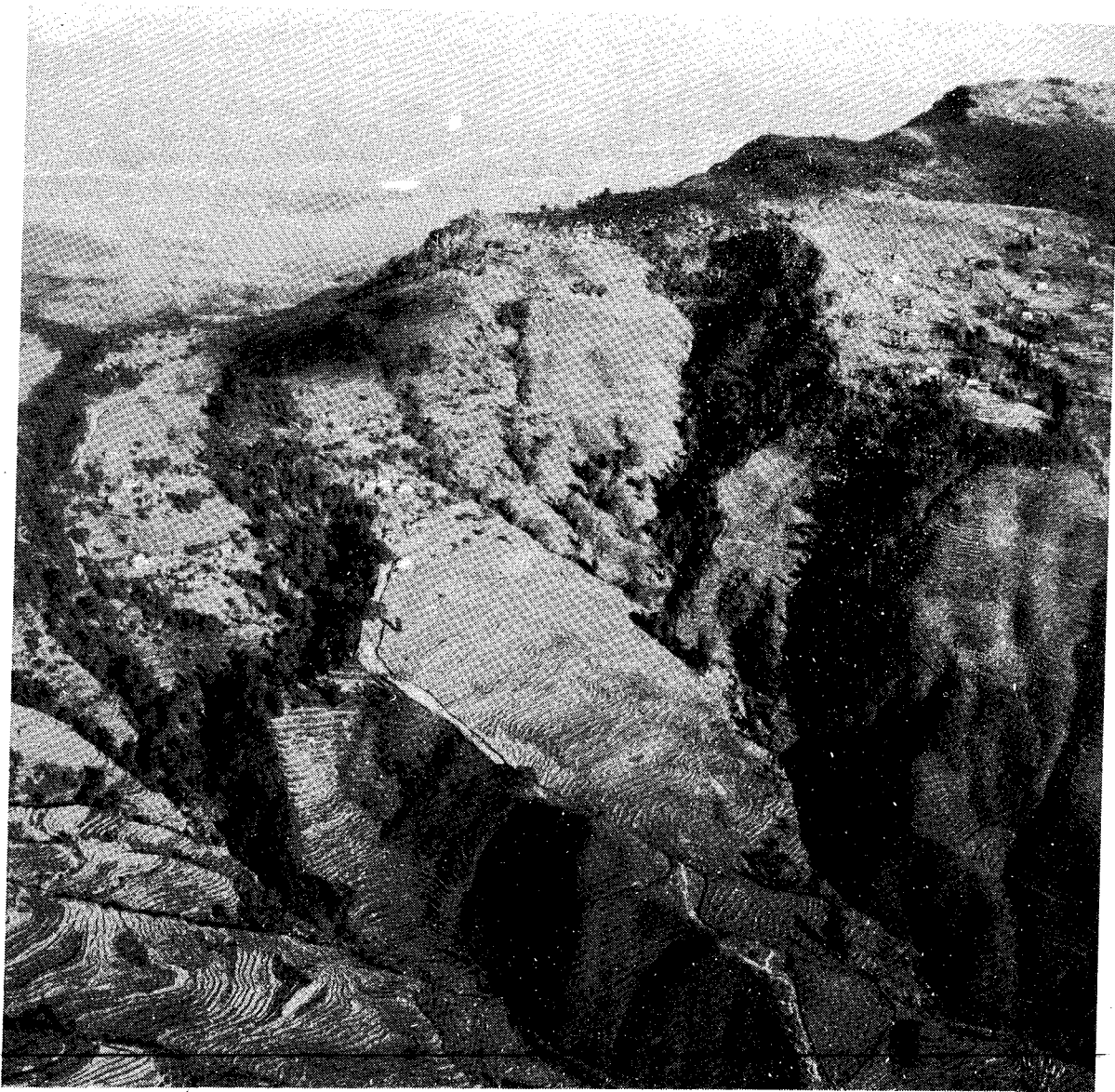
Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIIE1a	15	120	70	15	15B	low	1	5	5	5
IIIIE1b	30	30-60	5	70	15B/G 10G	very high	2	4	3	3
IIIIE1c	20	40-80	10	70	10B, 10G	high	1-2	3-4	3-4	4
IIIIE1d	20	80-120	60	20	20	low	1-2	5	5	5
IIIIE1e	15	0-15 alluv.fans 10-30 coll.toe slopes	0	95	5B/G	low	1	1 2 2	2	1-2

IIIIEla. Steep Crestlands, chilaune - chestnut - chir pine.

These steep to very steep north facing crestlands rise over 1800 meters. They have shallow loam soils with 10 to 30 percent stone and 6 to 8 percent rock outcrop.

These lands are densely forested by chir pine, chilaune, chestnut and oak (Q. lanuginosa) forests in isolated places.



2.36 Marsyangdi Assymetrical Ridge Land System (IIIIEl), Moderately Steep Dip Slopes (b) with Pokhara valley in the background.

This landtype should be maintained as is, under forest. The growing demand for fuelwood will cause high pressure on these forests, therefore efforts are needed to regulate or replace trees taken for fuelwood gathering. No special watershed management is required at present except conservation of wood resources.

IIIElb. Moderately Steep Dip Slopes, chilaune - chestnut - chir pine.

These are south facing, moderately steep, long undulating dip slopes. They are shallowly dissected. Soils are shallow to deep loam to clay loam with 10 to 20 percent stone and up to 4 percent rock outcrop. The vegetation is a mixture of chilaune-chestnut and chir pine. These lands are extensively used for agriculture. Lands unsuitable for agriculture are mostly too steep for grazing also. Most grazing is done on abandoned fields in winter. These lands are sensitive to erosion. Specific measures needed are control of surface water by diverting water into natural, vegetatively protected drainageways and increasing storage water in ponds for the dry winter. Accumulation of surface water at the lower parts of the landtype are the main cause of gullying and landslides.

There is a great need for fodder production and encouragement of stall feeding for cattle to diminish destructive random grazing and lopping of trees.

Some agricultural practices which need introduction here are: contouring of terraces; more efficient tillage; improved use of manure; better weeding; protection against crop diseases and insects, and improved crop rotation including addition of leguminous crops which can help maintain soil fertility.

IIIElc. Ridge Side Slopes, chilaune - chestnut.

These moderately steep to steep north facing scarps are rocky and benchy in places. They have shallow to moderately deep loam to clay loam soils with 10 to 20 percent stone and up to 4 percent rock outcrop. Lands are partly used for agriculture. Mass movement processes active here are not associated with dip slopes.

IIIEld. Steep Dissected Lower Slopes, chilaune - chestnut - sal.

These steep and very sensitive lands are or have been densely forested. They have shallow to deep, loam to clay loam soils with 10 percent stone and up to 2 percent rock outcrop. The vegetation is a mixture of chilaune-chestnut and sal forests. Subtropical semi-evergreen riverine forests are in damp sites. Natural erosion is high and can easily be accelerated by improper land management practices such as improper diversion of surface water or excessive grazing.

These lands are often within walking distance of settlements. With forest conservation they could be managed as a perpetual source of fuelwood.

IIIEle. Alluvial-colluvial Valley Bottomlands, sal.

These include alluvial fans, colluvial toe slopes, alluvial flood plains and narrow river beds. The soils are gravelly sand to loam, moderately deep, with 10 to 40 percent stone and no rock outcrop.

The vegetation is a mixture of subtropical, semi-evergreen hill forest in the narrow tributary valleys and sal forests on the terraces and toe slopes.

Most of the alluvial fans and streambeds have very coarse texture soils and are marginal for agricultural production. The colluvial toe slopes and alluvial flood plains are productive lands, because soils are less coarse and water, especially on the terraces, is readily available. These lands are usually very suitable for rice. Flood hazards are serious and unpredictable. It will be a challenge to devise cheap and efficient flood control measures.

IIIE2. Chepe Moderately High Ridge Land System.

This land system is a transitional area between the low relief of land system IIIE1 and the much higher relief Transition Zone land of system IID1. This land system has moderately high mountains with northward sloping dip slopes. River terraces along the narrow valleys are important features here. The elevation is 1000 to 2200 meters in the western part of the region and 600 to 2000 meters in the east. Relief is moderate. The materials are schists, with quartzite inclusions.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIE2a	10	120	20	10	70B/G	low	2	5	5	5
IIIE2b	25	40-65	25	40	35B/G	high	1-2	4	3-4	3
IIIE2c	45	60-120	35	25	40B	mod. high	1-2	4-5	5	5
IIIE2d	10	0-15	-	95	5B	high	1	1	1	1-2
IIIE2e	T	100	-	70	30B/W	low	3	5	5	5
IIIE2f	10	0-10	-	50	50W	low	1	1	1	3

IIIE2a. Very Steep Scarp Slopes, oak - chilaune - chestnut.

These very steep, mostly south facing, scarp slopes have very shallow to shallow, sandy loam soils with 20 to 30 percent gravel and up to 5 percent rock outcrop.

The vegetation is mainly chilaune-chestnut with open stands of oak (Q. lamellosa) and brush in the higher parts. These very steep, almost vertical lands, cannot be safely used for grazing or agriculture, as it would create a hazard for agricultural areas below. Therefore grazing or tree cutting should be restricted.

IIIE2b. Moderately Steep Dip Slopes, chilaune - chestnut.

These are steep dip slopes. They have moderately deep loam soils with 10 to 20 percent stone. The vegetation is chilaune, sal and chir pine. Much of the landtype is terraced. Excess surface water here must be diverted to well vegetated natural drainageways. Emphasis should be on improving agricultural practices, (see IIIE6).

IIIE2c. Steep, Mountain Slopes, oak - chilaune.

These steep mountain slopes are not clearly associated with dip or scarp slopes. They have shallow to moderately deep loam to sandy clay loam soils with 10 to 20 percent stone. In higher altitudes oak (Q. lamellosa) is common.

Agriculture is restricted to small areas where slopes are less than 65 percent. Regulation of use of forests and forage resources is required.

IIIE2d. River Terraces and Alluvial Fans, sal.

These river terraces merge with alluvial fans from tributary streams. They have three levels. The two lower levels are easily recognized, the highest level exists only in remnants sitting on higher slopes. They have moderately deep, sandy loam soils with 10 to 20 percent stones and gravel.

Sal is the natural vegetation here. Agriculture is dominant, especially on the flat river terraces. Measures are needed to protect interterrace slopes against gully erosion caused by uncontrolled run-off, and from landslides caused by stream undercutting. This can be done by planting protective strips of bushes or trees along the edges.

The steep scarps between river terraces have shallow sandy loam soils with 40 to 60 percent stone and 2 to 4 percent boulders. The vegetation is sal. These slopes have little value for agriculture or ~~grazing and need a covering of brush or forest.~~ Grazing should be restricted to protect the flat river terrace surfaces below from deposition.

IIIE2e. Valley Floors, sal - subtropical semi-evergreen riverine forest.

These are narrow side streams and meandering river beds with gentle gradients. The soils are gravelly loamy sand, very shallow to moderately deep, with 30 to 50 percent stone and 5 to 10 percent bedrock.

The vegetation is a mixture of sal and subtropical semi-evergreen riverine forests. Although suitable for temporary agriculture, flood hazard is quite high. Protective measures should be taken where river terraces are endangered by under-cutting.

IIIE3. Andhi Khola Mountain Land System.

These are intricately dissected mountain lands with sharp ridges in metamorphic materials in its northern extent. In the southern part of the system they are rather flat to rounded ridge crests in the limestone materials. A bench-like erosion surface was noted at about midslope on many of the ridges here. The elevational range is 750 to 1800 meters. Relief is moderate.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIE3a	35	60-120	15	25	30G, 30B/G	mod. high	3,4	5	5	5
IIIE3b	15	15-50	-	90	10B/G	very high	1	2-3	2-3	2-3
IIIE3c	35	60-120	10	60	15G 15B/G	very high	3	5	5	5
IIIE3d	7.5	20-50	-	100	-	very high	1-2	2-3	2-3	2-3
IIIE3e	7.5	0-5	-	75	25W	very high	1	1	1	1

IIIE3a. Rugged Steep Upper Mountain Slopes, chilaune.

These rocky slopes have very shallow to moderately deep soils with 10 to 20 percent gravel and stones and 5 to 8 percent rock outcrop. The vegetation consists of small patches of chilaune forest. This area is densely populated (more than 200 per square kilometer). Watershed condition, compared to its original condition, is fair to poor.

isolated hills, and meandering streams. These lands occupy small plateau between the large river valleys of the Seti, Madi, Marsyangdi and Darondi Kholas. The elevation is mostly 450 to 800 meters, with some hills reaching 1200 meters. Relief is low to moderate. The materials are schists with layers of dolomite and quartzite.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIE4a	65	30-100	15 south asp.	55 south asp.	30 south asp.	high	2	3-5	3-5	3-5
IIIE4b	15	100-150	60	5	35	mod. low	1	5	5	5
IIIE4c	20	2-25	-	100	-	very high	1	1	1	1

IIIE4a. Intricately Dissected Rolling Hills, chilaune - sal.

The more forested, north facing slopes are steeper than the south facing slopes. They have moderately deep loam to clay loam soils with less than 10 percent stone and few rock outcrops.

The vegetation is a chilaune and sal forest though the latter is generally absent on the north facing slopes.

Apart from a few small landslips, there are not many landslides or other disturbances here. The land is in good watershed condition (Class 2). Water is scarce which makes rice cultivation difficult.

Much of this unit has been recently cleared by burning, and brought under cultivation. With improved terracing about two thirds of the land here has good prospects for dry land cultivation on slopes. Other lands should be forested or covered by brush to provide necessary fuelwood. Grazing has to be regulated.

IIIE4b. Canyonlands, chilaune - sal.

These very steep slopes are along some minor streams, especially where the plateau, consisting of units IIIE4a and IIIE4c, drops down to the valleys of the major rivers. Soils range from very shallow, loamy sand to deep, red clay.

The vegetation is chilaune and sal. The lands are densely forested and watershed condition is excellent. There are some natural landslides, mostly due to undercutting by streams. If these lands are kept in their present use status, no additional conservation measures are needed.

IIIE4c. Broad Valley Floors and Alluvial Fans, chilaune - sal.

These valleys have alluvial deposits with moderately deep to deep, loam to clay loam soils. Where water is available the agricultural lands are highly productive, capable of producing 2 rice crops a year. Except for some bank erosion along meandering streams, there are no significant watershed problems.

IIIE5. Tanahu Low Parallel Ridge Land System.

This small system consists of low relief, rolling, parallel ridges with a north-south orientation. The elevation is 400 to 1000 meters. The materials are phyllitic schists and outwash from this kind of rock.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIE5a	60	20-40	75	25	-	high	1	2	2	3
IIIE5b	40	3-10	80	10	10	high	1	1	2	1

IIIE5a. Low Long Ridges, sal.

These north-south ridges are mainly under sal forest. Soils are deep, reddish, sandy loams and loams. Watershed condition is excellent with few signs of erosion.

IIIE5b. Long Smooth Valleys, sal.

These are the drainageways lying parallel to the above ridges. They are mostly under agriculture. Soils are deep sandy loams and loamy sands. Gravel content is up to 30 percent. Watershed condition is excellent.

IIIE6. Tar Land System, cultivated lands.

This is a group of high river terraces occurring in small blocks scattered along the major river ways in this region. Because of their extent, significance to agriculture, and general uniformity, these land areas have been recognized as a separate set of land units. This set is a land system

with representative units along the Andhi Khola, Seti, Madi, Marsyangdi, Darondi and Bari Gandaki. The elevation is 300 to 750 meters. Slope gradients are less than 3 percent on the terrace surfaces and over 100 percent on the interterrace slopes. The materials are sediments from schists and quartzite. Rounded cobble are in many soil profiles.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIE6a	30	0-3	0	90	10G	high	1	1	1	1
IIIE6b	60	0-3	0	75	25G	high	1	1	1	2-3
IIIE6c	10	100	20	40	40W	low	2	5	5	5

IIIE6a. Red Tars, sal.

These old, deeply weathered river terrace surfaces have deep, red, clay loam soils with 5 percent cobble.

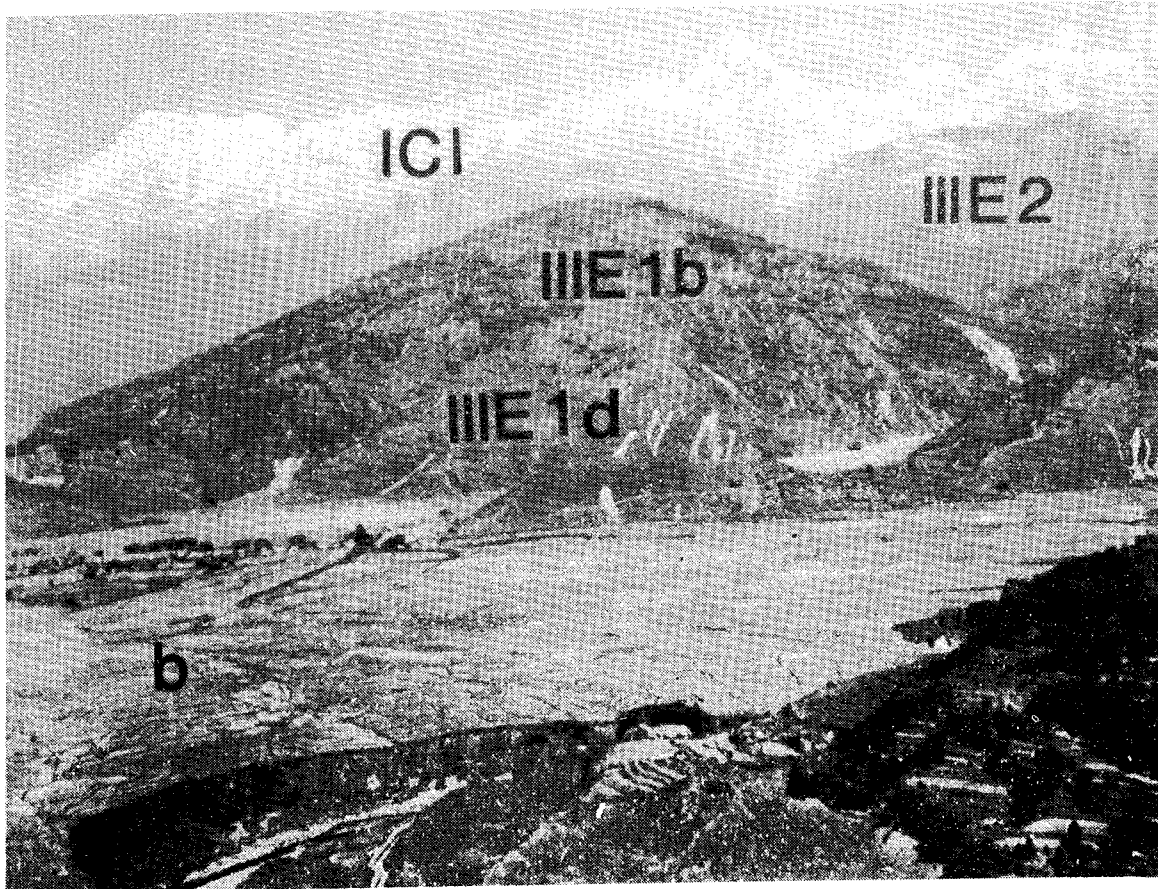
Sal forest is the vegetation here. These lands have high potential for agriculture and horticulture, especially when irrigated. Surface water has to be diverted into well protected drainageways otherwise it will cause gully erosion at the edges of the tars. Vegetative protection of terrace edges with strips of brush or trees is recommended.

IIIE6b. Pokhara Stony Tars, simal.

These are old, entrenched outwash plains of cemented, aggraded angular gravel and cobble size materials. Soils are very shallow to moderately deep, sandy loam with 20 to 40 percent gravel. Simal (*Salmalia malabarica* syn. *Bombax malabaricum*) is the principal tree here. Most of the area has been converted to grassland. Agricultural potential is low because of the shallow, stony and sandy soils. Fruit orchards might be possible here. No particular watershed management is needed except bank protection.

IIIE6c. Tar Scarps, sal.

These are steep, straight, stony slopes with very shallow to shallow, gravelly loam soils. The coarse fraction is 50 percent gravel and cobble. There is up to 10 percent rock outcrop. Sal forest is the vegetation. Lands are unsuitable for agriculture or grazing and should be forested or covered by brush. River control in the bottoms is needed in places where tars are endangered by undercutting.



2.38 Tar Land System (IIIE6) with Pokhara Stony Tars (b) shown. Background landtypes include the Rugged Upper Mountain Lands (IC1a, Annapurna I and Macchapuchhare); Chepe Moderately High Ridge Land System (IIIE2); Steep Dissected Lower Slopes (IIIE1d); and Moderately Steep Dip Slopes (IIIE1b). The numerous debris avalanches are in the dissected lower slopes.

IIIF. Kathmandu Region.

This region is the hub of Nepal. It includes the Kathmandu Valley, and the adjacent, upper Indrawati and Trisuli valleys. The landform is a high basin enclosed by low, rounded to high, straight hills. The river valleys have long, straight to concave slopes and broad, lowland terraces.

Summary of Region

Area 2252 sq Km

5 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush	1	2	3	4	5
5	70	25	24	20	32	15	9

Location: It covers parts of seven of the eight Bagmati Zone districts: Dhading, Nuwakot, Kathmandu, Bhaktapur, Kabhre, Lalitpur and Sindhu-palchok. Kathmandu is the principal city here. The region is in a major drainage divide and therefore occupies parts of the Narayani (via the Trisuli River), the Bagmati, and the Sun Kosi river systems.

Climate: Temperate monsoon. The mean annual precipitation is 1000 mm (Kirtipur) to 2200 mm (Dhading). Köppen's classification is subtropical monsoon to warm temperate rainy upland, with the maximum temperature before the monsoons (Cwag-Cwb_g).

Elevation/Relief: The elevation is 300 meters to 2800 meters. The high point is Pulchok, the lowest is on the Trisuli below Dhading. Relief is moderate to low.

Geology: The principal structure is a large syncline whose axis crosses through the southern part of the Kathmandu Valley in an east-west direction. The structure in the northern part of the region is a series of nappes. The materials are phyllites in nappes; and phyllites, metasandstone, limestone, gneisses and marble elsewhere. The Kathmandu Valley has thick lacustrine deposits.

Vegetation: The main forest trees are chilaune-chestnut (*Schima wallichii*/*Castanopsis indica*) in the valley; blue pine and oak (*Q. lanata*) on the valley peripheral hills; chir pine and chilaune on the river valley side slopes, and sal in the lowlands. The forest remains on very steep slopes, higher ridgeland, and in protected areas such as Nagarjun and Raniban. All other forests on flat lands have been replaced by agriculture. Most hill land is in brush. A "halo" pattern of land use is visible here, with towns and cultivated land in the center, encircled by a brush zone, a degraded forest zone, and then a forest zone in better condition.

People: The main groups in the hills are Tamangs. Newars dominate the Kathmandu Valley. Brahmin, Chhetri and occupational castes are scattered throughout. The population density is moderate in the country side to very high in urban areas, 75 people per square kilometer in Dhading district to 830 per square kilometer in Bhaktapur.

Bhaktapur has the highest density in Nepal based on area of land.

Based on numbers of people per hectare of crop, the density for these two districts reverses with 30 people per hectare in Dhading (highest in Nepal) to 8 per hectare in Bhaktapur (moderate class).

Divisions: The region has been divided into six land systems. These land systems differ by landform and elevation.

Comments: This is the "showcase" region of Nepal. Many short term visitors equate this region with Nepal as a whole. This results in a gross overestimate of the severity of watershed degradation. There are extensive areas of badly eroded slopes but this region also has, in the Kathmandu Valley, the largest block of good agricultural land in the Middle Mountain Zone. The region is the governmental, commercial and cultural center of Nepal. The heavy traffic to this area is one cause of its often poor watershed condition. Deforestation to meet the fuel needs of the many people is stripping the hills. The region presents a serious challenge to all watershed improvement activities in Nepal.

IIIF1. Kathmandu Valley.

This high basin is unique in the Middle Mountains. It sits like a broad bowl 1000 meters above the valleys of the southward flowing Indrawati-Sun Kosi rivers on the east and the Trisuli River on the west. It contains the largest single block of comparatively flat land north of the Terai in Nepal. This, coupled with its temperate climate, its strategic location on the routes between India and Tibet, and its protected isolation, has made the Kathmandu Valley historically the center of Nepal. It has been referred to as "Nepal", as though it were a separate political entity, by people throughout the hills for centuries.

Like many smaller valleys in the Middle Mountains, the Kathmandu Valley was the site of a Pleistocene lake. The lake here drained comparatively recently when the Bagmati River cut its gorge through the south rim of the valley. Three landtypes are recognized here.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIFla	15	30-60	25	20	55	mod.	1	2	2	3
IIIFlb	15	40-60	5	30	65	high	3-4	4	3	2-3
IIIFlc	70	1-5 70-100	T	90	10	high	1	1-5	1-5	1-5

IIIFla. Valley Rim, oak - chilaune - chir pine.

This landtype occupies the upper slopes of the encircling valley rim. It consists of broad ridge crests and the heads of intruding valleys. The slope gradients are 30 to 60 percent. The elevation is 1800 to 2200 meters. It is broken in pass areas on the east and west side of the valley. On the south it blends with the long, straight, higher relief ridges of the Mahabharat Lekh. The vegetation was originally dominated by a Schima wallichii/Pinus roxburghii community with oak (Q. lanata) and blue pine (P. wallichiana) on the higher parts. Much of the area has been converted to heavy brush cover by cutting and fire. The soils are deep silt loams to clay loams.

With its cover of brush and forest, the landtype is in excellent watershed condition. As lower forest lands become picked over for firewood, the pressure intensifies on the trees remaining here. Many chir pine have been thoroughly and roughly pruned of their lower branches. Some of the brush lands have been planted to chir pine. Where protected, the new stands are doing well. Small, scattered debris avalanches occur on the steeper slopes here.

The pressure will increase for firewood. The area cannot be completely closed. The only hope for maintaining these important watershed lands in their present condition is to devise a management plan for the area as a "firewood forest".

IIIFlb. Foot Slopes, chir pine - brush.

These are the critical lands in the Kathmandu Valley. They are the steep slopes between the forested uplands and the terraced valley floor. Agriculture appears to have enlarged its extent greatly over the last two decades. The soils are deep silt loams and clay loams. The slope gradients are 40 to 60 percent. The south facing slopes, those in the northern part of the valley are in the poorest condition. The material is deeply weathered quartzite. The substrata is a soft, clayey residue. The original forest cover has been changed to brush and terrace lands in most places.

Forest remains on the steeper, and protected slopes.

This landtype is in fair condition (Class 3) with some spots of poor and very poor lands. Examples of these latter conditions are on the south and western slopes of the Shivapuri ridge. Here are large, headward cutting gullies that fan out in their upper extent. Large landslides are common. Soft white substrata are exposed. Ridge crest trails have led to severe gully erosion. Roads here often fail along cut slopes in deep, cave-like landslides. Chemical weathering seems to be a factor in this type of erosion. A study of massive earth movements has been made in this unit in the north west part of the valley by a team sponsored by United Nations University. The report has not yet been published. This is a "sacrifice" zone, for the Kathmandu Valley. Where not terraced, it is often a degraded brush type. The slopes are picked clean for their firewood and are heavily grazed. The Department of Soil Conservation and Watershed Management has experiments with check dams in the Sankhu area to reduce severe gully erosion on steep, funnel-like drainages. Such structures when carefully located, designed and constructed, are effective erosion control devices for small areas.

Much remains to be learned about using check dams when deeply weathered substrata is exposed. Protection and tree and sod grass plantings are the best long term stabilizers on these soft, highly erosive materials.

IIIF1c. Valley Floor, cultivated lands.

This is the great expanse of multi level, lacustrine terraces that cover most of the basin and reach into coves along the edge of the valley. It is cut by a series of broad valleys. In the south for example, the exiting Bagmati River valley is a deep gorge between higher terraced lands.

Three sub-landtypes make up the landscape in the Kathmandu Valley: the terrace surfaces, the interterrace slopes, and the bottomlands. The surfaces have slope gradients of 1 to 5 percent with deep, silt loam and silty clay loam, stone-free soils. These are in broad tablelands, and narrow remnant surfaces. In places, incising streams have cut a finger-like pattern of deep gullies. These lands are in excellent hydrologic condition.

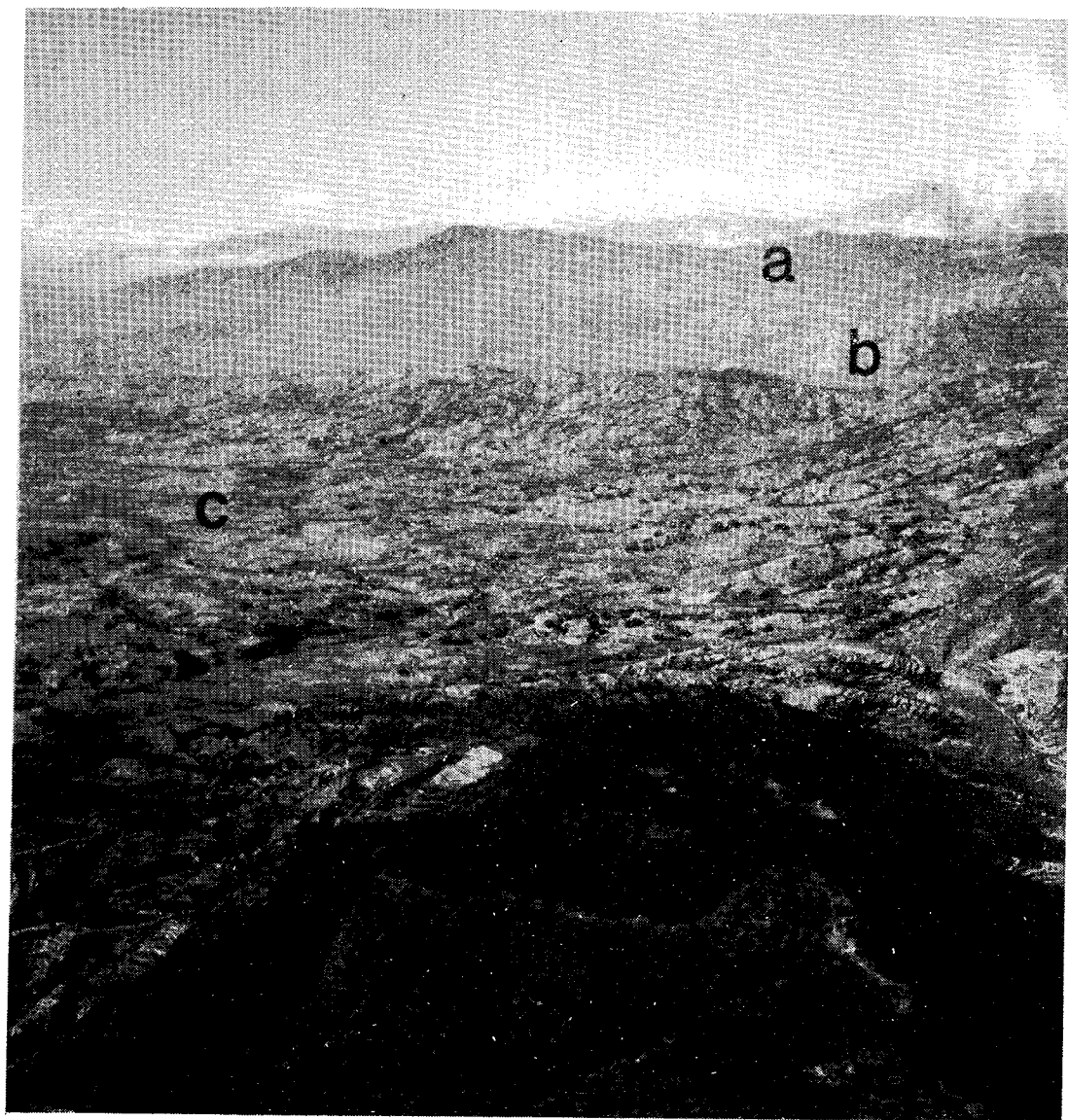
The terrace scarps are vertical bluffs in places. Most have slope gradients in the 60 to 100 percent range. Some are convex side slopes gentle enough for cultivation. The use made of this sublandtype is a function of slope gradients, height, and the width of the adjoining upper and lower terrace surfaces. Steep slopes in narrow valleys are usually forested. Alder and bamboo are some of the most common species. Moderately steep slopes are grass covered with discontinuous, narrow cultivated terraces; the gentle slopes are heavily cultivated, either in terraces or in manicured sloping (non-contoured) fields. The materials which are exposed in places are sediment layers ranging from coarse sands to varved clays. The soils are

colluvial mixtures with loamy sand to silt loam textures. Stone and gravels larger than a centimeter in diameter are uncommon. These scarp slopes are the most troublesome element in the Kathmandu Valley landscape where they are undercut by streams, roads, or where overgrazed. Some bare slopes are natural, e.g. those above the outward curve of streams. Most unstable spots however result from heavy grazing. Protection and tree planting are the most reasonable long range rehabilitation measures. Wattle barriers and check dams may be necessary in a few places to protect high value lands and structures. Stream embankments have been used to divert streams away from the toes of these slopes. This usually results in more intensive bank cutting elsewhere. Stream engineering is needed to properly lay out these structures.

The bottomlands are broad flats with shallow, meandering stream courses. They are intensively cultivated. The soils are deep, stone free silt and silty clay loams. There seems to be a continuous battle here to keep the rivers from bank cutting or flooding the fields. There are few houses in this unit so the threat to life is not great. The exception is on the outskirts of Kathmandu but generally a land use pattern has evolved that keeps damage low.

We have included the adjacent valleys reaching to Banepa, Dhulikhel, Panauti, and parts of the Rosi Khola drainage in this land system. This area is too small to justify a separate land system at our intensity of mapping. Here the Foot Slope unit (IIIF1b) is very similar to that in the Kathmandu Valley; the Valley Rim landtype (IIIF1a) is much reduced; the Valley Floor has more pronounced elements, the scarps are rounded, the bottomlands are narrower, and the terrace surfaces are steeper and narrower than those in the Kathmandu Valley.

As in the Kathmandu Valley, the foot slopes present the greatest challenge. These are completely deforested and gullies are common. Plantations have been made in a few spots. Protection and more tree planting are needed.



2.39 East end of the Kathmandu Valley (IIIF1). The landtypes in the valley are (a) Valley Rim, (b) Foot Slopes, and (c) the Valley Floor.

IIIF2. Indrawati Ridge and Valley Land System.

This is a series of ridges, valleys and basins lying to the east of the Kathmandu Valley. Its western edge is the rim of the Kathmandu Valley. The road to the Chinese border passes through this land system. Panchkhal valley is here. Land use is intensive in most parts of the land system. Forest remnants are on the steepest north-facing slopes. Three landtypes were described.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIF2a	25	70-100	10	10	80	mod.	3	4	4-5	3-5
IIIF2b	60	20-60	10	40	50	high	3-4	4	4	2-4
IIIF2c	15	2-5	0	90	10	high	1,2	1	1	1-4

IIIF2a. Upper Slopes, chilaune/chir pine.

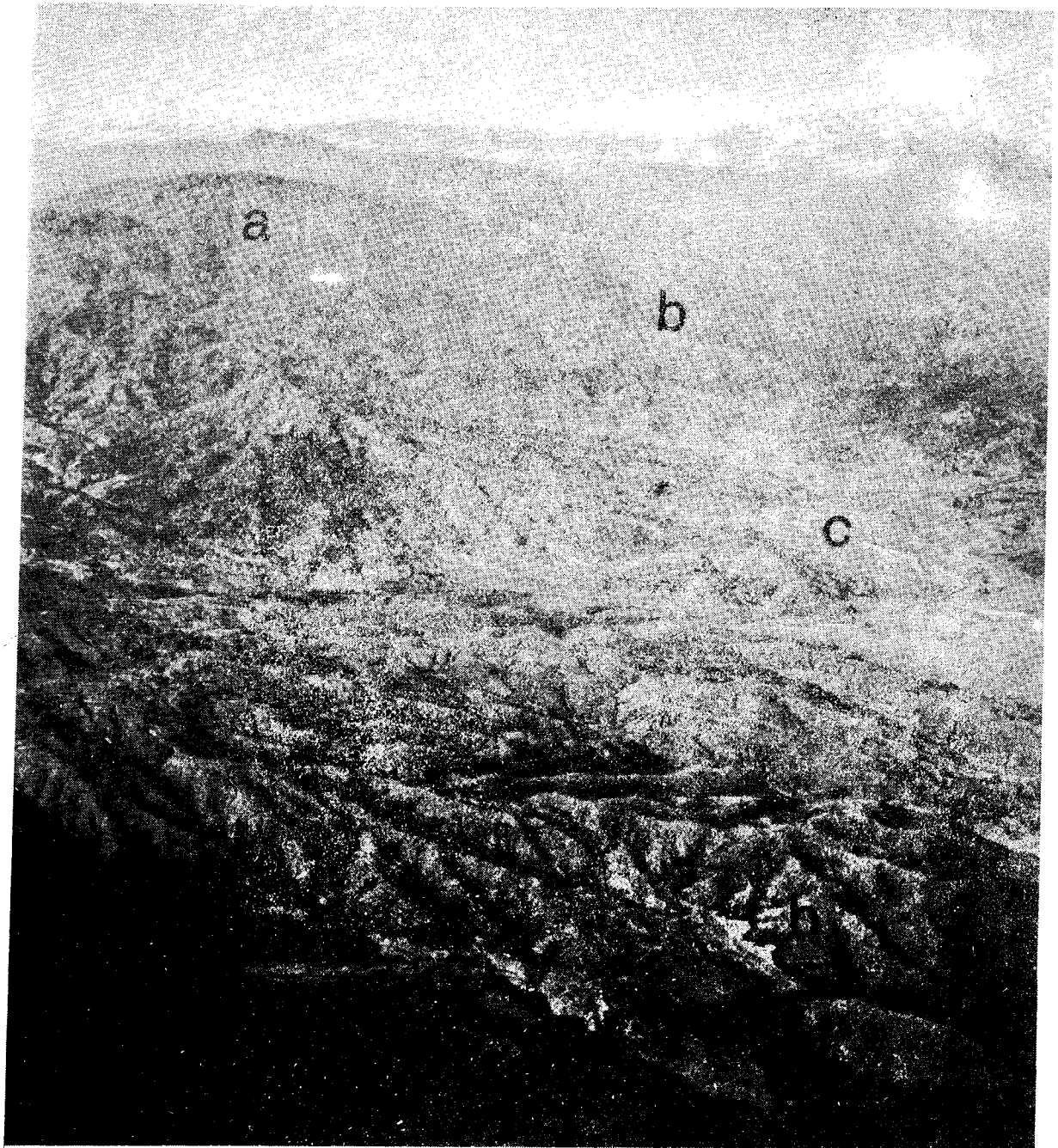
These are a series of narrow, steep ridges radiating from the circumference of the Kathmandu valley. The dominant aspects are east. The slope gradients are 70 to 100 percent. Soils are loams and silt loams with little coarse material. Rock outcrop is absent.

Agriculture covers about 10 percent of the area on ridge crests, headlands and more gentle side slopes. Terraces are often sloping at 10 to 30 percent. Shallow debris avalanches and gullied lands are evidence of excessive grazing and poor water control. The original chilaune-chir pine forest is reduced to remnant patches. Grazing control, reforestation and demonstration in terrace construction are needed.

IIIF2b. Secondary Ridges, sal - chilaune/chir pine.

These are the lower parts of the ridges described above. There is a main ridge with several, smaller secondary ridges. The relief is considerably lower than that in IIIF2a. The ridges are convex with steep side slopes. The original forest cover has been replaced by agriculture on the upper slopes and brush (with scattered trees) on the side slopes.

There are numerous small landslides on the side slopes. The stream channels carry heavy sediment loads. Low extensions of these ridges and toe slopes next to broad valley bottoms are severely eroded. Compacted, barren, reddish soils are on these slopes. Sal is heavily pruned for fodder here.



2.40 Indrawati Ridge and Valley Land System (IIIF2); Upper Slopes (a), Secondary Ridges (b), and Bottomlands (c).

It looks very difficult to get vegetation started on the eroded areas. Protection alone may in the long run result in improvements. Protected toe slopes have been successfully planted to trees. The bare red soils have lost their surface layers, requiring organic matter to be built up. It will take a lot of experimentation to devise rehabilitation methods. Grass and shrub seedlings should be tried.

IIIF2c. Bottomland, sal.

These are broad basin bottoms and wide river valley lands. In the upper Indrawati, a wide flood plain is in the middle of the bottomland. The stream meanders through the central part of the landtype. There are low terraces on the sides. The soils are deep, fine, sandy and silt loams. These are very productive farm lands. Flooding and stream bank erosion is a problem. Diversion structures and careful selection of land use next to the streams should be of value. There are some isolated lowspots of red soils that are eroded. Comments for IIIF2b apply here.

IIIF3. Chautara-Dolalghat.

This is a series of ridges and lower slopes laying adjacent to the upper Sun Kosi and in the "Y" between the Sun Kosi and the Indrawati. The section on the east side of the Indrawati is a fault block ridge which rises abruptly from Panchkhal valley floor. Three landtypes were noted.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIF3a	30	10-40	0	25	75	mod. high	2	3	3-4	2-4
IIIF3b	40	25-40	10	30	60	high	3	2	3	2-3
IIIF3c	30	40-70	50	10	40	low	3,4	4	5	3-4

IIIF3a. Upper Ridge Slopes, banmara (originally chir pine).

These are broad convex ridge crests and upper slopes with gradients of 10 to 40 percent. The soils are deep, reddish loams over clay loams. The forest cover has been replaced by banmara. About one-fourth of the landtype is agriculture land. There are a few gullies and small debris avalanches and abandoned terraces. The single biggest need is for afforestation. Check dams would be helpful in the gullies.

IIIF3b. Midslopes, chir pine - chilaune/chestnut.

These are dissected, somewhat benchy slopes below the smooth uplands. Agriculture covers most slopes where slope gradients are less than 40 percent. The vegetation in the ravines and on the steeper slopes is dominated by banmara with scattered chir pine. Small landslides are on the toe slopes of these ridges. Forest planting appears to be the overriding need.

IIIF3c. Toe Slopes, sal - chir pine.

These are 40 - 70 percent slopes in the lower part of the drainage. In places the Indrawati is at their base. The soils are deep, reddish brown (5 YR 4/4) clay loams. The tree cover here is open and most sal have been trimmed for fodder. There are spots of bare ground and land slips are present. The channels of side drainageways are in poor condition. This landtype is the lower wall of a canyon in the Dolalghat area. Not much can be done to improve this area. The poor channel condition originates on higher slopes. Many of the landslides are natural.



2.41 Landtypes:(a) Upper Ridge Slopes, (b) Midslopes, and (c) Toe Slopes of the Chautara-Dolalghat land system (IIIF3).

IIIF4. Helambu Ridgeland Land System.

We saw this land unit from the air only; no ground transects were made through it. It covers the upper drainage of the Tadi and Likhu Kholas in the Trisuli drainage, and the Helambu area in the Indrawati drainage. The rocks have been mapped as schists and quartzite. The vegetation is a chilaune - pine type with oak, Q. lanata, on the higher slopes.

Four landtypes were noted.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIF4a	30	60-80	50	10	40	mod.	2-4	4-5	3	3-5
IIIF4b	40	30-50	10	80	10	high	2	3	3	2-3
IIIF4c	20	70-100	20	10	70	low	3	4	4	5
IIIF4d	10	1-3	0	90	10	mod.	2	1	2	1,2

IIIF4a. Upper Valleys, oak - blue pine.

These are V-shaped valleys with long, straight, steep (60-80 percent) slopes. The vegetation is an oak (Q. lanata), blue pine type. Agriculture on the ridge crests and shoulders makes up about 10 percent of the landtype. There is a conspicuously high number of large landslides in the heads of secondary drainages here. Grazing and agriculture are associated with these landslides. More information is needed before recommendations can be made for treatment. The size of the landslides however suggest that little action can be taken directly to stabilize them.

IIIF4b. Broad Ridges, chilaune/chestnut.

These are convex mid and upper slopes of a group of ridges in the Helambu area. They are completely cultivated and are in good hydrologic condition as indicated by the sparsity of landslides and torrents.

IIIF4c. Lower Slopes, brush - chir pine.

These are straight, steep slopes between the convex higher slopes and the valley bottom. There is a pronounced slope break between the two landtypes. Little rock outcrop was noted. Slope gradients appear to be in the 70 to 100 percent range. These slopes are fairly uniform in their height and steepness. Many landslides are in this landtype.

Deforestation, grazing and run-off from above seem to be the causes of most erosion here. There is undoubtedly a high rate of natural erosion. Protection and tree planting are the most likely remedial measures.

IIIF4d. Bottomlands, cultivated - valley floor plain.

These are stream-side flats. They are over 90 percent cultivated. Some flooding and stream bank erosion was noted.

IIIF5. East Side Trisuli River Land System.

This is a series of moderate to low relief valleys lying between the rim of the Kathmandu Valley on the west and the Trisuli River on the east. The Kathmandu-Trisuli road crosses through this system. The ridges are rounded, convex in shape and have open valleys. They become sharper and straighter and the valleys narrower as one moves toward the higher ridges near Kathmandu. This is a heavily used land system as indicated by the extent of deforestation on the lower ridges, the large number of landslides, and the poor condition of many drainageways.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIF5a	15	75-100	60	15	25	mod.	2-3	2	2	4
IIIF5b	60	50-70	10	75	15	high	2-4	3	3-4	2
IIIF5c	25	5-10	10	80	10	high	1-2	1-2	2-3	1

IIIF5a. Upper Slopes, chilaune - chestnut.

These slopes reach up to the divide between the Trisuli and the Kathmandu catchments, and are the heads of secondary drainages. The rocks are biotite schists and phyllites. The vegetation is a fairly heavy stand of chilaune and chestnut. The soils are deep loam and clay loam. Rock outcrop is 3 to 5 percent. About 10 percent of the area with more gentle slopes is farmed. The ridges are not terraced. There are a few debris avalanches in the steeper canyons. The forest cover here is a remnant of a much broader coverage. Its proximity to Kathmandu make it a target for firewood collectors. Management of the forest, including fire control and grazing management, is needed. Alder planting along streams has shown success.

IIIF5b. Middle Slopes, chilaune - chestnut.

These are the agricultural lands of the system. Most slopes have been terraced. Small landslides are common. Trees are confined to the steep sided drainageways. The soils are moderately deep loams. The lower slopes here become steeper as they approach the foot of the ridge.

The principal need seems to be for improved terrace construction. Gully check dams have been tried in several places with marginal success.

IIIF5c. Bottomland, sal.

These include toe slopes, terraces and flood plains. The channel is rubbly in places with raw embankments. The soils are deep sandy loams. These lands appear to be quite productive.

Flooding and streambank erosion are problems. Sal and alder are the most common trees.



2.42 Upper Slopes (a) and Middle Slopes (b) of the East Side Trisuli River land system (IIIF5).

IIIF6. Dhading Ridge Land System.

This is a series of ridges, valleys and basins, all somewhat narrower and of higher relief than these units in IIIF5. This unit is bounded by Trisuli river in the east and south, the Thaple Khola on the west of this unit and the Katunje area lies in the north.

Land use is intensive in most parts of the land system and the population density is quite high.

Deeply dissected mountain slopes, steep to moderately sloping hill slopes and broad river valleys, are the characteristics of this land system.

Three land types are described here.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIF6a	25	70-100	85	5	10	low	2	2	2	4
IIIF6b	55	40-60	30	50	20	high	3-4	3	4	2-3
IIIF6c	20	5-10	15	75	10	high	2-3	1-2	2-3	1-2

IIIF6a. Upper High Ridges, chir pine.

These ridges are steep and covered with chir pine. Very few gullies are on the Upper High Ridges suggesting that the steep gradients have been a protection against excessive use. Slope gradient ranges from 70 to 100 percent. Soils are shallow to moderately deep loams. Outcrops of phyllites and quartzites are common. Agriculture is very limited on these ridges.

IIIF6b. Steep to Moderate Hill Slopes, chilaune - sal.

This is the largest landtype in this land system. About half the landtype is cultivated. Degraded sal forest, barren lands and over-grazed lands are in this landtype. The topography is very rugged. Soil is loam and sandy loam. Landslides are common in the degraded forests and barren lands. Very few gullies are present. Chilaune is the main vegetation type of this landtype. Improved grazing and tree planting would be beneficial.

IIIF6c. Bottomlands, sal.

Included here are valley floor, colluvial deposits in the foot slopes and several levels of river terraces. These river terraces are intensively cultivated. Slope gradients are less than 10 percent. Soils are deep loam. Floods and river cutting are the problems. Sal is the main vegetation type. Stream embankment and reinforcement measures should be tested here.

IIIG. Sun Kosi Region.

This is a very complex series of ridges and valleys in the central Sun Kosi drainage. It is similar to the Arun-Tamur Region (IIIH), but it is more intricately dissected, and has a wider variety of landforms. More detailed study, particularly in the southern part of the region, (the Okhaldhunga-Ramechhap Ridgeland land system) is needed to understand the processes responsible for some of the spectacular landslides here.

Summary of Region

Area 3357 sq Km

8 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush	1	2	3	4	5
13	36	51	11	62	14	13	0

Location: In the Janakpur Zone - the Ramechhap and Dolkha districts; in the Sagarmatha Zone - mainly the Okhaldhunga district. The principal towns are Jiri, Rameshnap and Okhaldhunga. The region is drained by the Sun Kosi whose major tributaries here are the Tamba, Khimu, Likhu and Dudh Kosi.

Topography: Elevation - 400 meters along the Sun Kosi, to about 3000 meters north of Jiri. The relief in any single drainage is moderate, up to 2000 meters.

Climate: Temperate monsoon. Mean annual precipitation ranges from 900 to 2300 millimeters a year. It is a combination of subtropical monsoon and warm temperate monsoon with the maximum temperatures before the rainy season (Cwag-Cwbq) according to the Köppen system of classification.

Geology: The materials are a mixture of schists, gneisses, augen gneisses, migmates and phyllites. Structurally it is a series of nappes which are separated by thrust faults.

Vegetation: This is dominantly a chilaune/chestnut type with chir pine, oak, rhododendron, and blue pine on the higher slopes. Banmara has invaded most of the region either as the main vegetation or as forest ground cover.

People: The main groups are Tamangs. Jirel are in the northern part, Brahmins, Chhetris and the occupational castes are scattered throughout. Newars occupy the bazaars. The population density is moderate and high at 65 to 111 per square kilometer. Based on cultivated land, the population per hectare of crop is 8 to 16. The 16 people per hectare of crop figure is for Dulkha, and is in the very high class.

Comments: There are large landslides on the south-facing slopes of the Sun Kosi canyon and its main tributary canyons. These apparently are the result of deforestation and heavy grazing. The lacustrine deposits in the Okhaldhunga-Dudh Kosi area are particularly sensitive. Most landslides are beyond rehabilitation by structural means. Reforestation, grazing management and proper disposal of excess irrigation waters are needed.

Two other particularly fragile sites should be noted. The toe slopes in secondary drainages have numerous small landslides. Large landflows, some only partially stabilized, in side valleys in the middle part of the region (IIIG2) could be activated by irrigation.

Divisions: The region was separated into three land systems in a north-south zonal pattern.

IIIG1. Jiri-Phaphlu Upland Valleys Land System.

This small land system consists of a series of north-south valleys mapped in two segments in the Tamba Kosi and Dudh Kosi drainages. The open, basin-like valleys are unique in eastern Nepal. The entrenchment of the main streams is minimal here. This land system is on the upper edge of the region with elevations of 2000 to 3000 meters. The forest type is blue pine (*P.wallichiana*) and oak (*Q. lanuginosa*) with a high percent of grasslands. The soils are noteworthy for this elevation in eastern Nepal because of their comparatively fine textures and reddish colors.

The three land types in the system were separated on the basis of slope position.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIG1a	15	2-10	5	70	25	high	1	1	1	1
IIIG1b	40	30-80	20	50	30	mod.	2	3	3	3
IIIG1c	45	30-50	50	20	30	mod.	2	2	3	2

IIIG1a. Bottomlands, cultivated.

These are depositional lands adjacent to shallowly (less than 2 meters) incised streams. The valleys bottoms slope at 3 to 5 percent toward the south. The soils are deep, very dark grayish brown, sandy loams. Where not cultivated the vegetation consists of sod-forming grasses. Stream embankments are used here to protect fields. Condition is excellent.

IIIG1b. Lower Slopes, oak/blue pine.

These are moderately steep, dissected lower ridge slopes. In places there are faceted toe slopes with rock outcrop. The soils are deep and have loam to loamy sand, with black to dark brown surface layers over dark yellowish brown, gravelly clay loam subsoils. The vegetation is a mixture of oak (Q. lanuginosa) and blue pine (P. wallichiana) with some open grass lands.

These are heavily used slopes as indicated by the high percent of terracing. Only the steepest areas are not cultivated. Non-cultivated areas are heavily grazed. A few gullies were noted in this landtype. Greatest conservation needs are control of grazing and check dam construction in a few key areas. Tree planting (with protection) on steep, banmara-covered slopes would be beneficial.

IIIG1c. Upper Ridge Slopes, oak/blue pine/rhododendron.

These are largely undissected slopes with 30 to 50 percent gradients. They cover the intervalley ridges and blend into higher slopes of the Transition Zone. The soils are deep, black to dark reddish brown, silt loams and loams over reddish brown to dark yellowish brown clay loam subsoils. The forest type is a combination of oak and pine in the lower part with rhododendron coming in on higher slopes. Banmara is an invader on steep, disturbed sites. Grasslands cover some ridge crests such as that at Jiri. The amount of cultivation is quite variable, from a patchy pattern of fields to complete coverage. Abandoned terraces were noted in the Sitri Khola watershed in this landtype.

This landtype is on the upper margin of cultivation. Care is needed to select suitable agricultural land. In spite of the heavy grazing, the ground cover of sod grasses is in good condition in most places. Check dams would be beneficial in a few gullies. Trees should be planted here.

IIIG2. Charikot Ridge and Valley Land System.

This complex land system is centered on the Tamba Kosi drainage but includes parts of the Likhu Khola, Sun Kosi and Chan Khola drainages. The land system is characterized by deep, steep-sided main valleys and broad, secondary valleys. The type reaches from 800 to about 3000 meters elevation. The vegetation is a fir/oak/chir pine type.

This land system was divided into two subsystems. There is a continuum between the upper, narrower valleys and the more open, lower downstream parts of this landtype. The two subsystems are: IIIG2-1 Upper Valley Subsystem (consisting of 3 landtypes), and IIIG2-2 Lower Valley Subsystem (consisting of 4 landtypes).

IIIG2-1. Upper Valley Subsystem (50% of Land System IIIG2).

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIG2a	15	60-80	10	30	60	low	2	4	3	4
IIIG2b	25	30-50	T	60	40	high	1	3	2	3
IIIG2c	10	40-70	20	10	70	low	2	2	3	2

IIIG2a. Steep Toe Slopes, sal/chilaune/chestnut.

These slopes are in contact with the main stream. Most are steep, truncated faces of lateral ridges. Near vertical-walled gorges are also present. The maximum relief is 300 meters. The soils are generally deep, very dark grayish brown, gravelly loams. High boulder and rock outcrop volume is common.

The slopes here range from complete forest cover to complete terrace cover. Most have a forest-brush mixture. Landslides, slumps and straight, raw-banked stream channels are common. Terraces are narrow and difficult to construct and maintain due to steep slopes, unstable soils and high boulder content. Terrace failures are common. Soil disturbance here result almost directly in stream sedimentation. Roads that must cross this landtype should be located to minimize their length through this landtype. The general management objective should be to keep all man-caused disturbance as small as possible. The gorges here are in a hydrologically sound condition enhanced by their high rock content.

IIIG2b. Midslopes, chilaune/chir pine.

Slope gradients at 20 to 40 percent, are less steep in the midslope position than in lower or upper slopes. These are broad, gently sloping to steeply sloping, undulating benches where cultivation is possible. Thick, rubbly, stabilized, landslide deposits cover much of this landtype.

Streams cross these slopes in broad swales. In places the benches are broken by gorges extending from the main river. The soils are usually deep, dark brown or very dark, grayish brown, sandy loam, loam or silt loams over brown, heavy sandy loams, gravelly and stony in places. Boulders litter the benchy surfaces. The forest types here are chir pine and chilaune. Although all aspects are represented, south facing slopes seem to have particularly droughtprone, stony, generally harsh environments.

This landtype is where the people live. The habitable benches may be continuous or broken. Watershed condition is excellent. The south facing slopes supporting chir pine have more rill and gully development than slopes with other aspects. The problems here are on adjacent landtypes, i.e. terracing is extended on to less stable, steep, lower slopes and on to the steep slopes of dissecting drainageways.

Excessive grazing and fuelwood collection on the upper slopes affect the people living here also.

IIIG2c. Upper Slopes, oak/blue pine.

These are largely undissected slopes above the midslope benches. In places they form the ridge crests. On higher slopes they reach to the Transition Zone (IIE2). The original cover was oak (Q. semecarpifolia) and blue pine (P. wallichiana). The soils are deep, dark brown sandy loams.

Although much of this landtype is occupied, it has an important support role as a source of fuelwood to communities on lower benches. It is heavily grazed and in places banmara forms a continuous ground cover. Gullies are present where use is especially heavy. Tree planting and grazing control are needed here.

IIIG2-2. Lower Valley (Secondary Canyon) Subsystem (50% of system)

The lower valley has secondary drainages which extend in an east-west direction at right angles to the main canyons. A similar land pattern exists here as in the upper valley: steep lower slopes, bench-like mid-slopes and rounded upper slopes. The differences are (i) total relief is usually less than 700 meters, but increases up to 1000 meters for the main canyon; (ii) and control of slope shape. Rock structure is important here while the main canyons have less structural control.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIG2d	10	60-90	30	20	50	low	2	4	4	4
IIIG2e	20	30-50	10	70	20	mod.	2	2	2	2
IIIG2f	15	60-90	50	20	30	low	2	4	3	4
IIIG2g	5	40-60	10	15	75	low	3	2	3	3

IIIG2d. Lower Slopes, sal - oak.

The lower reaches of the streams pass through gorges and very steep walled canyons. The upper valleys are more open, but the slopes are longer. In some side canyons there are deep, benchy, landflow deposits which have been dissected by streams. These are extremely sensitive sites. The slope gradients are over 60 percent. The soils are moderately deep to deep, gravelly loams.

The vegetation types are sal on lower slopes, chilaune/chestnut on mid-slopes and oak/rhododendron above. This is a very easily disturbed landtype. Where cultivated, or over-grazed, landslides and deep gullies are common. As with most steep land areas in contact with live streams, the less pressure the better.

IIIG2e. Midslopes, chilaune/chestnut.

These are undulating benches and ramp-like surfaces. North aspects tend to have step-like benches with steep interbench slopes. The soils are deep and have loam and sandy loam, with very dark, grayish brown to reddish brown surface layers over brown to reddish brown loam to clay loam subsoils. The natural forest types here are dominantly chestnut (Castanopsis indica) and chilaune, and chir pine on south aspects. Banmara is on most uncultivated, unforested slopes.

This landtype has most of the agricultural land in the system. About 40 percent of the steeper, north-facing slopes are cultivated also. The erosion problems occur with extension of cultivation on to the interbench and lower canyon slopes. The bench areas are generally stable. Small debris landslides are common on the lower margins of this landtype.

IIIG2f. Headlands, chilaune/chestnut/oak.

This landtype forms the upper canyon and head walls of drainageways. Slopes are over 60 percent. The soils are deep and have sandy loam or silt loam, with very dark, grayish brown surface layers over sandy loam subsoils. The forest type is dominantly chilaune/chestnut with oak (Q. lanata and Q. semecarpifolia) and rhododendron (R. arboreum) on the upper ridge slopes.

This is mostly a forest covered landtype in the heads of the valleys and brush covered (mainly banmara) on the ridge crests. Many landslides appear to be natural here. Encroachment by cultivation, and excessive grazing and forage collection, is increasing the number of landslides. This is a vital watershed unit. The forests here should be protected and enlarged. Afforestation opportunities are plentiful.

IIIG2g. Ridge Crests, chir pine/chilaune.

This small landtype forms the upper slopes and ridge crests. These are essentially steep, straight to convex slopes covered with scattered chir pine and chilaune and a nearly continuous cover of banmara. A few lines of cliffs are present. The soils are mostly deep, sandy loams.

This type has been heavily used for grazing and fuelwood collection. It is nearly totally deforested. The south aspects are a source of high runoff and mud deposits on the upper tier of farms on the mid-slope benches (IIIG2e). Although low contour furrows would probably be beneficial to check this runoff, protection of these slopes from overgrazing should be given first priority. The entire landtype is a potential afforestation site.



2.43 The Lower Valley Subsystem of the Charikot Ridge and Valley land system (IIIG2), showing the following landtypes: (d) Lower Slopes; (e) Midslopes; (f) Headlands (not well represented); and (g) Ridge Crests.

IIIG3. Okhaldhunga-Ramechhap Ridgeland Land System.

This is a ridge and valley system between the Dudh Kosi and the Chauri Khola, lying north of the Sun Kosi. The elevation is approximately 300 to 2300 meters. The streams are in a rectangular pattern, being controlled by major east-west faults. The natural forest group here is sal/chir pine/oak.

This is an intensively used area, as reflected to some extent in the abundance of landslides. No other land system equals this unit in the number of its large landslides. The climate here is conspicuously drier and warmer than it is in other systems in this region.

The six landtypes are keyed to slope aspect and position.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIG3a	15	60-100	20	5	75	mod.	3-4	4	4	5
IIIG3b	25	40-70	T	20	80	high	3	2	3	2-4
IIIG3c	25	70-120	T	10	90	low	4	4	4	5
IIIG3d	30	30-60	10	70	20	high	2	2	3	2
IIIG3e	T	3-5	T	90	10	mod.	2	1	1	1
IIIG3f	T	< 5	0	0	100*	low	1	1	1	0

* no permanent vegetation.

IIIG3a. Secondary Canyon Slopes, chir pine - sal.

As in other land systems in this region, the secondary canyons have steep to very steep rocky slopes. The dominant aspects are east-west. The vegetation is sal in the lower portions and chilaune and chir pine above. These are very rugged, faceted canyon faces. Rock outcrop may be 20 percent of the surface where the slope is directly undercut by the river. Stone content in the soils is high.

The slopes here are very variable - from rocky, truncated spurs to moderately steep, rock free, valley side slopes. The soils may be low to moderately deep. They tend to be reddish brown, clay loams. Stone is angular. Sheet and rill erosion was noted. Landslides were not numerous. The high rock and stone content here is protective but grazing pressure should be decreased. Silvicultural practices for hill sal forest should be developed and applied here. Terraces,



2.44 Okhaldhunga-Ramechhap Ridgeland land system (IIIG3).
Landtypes : (a) Secondary Canyon Slopes; (c) South-facing
Secondary Canyon Slopes; (d) North-facing Secondary
Canyon Slopes; and (e) Bench and Terrace Land are shown.

20 to 100 meters wide, occupy some canyon bottomland here. The rivers are entrenched 10 - 20 meters within these terraces.

IIIG3b. Sun Kosi Canyon Slopes.

This is made up of the south-facing slopes of the Sun Kosi valley. The lower slopes are dissected by a parallel series of small canyons that drain directly to the Sun Kosi. The slopes are straight to convex and are steep to very steep. The upper slopes are benchy and have low to moderate gradients. The soils are grayish brown to reddish brown, gravelly loams to gravelly, clay loams. The original forest type on the upper slopes was chir pine, but now only a few individuals and remnant pockets are present. The lower slopes support a sal type with additions of Mallotus philippinensis, Acacia catechu and Dalbergia sissoo. Much of this landtype has a continuous cover of banmara.

This is a warm, dry land type that receives high intensity storms. Landslides, rilling and splash erosion are present. Some large land flows are in the eastern part of this landtype. The higher terraced areas are stable. Excessive grazing pressure is the major problem as indicated by the prevalence of banmara. The forests in the upper part are destroyed. Reforestation is needed.

IIIG3c. South-facing Secondary Canyon Slopes, sal/chir pine.

The secondary valleys in this landtype are oriented in an east-west direction, parallel to the Sun Kosi. This landtype is the very steep, south-facing slopes of these valleys. These slopes have weakly developed benches in places. The soils are moderate to moderately deep, dark grayish brown, gravelly sandy loams. The vegetation is a sal and chir pine type. Bunch grasses and banmara cover most slopes.

There are some very large landslides in this landtype. A combination of phyllitic, steeply sloping bedrock, very steep slopes and near total deforestation, appears to be responsible for high landslide frequency. Intensive grazing and high intensity storms also contribute to this problem. Drainage bottoms below these slopes are choked with rubble from the landslides. Other than protection and reforestation, little can be done. The sediment production rate is high. Developments, i.e. buildings, canals, roads should be located so as not to be damaged by the landslides and not to increase the landslide hazard. A high flood hazard makes the bottomlands unsuitable for any structures.

IIIG3d. North-facing Secondary Canyon Slopes, sal/chilaune.

Slope gradients are 30 to 60 percent. These are benchy, undulating slopes with a steep toe slope. The internal drainage is shallowly incised. The soils are deep, reddish brown, clay loams. The vegetation type is sal on the lower slopes and chilaune above.

Most of these slopes are under cultivation. Continuous sal forests cover the steeper, stonier slopes near the main canyons. The bottomlands below this type, where not filled with rubble from landslides in IIIG3c, are intensively farmed. Occasional deep gullies in these bottoms suggest high erosion hazards. The steep but short toe slopes of this unit are brush covered and crossed by many landslides. Care must be taken to protect these slopes. The bulk of these north-facing slopes are very stable and in good condition. It was noted that a braided terrace system with sloping benches is used here. The inter-terrace slopes are not abrupt. The fields are sloping at 5 to 15 percent.

IIIG3e. Bench and Terrace Land, acacia - sal.

These are a series of sloping benches dissected by rubble-laden streams in vertical walled drainageways. Erosion on the steep margins of these benches is moderate. The surfaces of the benches are cultivated. These benches and associated floodplains reach northward along the main tributaries.

IIIG3f. Floodplains and Fans, no permanent vegetation.

These are broad, gravel plains that are flooded in the monsoon. Broad fans cover these plains at the mouths of entering streams.



2.45 Sun Kosi canyon in the Okhaldhunga-Ramechhap Ridgeland land system (IIIG3). Landtypes: (b) Sun Kosi Canyon Slopes; (e) Bench and Terrace Land; and (f) Floodplains and Fans, are shown.

IIIIH. Arun-Tamur Region.

The bulk of the region consists of the very broad main ridges separated by the broad valleys of the Arun and Tamur Rivers. These main ridges are redivided into numerous secondary ridges and valleys. The combination of rounded, convex midslopes and steep lower slopes gives the region a "spralling" appearance. The Ilam area is a land system mapped in this region.

Summary of Region

Area 5536 sq Km

14 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush	1	2	3	4	5
29	40	31	4	76	20	0	0

Location: Khotang and Bhojpur districts of the Sagarmatha Zone; Terathum, Sankhuwasabha, and Dhankuta districts of the Koshi Zone; and the Panchthar, and Ilam district of the Mechi Zone. There are several large towns here including Diktel, Chainpur, Taplejung, Dhankuta and Bhojpur. It is drained by the Arun, Tamur, Sun Kosi and their tributaries. These three larger rivers join here to form the Sapt Kosi and exit to the plain.

Elevation/Relief: The elevation is from 200 to 3000 meters. The dominant relief class is moderate.

Climate: Temperate monsoon, mean annual precipitation is from 800 to 2300 millimeters. Most stations here reported annual rainfall in the 1400 mm to 1700 mm range. The large canyons in the southern part of the region appear to be drier than the northern part. According to Köppen's system, this is warm temperate rainy upland and subtropical monsoon climate (Cwb/Cwa).

Geology: This is a series of faulted nappes forming thrust zones. The Mahabharat Lekh syncline is the southern border. The materials are schists and gneisses. Rock outcrop is uncommon here but there are a few rock-lined stretches in the canyons.

Vegetation: There is a zonal pattern going from tropical hill sal on the lower slopes and in the valleys; a midslope belt of chilaune (*Schima wallichii*), and chestnut (*Castanopsis indica* and *C. tribuloides*); then an upper slope and ridge top group consisting of *Rhododendron* sp, *Alnus nepalensis* and oak (*Q. semecarpifolia*). Much of the central zone has been converted to agriculture.

People: Rais and Limbus are the largest groups. Gurungs, Brahmins, Chhetris and occupational castes are scattered throughout the region. Newars are

in most of the towns. The population density is in the high category (80 - 150 people per square kilometer) for most of the districts. The exception is Sankhuwasabha district with 35 people per square kilometer. Based on numbers per hectare of crop, the range is from six people to 17 people per hectare, i.e. from moderate to very high. Khotang district has the highest density; Ilam and Dhankuta the lowest.

Comments: This large region is in remarkably good watershed condition. Its eroded areas include toe slopes, the large landslide areas in the Taplejung area, and the heads of drainageways south of Ilam. Detailed investigation of the long, south-facing slopes of the Tamur is needed as a basis for improving agricultural practices and watershed condition. These have some of the harshest sites in the region. As usual, grazing management of noncultivated lands and tree planting are needed.

Division: This region is mapped in two land systems - the larger main part of the region (90 percent), and the Ilam land system. This latter land system is separated from the main body of the region by the eastern end of the Mahabharat Lekh, Region IIIL.

IIIH1. Lower Sapt Kosi Basin Land System.

This system occupies the area between the Dudh Kosi and the eastern boundary of Nepal. Elevations are from 300 to 3000 meters. The geologic materials are schists and phyllites. The structure of this material is a combination of overlapping schuppen and a large autochthonous zone. The vegetation ranges from tropical hill sal, to rhododendron. Castanopsis and Schima are the most widespread tree genera.

This is the largest land system mapped in Nepal. The landtypes, and consequently land use and management problems are in a banded pattern strongly tied to slope position.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIH1a	20	70-120	35	10	55	low	2-3	4	4	5
IIIH1b	50	40-60	20	60	20	high	1-2	2	2	2
IIIH1c	20	70-110	50	20	30	low	1-2	3	2	3
IIIH1d	5	10-30	20	-	80	low	2	1	2	5
IIIH1e	5	20-40	20	50	30	mod.	2	2	3	2

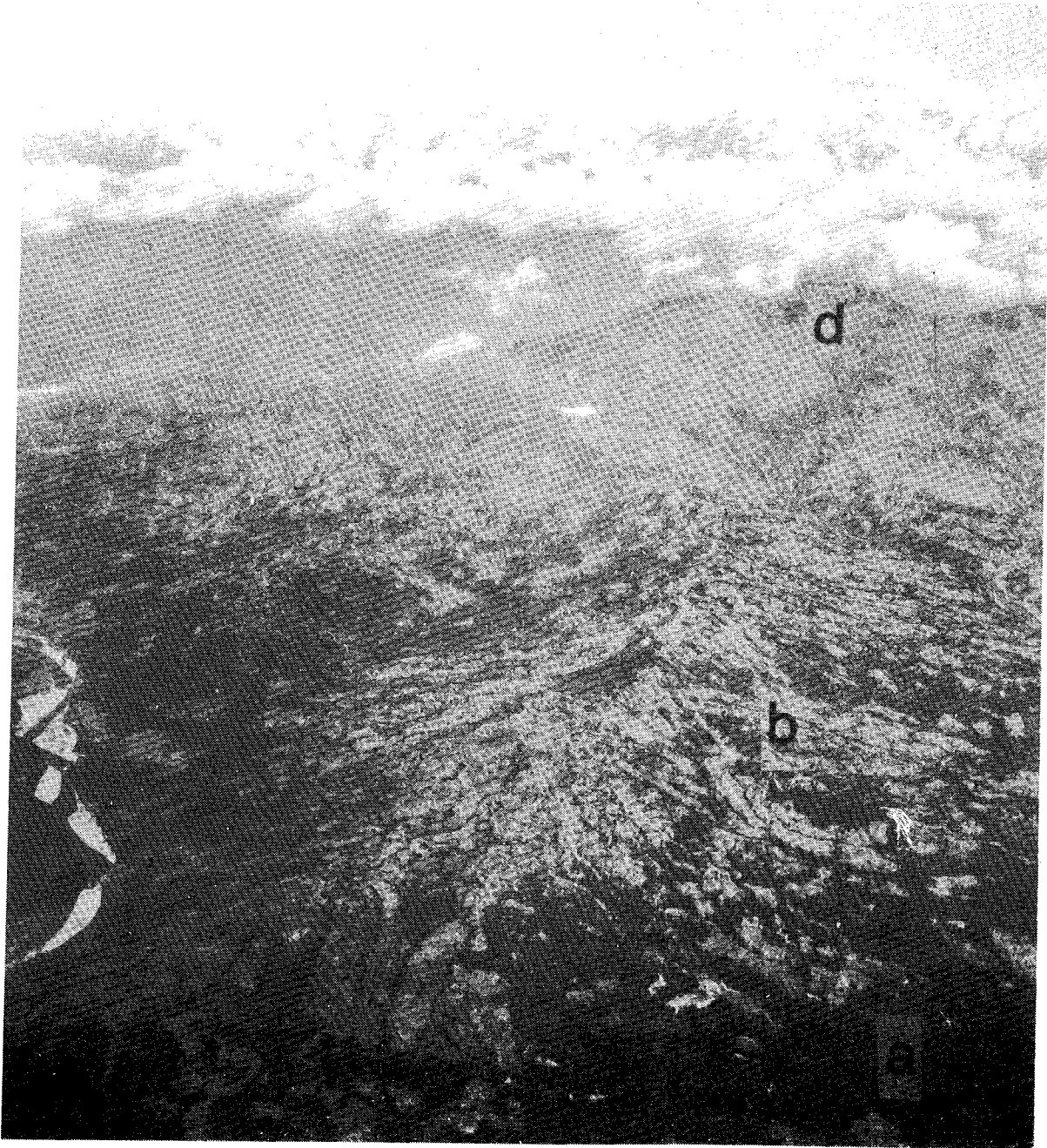
IIIH1a. Lower Main Canyon Slopes, sal.

These are mostly straight, truncated spur ridges. The slope gradients are steep to very steep and vary in height from 20 to 500 meters. The soil is gravelly sandy loam or loam, over grayish brown, gravelly loams or clay loams. Rock outcrop is about 2 percent. The vegetation is of the tropical hill sal forest type. Steep slopes, high temperatures, shallow soils and contact with streams makes this a very sensitive unit. Major needs are for grazing control and better management practices of the hill sal type. Roads here would encounter high landslide and flood hazards.

Stream terraces are small but critical inclusions in the landtype. Most are deeply entrenched. Flood plains are narrow and annually covered by monsoonal flows.



2.46 Tamur valley of the Lower Sapt Kosi Basin Land System (IIIH1). The Lower Main Canyon Slopes (a); Midslopes (b); and Secondary Canyons (c) landtypes are shown.



2.47 The Lower Sapt Kosi Basin Land System (IIIH1), showing landtypes (a) Lower Main Canyon Slopes; (b) Midslopes, and (d) Ridge Crests. Mt. Makalu is on the skyline.

IIIHlb. Midslopes, chilaune/chestnut.

This is the largest and by far the most important landtype. Most towns and agriculture are located here. The slopes are moderate to steep. Most are broad, straight to convex. All aspects are represented. The elevation is between about 400 and 2000 meters. Soils are deep and have very dark, greyish brown loam surface layers over grayish brown, loam to clay loam subsoils. This, the largest landtype, has 80% of the agricultural land in this system. Further divisions could be made on aspect.

The north facing slopes are consistently in class I watershed condition. Other aspects are in class 2 condition. Afforestation is needed near villages. Extension here should stress terrace construction. Some land slips are on steeper lower margins of units.

IIIHlc. Secondary Canyons and Headlands, sal - rhododendron.

These canyons extend in an east-west direction from the main rivers, generally with short, steep slopes in their lower part but enlarging near the main ridge to form very steep headwalls. Some benches are in the upper parts of the drainages. Elevations are 400 to 3000 meters. All aspects are present. The soil are deep, loam to loamy sand, very dark grayish brown over dark grayish brown gravelly loams. The forest types, as for the whole land system, are sal in the lower part, rhododendron and oak in the upper part and chilaune/chestnut between.

Most of this landtype is in good to excellent condition. Cultivation is being extended into the landtype leading to an increased erosion rate. Small debris slides, many originating in the cultivated lands above the canyon portion of this unit are also present. A few large landslides are in the steepest slopes of the headlands. Uncontrolled grazing is a major problem resulting in land slips and a nearly complete ground cover of banmara. Deforestation for fuelwood is causing the forest to recede on all fronts. The unit has many sites for reforestation. Road excavation here would cause landslides.

IIIHld. Ridge Crests, oak/rhododendron.

This landtype is on the top of the main north-south oriented ridges. These are narrow extensions of the Transition Zone (IIE2). The landscape is a rolling upland with slopes mostly less than 30 percent. Elevation is about 2800 - 3000 meters. Soils are deep with thin black, loam surface layers over yellowish brown loam subsoils. The vegetation is oak/rhododendron forest with large grass-covered openings. This landtype is used mostly for grazing. There is no agriculture or permanent settlement. The biggest problem is soil erosion where the sod has been broken along trails by excessive grazing.

IIIHle. East Slope Uplands, oak/rhododendron.

These are sparsely dissected, benchy, basin like areas mostly on the east sides of the main ridges. They are in contact with landtype (d) above. Slope gradients are generally less than 50 percent. The soils are deep with very dark, grayish brown loam surfaces over dark, grayish brown, clay loam subsoils. The forest types are oak and rhododendron.

This landtype is mostly under cultivation with grass and brush covering the upper slopes. Trees are in ravines and on the steep edges of the unit. Some deep gullies and abandoned terraces suggest more intensive past use than at present. The major problems come from excessive grazing. Check dams would be helpful in stabilizing headward cutting gullies. Slumping occurs here where deep excavations are made. Water is scarce in much of this unit. This landtype is quite stable but there is a definite need for afforestation.

IIIH2. Ilam Ridge Land System.

This is a comparatively small land system separated from the main body of the region by the eastern end of the Mahabharat Lekh range. Ilam, the principal hill town in southeastern Nepal, is in the system. This system differs from the larger system IIIH1 by having lower relief, a dominantly southern aspect, and less well developed secondary valleys. The pattern of landtypes in relation to ridges however, are similar to those in the large system. The population density is high. The principal groups are Limbu, Rai, Lepcha, Brahmin, Chhetri and occupational castes.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIH2a.	20	40-60	20	70	10	mod.	1	2	2	2
IIIH2b	40	10-50	10	65	25	mod.	2	2	2-3	1
IIIH2c	20	40-70	50	40	10	low	1	2	3	3
IIIH2d	20	50-100	50	30	20	low	3	3	4	4

IIIH2a. Upper Ridge Slopes, chilaune - bamboo.

These are coarsely dissected, broad ridge crests at 1400 to 2000 meters. Slope gradients are 20 to 50 percent. The soils are deep loams and silt loams over clay loam subsoils, mostly stone-free. The vegetation is chilaune and bamboo, with banmara the most common ground

cover. About half the unit is forested, but all of it is grazed. Watershed condition is excellent. The forest is being rapidly reduced. Afforestation and grass planting are needed.

IIIH2b. Midslopes, sal/castanopsis.

At elevations of 800 to 1600 meters, these midslopes are dissected by a coarse pattern of shallow drainageways. Slopes are 20 to 60 percent. The soils are mostly deep loams with less than 2 percent gravels and gravelly loam substrata. The vegetation is a mixture of tropical hill sal and chestnut (Castanopsis tribuloides). Watershed condition is good. Agriculture is the dominant land use. Forests occupy only about 20 percent of the area. Piping in the terraces was noted, and some terraces have failed. Instruction in terrace construction would probably be helpful.

IIIH2c. Lower Slopes Complex, chilaune - chestnut.

These are toe slopes of main ridges with terraces and bottomlands. The elevations is 300 to 800 meters. Slopes have 5 to 10 percent gradients at the bottoms and 40 to 70 percent on the sides slopes. The main soils are deep loams and sandy loams. There is a heavy brush ground cover. Watershed condition is excellent. Agriculture makes up less than half of the area. Special attention is needed to keep stream banks vegetated. Stream embankments and spurs may be beneficial. Potential for enlarged irrigation systems should be investigated. Alder does well here.

IIIH2d. Marginal Ridgeland, sal.

This is the dissected edge of a surface forming the Ilam uplands. It is a series of ridges and valleys at elevations of 300 to 1500 meters, with 45 to 80 percent slope gradients. The soils are variable, shallow to deep, loamy sand to loam, usually with 10 to 20 percent gravels. The vegetation is mostly sal forests. The land use is mixed, with about equal proportions of forest, agriculture and brushland.

This is generally in fair watershed condition but poor sites are also noted. Large landslides and gullies are on steeper slopes at the heads of streams. Over-grazing is a major problem. Grazing control and reforestation of brush lands are needed.

IIIL. Eastern Mahabharat Lekh Region.

This is the eastern third of the Mahabharat Lekh in Nepal. It is an elongated ridge which is cut through by the Sapt Kosi. The region consists basically of a single main ridge and secondary ridges extending from it. It is a heterogeneous region, varying greatly in height, width, and in the development and form of the secondary ridges.

Summary of Region

Area 3600 sq Km

8 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush	1	2	3	4	5
47	22	31	0	86	14	0	0

Location: From about Sindhuli Garhi to the eastern boundary of Nepal, covering parts of six districts: Sindhuli, Udaipur, Sunsari, Morang, Ilam and Jhapa.

It is drained by the Sun Kosi and Tamur on the north and various Terai-Siwalik streams of the south, including the Kankai, Trijuga, and Marin Kholas and the Kamala Nadi.

Climate: Temperate monsoon with 2000 to 2100 mm of mean annual precipitation. Although data is not available to confirm field observations, it would seem that the Mahabharat Lekh here is responsible for a rain-shadow effect on the Sun Kosi, lower Arun and Tamur River valleys. Köppen's classification is subtropical monsoon, with maximum temperature before the rainy period (Cwag).

Geology: The structure is synclinal. The materials are granites and gneisses in the central part and schists and sedimentary rocks on the flanks. The Mahabharat Lekh is a young ridge system, believed to have been uplifted during the Pliocene. Hashimoto (1977) said the rivers of eastern Nepal were diverted from their southerly course by the uplift of these ridges, creating the funnel river pattern that exits the mountain area as the Sapt Kosi.

Vegetation: Two major communities were observed here: chir pine/chilaune/chestnut in the western part of the region and sal/chilaune/chestnut in the east. Oaks are common along the high ridges and front slopes (Q. semecarpifolia, Q. lamellosa).

People: Limbu is the most common ethnic group in the eastern part of the region. Various subgroups of Chhetris are dominant in the western part. Newar, Brahmin and occupational castes are scattered throughout the region. The population density is moderate.

Comments: The Mahabharat Lekh has been a barrier between the Ganges Plains and the heavily populated eastern mountains of Nepal. The valleys on each side of, and reaching into the region have been populated for a considerable time. It is inevitable that the intensity of land use on the slopes of these ridges would increase. This is apparently occurring now. There seems to be an upward trend in erosion, as indicated by spots of abundant debris avalanche. Attention should be given to the effect of fields on steep (40% - 60%) slopes with coarse textured soils derived from granite and/or gneiss.

Banmara has been a vigorous invader on abandoned terraces and overgrazed land. This may be a good place to study various methods to control this plant.

Divisions: Two land systems were identified based on kind and degree of development of secondary ridges.

IIILL. Sindhuli Garhi Ridge Land System.

This is the western segment of the region. It is a fairly uniform system consisting of the single main ridge and lateral ridges and valleys extending at right angles to the axis of this ridge. Four landtypes were separated.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIILLa	30	10-20 60-90	60	20	20	mod.	2	4	3	1-4
IIILLb	20	70-90	50	10	40	mod.	3	3	4	4
IIILLc	30	10-50	40	20	40	mod.	2	3	3	1-4
IIILLd	20	50-90	30	20	50	mod.	2	2-4	3	2-4

IIILLa. North Slope Ridge and Canyons, chir pine - sal.

This is a series of steep, V-shape canyons that open at their lower extent to have narrow, steeply sloping bottomlands.

The elevation is 600 to 1500 meters. Slope gradients are 60 to 90 percent in the side slopes and 10 to 20 percent in the bottomland. The granitic rocks are in layers dipping at about 80 percent toward the south. The bottomlands have bouldery alluvium in their upper part. The soils are very dark grayish brown, gravelly sandy loams. They are moderately deep to deep. The vegetation is a sal type in the bottoms

and chir pine on the side slopes. Banmara is the most common ground cover. The side slopes are 80 to 100 percent forested.



2.48 Sindhuli Garhi Ridge Land System (IIILL), with landtypes (a) North Slope Ridge and Canyons; (b) Ridge Crest and Upper Canyons; and (c) Lower Ridge Slope Lands.

The bottoms are terraced, mostly irrigated fields. At the lower elevations the side slopes have a sal vegetation cover and reddish soils. There rilling, gullies and small landslides are common. Over grazing is responsible for this condition. Some debris avalanches are on the longer, south facing slopes. The northern aspects are in good condition.

The greatest need is for a community effort to control grazing on the warmer, sal zone slopes.

IIILlb. Ridge Crests and Upper Canyons, oak - chilaune.

This consists of the main ridge crest and the associated upper canyon slopes. The elevation is 1500 to 2800 meters. Slopes gradients are 70 to 90 percent. The parent materials are granitic rocks, in layers dipping toward the south at 25 to 30 percent. The soils are deep, very dark grayish brown, loamy sands. The vegetation is a mixture of chilaune on the northern aspects and the ridge crest, with chir pine and oak (*Q. lanata*)/rhododendron communities on the steep southern aspects. This area is predominantly forested but small fields occupy about 10 percent of the area.

The soils are very erosive because of coarse textures and weak structure. The sloping terraces here are unstable. Some landslides are associated with cultivation. Encroachment by agriculture into forested lands should be controlled.

IIILlc. Lower Ridge Slope Lands, chilaune - chir pine - sal.

This is a series of north-south canyons and bottomlands reaching to the south margin of the Mahabharat Lekh. The elevation is 600 to 1200 meters. The aspects are dominantly south. The soil has deep, very dark grayish brown, sandy loam and loam textures. Reddish loam soils are on the basal slopes. The vegetation is considerably heavier here than in the more northern landtypes described above. The forest types are chilaune/chir pine with sal on the lower slopes. About 20 percent of the unit is cultivated.

This landtype is in good hydrologic condition and has few landslide problems. Agricultural encroachment into forest lands appears to be occurring at a rapid rate.

IIILld. Sun Kosi Canyon Slopes, sal - chir pine - banmara.

This landtype is dominated by the long slopes of the Sun Kosi canyon. The elevation is 400 to 1500 meters. The slope gradients are 50 to 90 percent. The soils are gravelly loamy sands and sandy loams. Most are moderately deep. The vegetation is a sal type much of which has been converted to brush. The area is heavily grazed.

There are many long debris avalanches caused by deforestation in combination with overgrazing. We could not visit this area on the ground.

IIIL2. Far Eastern Mahabharat Lekh Land System.

This is the main Mahabharat Lekh ridge and associated lateral ridges on the east side of the Sapt Kosi. It is composed of three landtypes.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIL2a	50	40-80	40	20	40	mod.	2,3	1-3	2	1-3
IIIL2b	30	10-30	50	20	30	low	2	2	1-2	2-3
IIIL2c	20	30-50 (N) 70-110 (S)	70	T	30	low	2	3	4	5

IIIL2a. North Slope Ridgeland, chilaune - chestnut - alder - rhododendron.

This landtype has a dense pattern of north-south oriented ridges and valleys at 300 to 1600 meters elevation, with 40 to 80 percent slope gradients. The soils are very dark, grayish brown, heavy loam to gravelly sandy loam. Lands are in good and fair condition. The forest is being severely reduced by agricultural encroachment. Unterraced fields on moderately coarse soils are causing soils loss on slopes too steep for cultivation. Improved terrace construction methods and protection of remnant forest stands are needed.

IIIL2b. Bench and Basinlands, oak - rhododendron - grass meadows.

These bench and basinlands are at 1300 to 2000 meters. They have 10 to 30 percent slope gradients. The landform is a series of upland surfaces at the foot of the main ridge and extending along the crests of lateral ridges. The soils are deep loams over clay loams, mostly stone free. The vegetation is a mixture of oak (Q. lamellosa), rhododendron and grass meadows. The land type is used intensively for grazing, leading to development of deep gullies in a few places. Check dams would be useful and grazing management is needed.

IIIL2c. Main Ridge Crest, oak - rhododendron/chilaune/chestnut.

These asymmetrical ridge crests at 1500 to 3000 meters elevation have 30 to 50 percent slope gradients on the north aspect and 70 to 110 percent gradients on the south aspects. The soils are moderately deep to deep, sandy loam. There is gravelly loamy sand on some southern aspects at lower elevations. Rock outcrop is 2 to 5 percent on the south facing slopes. Oaks here are Q. semecarpifolia, Q. lamellosa

at lower elevations. Numerous landslides were observed in this landtype south of Durhan. Improved agricultural practices, especially erosion control on sloping fields is needed. Protection of headlands of streams from agricultural encroachment is needed.

IIIM. Central Mahabharat Lekh Region.

This is a complex system of high ridges, basins and canyons. It is the widest part of the four Mahabharat Lekh regions that together reach the length of the kingdom.

Summary of Region

Area 2847 sq Km

7 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush	1	2	3	4	5
21	28	51	0	66	34	0	0

Location: It is located south of the Kathmandu Valley and includes parts of four districts: Dhading, Chitwan, Makwanpur and Janakpur. It is part of the Bagmati, Rapti and Trisuli drainages.

Climate: Temperate monsoon with 2000 to 2500 mm of annual precipitation. The climate has been classified using Köppen's method as a combination of warm temperate rainy upland and subtropical monsoon with the maximum temperature before monsoon (Cwb_g and Cwag).

Elevation/Relief: The elevational range is from 300 at the confluence of the Seti and Trisuli Rivers to almost 3000 meters on Phulchok Danda. Relief on individual slopes is moderate.

Geology: The structure is the typical, east-west trending syncline of the Mahabharat Lekh. The rock types include granite, sandstone, mica schists, quartzite, gneisses, phyllites and limestones. The northwest-southeast trending synclines are separated by minor anticlines and cut transversely by a series of faults. The main boundary thrust fault marks the southern edge of the region.

Vegetation: The vegetation is a mixture of chir pine/chilaune/chestnut/sal forest types with the oaks (Q. semecarpifolia, Q. lamellosa and Q. lanata) on the ridges above 1800 meters. The river valleys reaching into the region from the south support sal, Terminalia sp, sissoo, and khair.

People: The people are mostly in the Tamang, Gurung and Chepang ethnic groups. Brahmins, Chhetris and occupational castes are scattered throughout the region. Population densities are in the moderate class, i.e. about 75 people per square kilometer. Based on crops, the population density is in the moderate class also at 5-8 people per hectare of crops.

Comments: The mountains of this region have served as a barrier to invasion of Kathmandu Valley for centuries. The river valleys have been intensively used. The proximity of Kathmandu has contributed to the excessive use of

many of the high mountain slopes. Deep, large landslides were noted on the steep, north facing slopes in this region. A "hotspot", an area of severely degraded watershed condition, was noted in the lower Bagmati drainage.

Division: Two land systems were identified here. Further study would undoubtedly reveal significant additional land systems.

IIIM1. Mahabharat Lekh Highland Land System.

This is the larger and higher of the two systems. It is composed of the ridges, basins and slopes along the main axis of the Mahabharat Lekh range in central Nepal. Four landtypes are recognized within the land system.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIM1a	30	40-120	20	5	75	mod.	1-3	5	4	3
IIIM1b	10	10-20 basin	20	50	30	mod.	2	1-5	1-3	1-5
IIIM1c	60	60-110	25	35	40	mod.	2-4	4	3	3-4
IIIM1d	T	3-20	10	80	10	high	2	1	3	1,3

IIIM1a. Main Ridge Crests, oak/rhododendron/chilaune.

These steep, assymetrical, upper ridge slopes and ridge crests are controlled by their geologic structure. Most are straight long slopes with 40 to 120 percent slope gradients. The elevations is from 1500 to 2700 meters. The soils are shallow, sandy loams and loamy sands on convex positions; deeper loams and sandy loams are in places of accumulation, especially on ridge shoulders and benches on north slopes. The vegetation is oak (*Q. lamellosa*, *Q. semecarpifolia*) with rhododendron and small spots of hemlock on upper slopes and chilaune on lower slopes. Heavy brush covers up to 90 percent on some north facing slopes. Watershed condition is excellent in most places, but large landslides, torrents and gullies are common on north facing slopes that have been deforested. There is a little agriculture on some benches, noses and secondary ridge crests on the north sides of main ridges. Protection from fires, over grazing and improper water disposal are needed. Many large landslides here are beyond mechanical



2.49 Mahabharat Lekh Highland Land System (IIIM1) showing landtypes (a) Main Ridge Crests; (c) Secondary Ridges; and (d) Valley Bottoms.

stabilization methods. Road construction is responsible for long, unstable, fill slopes and landslides in cutslopes. Detailed study is needed for future road design and location. Use of fires to promote grass regeneration should be discouraged. The brushlands could be planted to trees.

IIIMlb. Kulekhani Basin and Canyonland, chilaune/chir pine/oak.

This is a dissected basin with isolated benches. It is surrounded by higher slopes of the Main Ridge Crest landtype. The elevation is from 1500 to 1700 meters. The slope gradients are 10 to 20 percent in the basins and 60 to 150 percent on canyon slopes. Soils are deep, sandy loams to loams in the basins and on the bench surfaces. Shallow to moderately deep, gravelly loams are on the canyon slopes. The natural vegetation is a mixture of chilaune/chir pine types with oak (*Q. lanata*) and blue pine on side slopes. Most of the basins and benches are cultivated. The canyon slopes are in brush or open forests. This complex, comparatively small landtype presents a pattern of some of the most stable agricultural land and some of the most landslide-prone canyon slopes in this land system. Because of the extreme sensitivity of canyon slopes, control of water on side slopes and minimum road construction are needed. Afforestation in the basin should be increased. The future reservoir planned for the canyon here will probably cause landslides at the waterline.

IIIMlc. Secondary Ridges, oak/chilaune - sal.

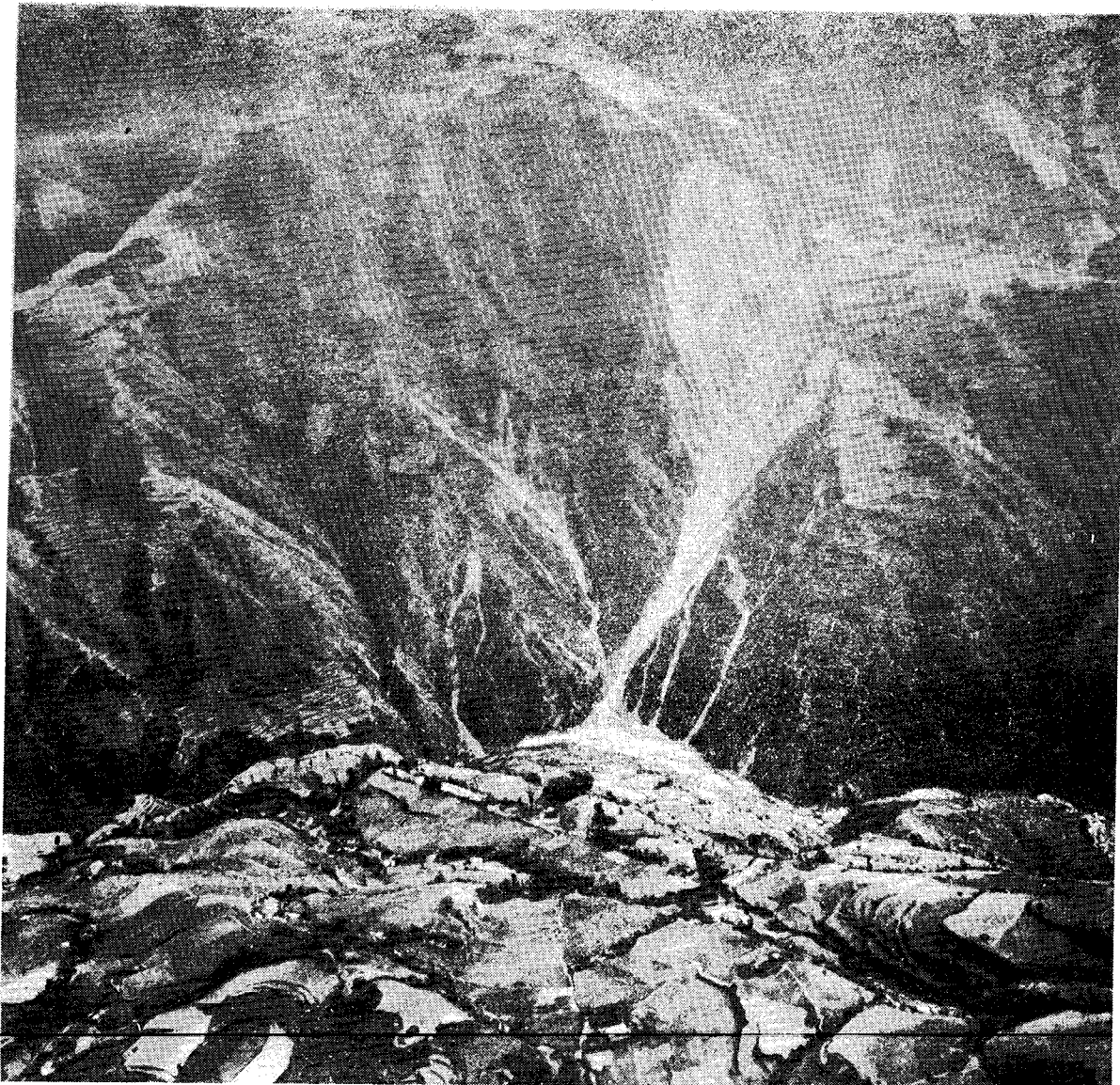
This unit is composed of broad secondary ridges forming the foot slopes to the Main Ridge Crest landtype (IIIMla). The elevations are from 600 to 1800 meters and the slope gradients are 60 to 110 percent. The soils are loamy sands and sandy loams, shallow to moderately deep. The vegetation is a mixture of oak/chilaune at upper elevations, and sal/chilaune at lower elevations with chir pine. Watershed condition is good to fair as indicated by the lack of landslides. Agriculture covers nearly half of these slopes. Forests cover 10 to 20 percent of the landtype in a belt of steep toe slopes at the base of the unit and on upper canyon slopes. Brush is on the remaining land.

A variation on this landtype is to the east of the Bagmati river. The main, higher, east-west ridge block is less clear here. The dissection is more intense, the canyons and ridge tops are narrower and the slopes are steeper than in the main body of the landtype. Agriculture makes up about 10 percent of the area, forest cover is about the same. Large landslides indicate the poorer watershed condition here. Protection and planting of forests, grazing control and structures in vicinity of roads are needed. The landslides are mostly too large for meaningful rehabilitation practices. Some can be linked to cultivation in unstable landscapes, suggesting a need for careful study before agricultural expansion.

IIIMld. Valley Bottoms, sal - acacia.

These are narrow terraces and flood plains. The elevation is 400 to

1000 meters and the slopes have 3 to 20 percent gradients. The soils are mixed, mostly deep, stony sandy loams and loamy sands with shallow soils on toe slopes. The vegetation is a mixture of sal and khair with Terminalia spp. This is a small but key landtype. It is too narrow for extensive agriculture. The bottomlands are nearly fully occupied by flood plains. The forested lower slopes of the adjacent landtype (IIIMlc) are generally in good condition giving protection to this unit. In this valley bottom, little forest is left and most stream channels are unstable due to periodic floods. Fans from side slopes cover agriculture lands in places. Development in flood plains should be discouraged or carefully located and planned.



2.50 Landslides in Secondary Ridges landtype (IIIMlc) in the lower Bagmati drainage.

IIIM2. Trisuli Khola Ridgeland Land System.

This land system is a series of ridges and canyons in the northwest quarter of the region. The bulk of the land system is drained by the Trisuli river. Three ecological land units are recognized within the land system on the basis of proximity to the principal drainageways.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIM2a	50	40-120	20	5	75	mod. high	2-3	4	4	3-4
IIIM2b	10	0-10	10	70	20	high	1,2	1-5	1	1-5
IIIM2c	40	40-70	40	20	40	mod.	2-3	3	3	2-4

IIIM2a. Trisuli-Marsyangdi Canyon Slopes, sal/chilaune/brush/chir pine.

These are high, long fluted slopes in the lower Trisuli-Seti river canyons and their major tributary canyons. The elevations are between 250 to 2000 meters. The slopes have 40 to 120 percent gradients. The soils are deep, sandy loams to clay loams, (gravelly and stony in about 50 percent of the landtype). The vegetation is a sal/chilaune forest type with heavy brush cover on north aspects. It is more open on south facing slopes. In other areas were noted Adina sp, Terminalia spx, Lagerstroemia sp. Chir pine is on ridge crests. The unit is dominantly forested and covered by brush. Much of the area is grazed. Minor amounts of agriculture (5%) using sloping fields on shoulders and benches are present. A few torrent-like secondary channels are present. Watershed condition is generally good, but high south facing slopes are rilled and gullied in spots. Expansion of agriculture onto steep slopes should be curtailed. Road construction and maintenance is a major sediment producer here. Some south facing slopes are severely over grazed; this has led to many landslides on the part of this landtype south of the Marsyangdi river.

IIIM2b. Trisuli-Marsyangdi Bottomland Complex, sal/khair.

This is a nearly continuous series of benches and terraces with a vertical-walled, meandering inner gorge enclosing the rivers. A narrow, stream side flood plain is present in places. The elevation is from 150 to 400 meters. Slope gradients are generally less than 10 percent on the terrace and bench surfaces but very steep (70-120 percent) in inter-bench slopes. The soils are deep, sandy loam to clay loams, mostly stone free. The vegetation is a sal forest type

with khair and siris (*Albizia* sp). The unit is almost entirely cultivated except on inter-bench slopes, gorge walls and streambanks. Watershed condition is good to excellent. Some cobbly fans are overgrazed.

IIIM2c. Ridge and Valley Lands, sal - chilaune/chir pine.

Situated at elevations of 400 to 1500 meters, this maturely dissected ridge system with V-shaped valleys has 40 to 70 percent slope gradients. The soils are shallow to moderately deep sandy loams. Sal is on lower slopes; chilaune with chestnut and chir pine are on higher slopes. This is a very complex unit. There is a general pattern of use according to slope position. Most lower slopes are forested. Middle and upper slopes are cultivated. Some valleys are broad enough to permit cultivation. Watershed condition is fair to good. Debris avalanches, poor stream channel condition and large areas of brush are indications of degraded condition. Afforestation and stream embankments are probably the most needed works.

IIIN. Western Mahabharat Lekh Region.

This region occupies a strip of mountains along the axis of the Mahabharat Lekh reaching from the Karnali River in the west to the Narayani River in the east. It is over 300 kilometers in length. The landscapes vary from a single ridge to complex mountain-basin systems.

Summary of Region

Area 2422 sq Km

5 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush	1	2	3	4	5
31	27	42	7	44	49	0	0

Location: The region crosses through the Seti Bheri, Rapti and Lumbini Zones. The largest districts are Palpa and Surkhet. Tansen is the largest town and the Tinau Khola is the largest stream originating in the region.

Topography/Relief: Elevation is 600 to 2200 meters. Relief is moderate and low. Elevation and relief increase from east to west.

Climate: Temperate monsoon with mean annual precipitation between 1200 and 2000 millimeters. Köppen's classification is warm temperate rainy upland and subtropical monsoon with the maximum temperature before the rainy season. (Cwb_g/Cw_{ag}).

Geology: The basic synclinal structure of the Mahabharat Lekh is visible in canyons here. The materials have been mapped as muscovite-biotite garnet schist with numerous thick layers of dolomite. An area of sedimentary rocks has been mapped in the vicinity of Tansen. Fault lines are mapped parallel to the region's north and south boundaries. Several faults have also been noted.

Vegetation: Chilaune/chestnut is the most widespread forest type. Sal is on lower slopes; chir pine dominates many south facing slopes, and oaks (*Q. lamellosa* and *Q. semecarpifolia*) with rhododendron are on higher slopes and ridge tops. Brush and grass have replaced most of the forests.

People: Main groups are Magar, Brahmin, Chhetri and occupational castes with Newars in the bazaar towns. The population density is moderate except in the Tansen area where it is high. Based on cropland, the density is high throughout the region.

Comments: This is the most intensively used part of the Mahabharat Lekh. Grazing management and afforestation are the most pressing needs.

Divisions: The region is divided into four land systems based on geomorphology and related stratigraphy.

IIIN1. Mahabharat Lekh Ridge Land System.

This is a narrow ridge system (less than 5 Km wide in places) on the main axis of the Mahabharat Lekh. It consists mainly of a single main ridge with weakly developed secondary ridges. It forms the front of the middle mountains for about one-third of the length of the country. This land system nearly blends with adjacent ridges north of the Mahabharat Lekh in its western half. The elevational range is 900 to 2200 meters. The principal materials here are schists and coarse textured quartzites.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIN1a	70	25-60top 80-120 sides	30	30	40	Not available	2-3	3	4	3-4
IIIN1b	20	120	60	5	35		2	5	5	5
IIIN1c	10	0-10	-	20	80W		2	1	4	4

IIIN1a. Rounded Upper Ridge Slopes, oak/rhododendron.

These steep upper slopes have shallow to moderately deep, loamy sandy and sandy loam soils. Stone content is as much as 40 percent. The vegetation is oak (*Q. semecarpifolia*) and rhododendron on the higher slopes, with chir pine on lower slopes. The landtype is intensively grazed. About one third of it is under cultivation. Nearly half the unit is brushland. Landslides, mainly small debris avalanches, are common. Trailing is intensive in spots. Some untterraced fields were noted.

The major needs are for grazing management, improved terrace construction and afforestation. Check dams would be helpful on some of the less steep slopes.

IIIN1b.

These slopes are below those described in IIIN1a above. They are very steep and have both north and south aspects. Some cliffs are present. The soils are shallow, loamy sands to sandy loams. The vegetation is mostly forest with sal, *Adina* sp and *Albizia* sp as the major trees. The land is grazed but has less than 10 percent agriculture. Many

natural landslides were noted here. The landtype is valuable watershed land. The slopes are extremely sensitive. Protection should be the primary management objective here.

IIIN1c. Bottomlands, riverine forest.

These are rocky, rubble-choked drainage channels with discontinuous blocks of cultivated, terrace land. The soils are sands and loamy sands. The vegetation consists of sal with khair and sissoo.

The terraces, mainly at the confluences of streams, have a few villages. The lands are cultivated.

IIIN2. Tansen Valley and Ridgeland Land System.

These are the network of ridges and the large valley in the Tansen area. The elevation range is 600 meters to 1600 meters. The relief is moderate to low. The materials are sandstone, shales, lacustrine deposits and schists.

Land System Summary

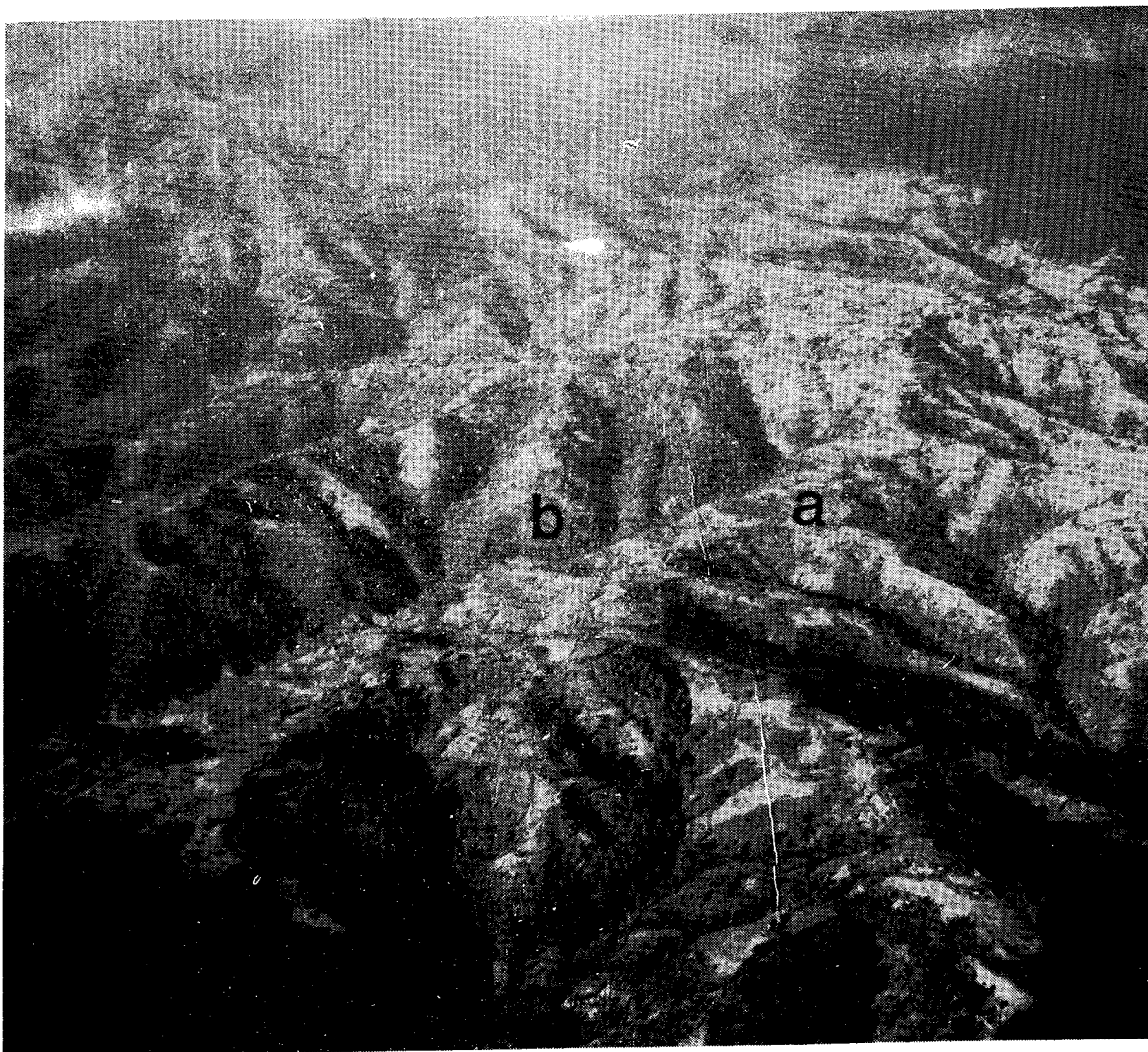
Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIN2a	60	30-80	5	60	20B/ 15G*	mod.	3	3-4	3-4	3-4
IIIN2b	20	100	35	10	30B/ 25G	mod.	2,3	4	5	5
IIIN2c	20	15-30	5	60	20B/ 15G	high	2	3	3	3

* G = grass land.

IIIN2a. Upper Convex Slopes, sal/chilaune.

This covers the upper slopes and ridge crests of convex ridges. The soils tend to be moderately deep, reddish (5 YR), gravelly loams and clay loams. The vegetation is a subtropical mixed broadleaf forest with sal as the principal tree. The forest cover is much reduced. Most trees are heavily lopped for fodder. Much of the area has been converted into terraced fields. Grazing appears to be heavy although the ground forage production is very low.

Land slips, gullies and large land slides are scattered over the area. Forest planting, gully control, terrace improvement and grazing management are needed.



2.51 Ridgeland south of Tansen, land system (IIIN2); landtypes (a) Upper Convex Slopes; and (b) Steep Lower Slopes.

IIIN2b. Steep Lower Slopes and River Bottomlands, sal.

These lower, very steep (70% to over 100%) stream valley slopes are below the convex upper slopes described in IIIN2a above. The soils are moderately deep loams and sandy loams with 20 to 40 percent gravels. The vegetation is an open stand of sal trees. Over half of the landtype has been converted to grass and brush. These slopes are heavily used and have some shoestring debris avalanches. Grazing control and afforestation are the biggest needs. Further study is needed here.

The bottomlands have rubble filled drainageways and broken terraces, with brush vegetation. The forest has been cut. This area is unsuitable for agriculture.

IIIN2c. Foot Slope and Valley Floor, sal.

This landtype is composed of the gentle slopes at the base of the steeper, upper ridge slopes (IIIN2a), as well as valley bottomland flats. The soils on the slopes are deep, sandy loams. Those in the bottomlands are deep, stonefree loams. The footslopes have remnants of a forest cover with a brush/grass ground cover. The bottomlands are completely under cultivation. Rubbly fan materials are deposited where many small streams reach the valley floor.

Afforestation on the footslopes is needed. The management focus in the bottomlands must be for greater agricultural production.

IIIN3. Kali Gandaki Valley and Ridgeland Land System.

The east-west section of the Kali Gandaki river valley forms the central part of this land system. Ridges on each side of this valley are included. The elevation is 1200 to 1800 meters. The materials are a mixture of schists and sedimentary rocks - sandstones, shales, limestone.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIN3a	50	60-120	35	25	20B/G, 20G	mod. high	2	4	5	4
IIIN3b	15	120	25	10	25B/G, 40G/W	low	2-4	5	5	5
IIIN3c	20	5-45	-	60	25B/G, 15G	high	2	1-3	2-3	2-3
IIIN3d	15	0-10	-	20	80	low- high	2	1	4	4

IIIN3a. Upper Ridge Slopes, sal.

This landtype consists of very steep upper slopes and ridge crests. The soils are moderately deep, reddish (7.5 YR, 5 YR) clay loams. The vegetation is a mixed subtropical broadleaf type with sal, Aegle marmelos, Lagerstroemia parviflora, and Cassia fistula. Nearly 40 percent of the area is cultivated. Some of the steepest terraced land in Nepal is here. Rock falls and landslides are common. Terrace design and construction should be improved.

Afforestation is needed in spots throughout the area. Grazing should be managed.

IIIN3b. Canyon Slopes, sal/chilaune.

There are steep lower slopes next to major streams, the Andhi Khola and the Kali Gandaki. Cliffs are present in about 5 percent of the landtype. Soft black shales and white quartzite beds are exposed in some slopes. The soils are mixed shallow, loamy sands and moderately deep, clay loams. Rock outcrop is common. The vegetation is a mixture of sal, chilaune, extensive grass covered slopes and open chir pine forests.

All but the very steepest slopes are grazed. Cultivation is very limited. Landslides, slumps and gullies are common. These are mostly the result of excessive grazing.

Grazing management and afforestation, with protection of abused areas are needed.

IIIN3c. Toe Slopes, cultivated lands, sal.

These slopes are mostly on the south sides of the Kali Gandaki Valley. They are at the base of the upper ridge slopes. The valley floor is at their foot. The soils are deep, sandy loams and loams. The vegetation was originally a sal type. It has been nearly totally replaced by cultivated lands, brush and grass. Most of the area is terraced. Sloping fields are used where water is not available. Some stream bank erosion was noted.

Improved irrigation systems and afforestation are needed.

IIIN3d. Bottomland and Gorge Complex, sal.

This is the great valley of the Kali Gandaki in its eastward flowing stretch. It is a unique feature in Nepal. Three landforms can be distinguished here: flat river terrace surfaces; very steep, walls of a central river gorge; and a rough, rocky stream channel and flood plain. The soils on the terrace surfaces are deep clay loams. Most of these terraces are under cultivation. No watershed problems were noted. The gorge walls, because of deforestation and heavy grazing use, have numerous small land slips. The landslide hazards here are extremely high. These slopes need protection from excessive grazing pressure. Hand clipping may be possible, but livestock should be prevented from grazing on these very steep slopes.

IIIN4. Surkhet Mountain Lands Land System.

This land system is the section of the Mahabharat Lekh north of the Surkhet valley. It consists of a complex set of secondary ridges extending in a weakly integrated pattern from the axis of the main Mahabharat Lekh ridge.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIN4a	20	70-90	65	5	30	low	1	4	-	4
IIIN4b	70	40-70	40	25	35	mod.	3	3	2	2,4
IIIN4c	10	70-100+	80	10	10	low	1	4	3	4

IIIN4a. Ridge Crest and Upper Ridge Slopes, Oak.

These are the smooth upland slopes on the highest ridges in the system. The crest is broad enough in places to permit the development of a few rolling fields. The elevation is 1500 to 2200 meters. The slope gradients are 50 to 80 percent. The materials are dark brown, hard schists. The soil are stony sandy loams, moderately deep. Angular gravels make up 20-30 percent of the profile. The vegetation is an oak type (*Quercus semecarpifolia*). These ridge crests are islands of forest land in this region of the Mahabharat Lekh. The small amount of cultivation here has no impact on the hydrologic properties of the landtype. Water is scarce.

The forests here should be protected. The high content of angular gravels in the soils seems to be a stabilizing factor.

IIIN4b. Mid-slope Ridges, chir pine/oak.

This is a very extensive network of ridges between the steeper slopes along the ridge crests and those next to the major drainages. The elevational range is 900 to 1500 meters. The slope gradients are 40 to 70 percent. The soils are moderately deep to deep, loams and sandy loams. The vegetation is a chir pine type with broadleaf trees.

This is a complex unit. Cultivation has covered slopes on all aspects. The steeper slopes remain in forest however. There are a large number of landslides in parts of this unit. The toe slope and south aspects are especially prone to erosion. Some channels are sediment choked. The greatest needs here are for guidance in terrace construction and grazing management. Gully control would be valuable in some of the deteriorated lands.

IIIN4c. Lower Slopes, chir pine.

These slopes form a band of escarpments along the north and west boundaries of the system. They are very steep (70 percent to over 100 percent slope gradient) but their relief, from 900 to 1300 meters, is low. The rocks noted were phyllitic schists. The soils are moderately deep, sandy loams. There is 20 percent stone. The vegetation is a chir pine stand with a grass ground cover. Sal is on the lowest part of the slope.

These slopes are largely unused except for grazing. Some cultivation is creeping in from higher slopes. Such tendencies should be discouraged. Fire protection is needed as these are mostly mature pine stands. Forest management opportunities for harvesting and planting would be worth investigation.

IIIP. Far Western Mahabharat Lekh Region.

This is an elongated region reaching from the western border of Nepal to the great bend in the Karnali River. Our on-the-ground observations were unfortunately confined to the short stretch crossed by the Dhangarhi-Dandeldhura road. This is a very rugged area with little access. Agriculture appears to be a minor but expanding land use. Further attention may be given to this region as the site of hydro-electric developments on the Seti and Karnali Rivers.

Summary of Region

Area 3293 sq Km

8 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush	1	2	3	4	5
67	15	18	50	40	10	0	0

Location: Dandeldhura district of Mahakali Zone, Doti district of Seti Zone and Surkhet district of Bheri Zone with minor extensions into the Accham, and Dailekh districts. It occupies parts of the Mahakali and Karnali drainage systems. Principal rivers within the region are the Thuli Gad and the Rangu. There are no towns of any size here.

Elevation/Relief: Elevation is from 600 to 2700 meters. Maximum internal relief is about 1200 meters (moderate) in the Rao Khola drainage.

Climate: Temperate monsoon with precipitation in the 1000 to 1500 millimeter range. According to Köppen's classification, it is a combination of warm temperate rainy upland climate (Cwb) and subtropical monsoon (Cwa). There is winter precipitation here as in other far western regions.

Geology: Hagan (1969) describes this area as the "Dandeldhura autonomous massif" meaning a large exposed, emplacement of basement granitic rocks. There are schists and limestones on the flanks of the main ridge here.

Vegetation: Oaks are the main trees here (Q. incana, Q. lanata, Q. dilatata) with laurels and shrubs. On higher slopes there is an oak (Q. semecarpifolia)/hemlock (Tsuga dumosa)/fir (Abies pindrow) type. At lower elevations there is an oak (Q. incana)/chir pine (Pinus roxburghii) community. Other trees in the lower part are horse chestnut and maple, with sal stands on the river valley slopes. A khair-sissoo type was mapped in the lower reaches of the Seti river valley.

People: Mostly Chhetri and Thakuri. Also Brahmin and the occupational castes. Population density is low in much of this sparsely populated region. On a district wide basis, there are 32 to 60 people per square kilometer placing this region in the moderate population density class.

Comment: This is a remote region. Most of it is relatively undeveloped. A more detailed look at the agricultural land is needed before management recommendations can be made.

Divisions: Three land systems were identified here: (1) the main high ridges of the Mahabharat Lekh; (2) a peripheral system of lower ridges, and (3) the large canyons of the Seti and Karnali Rivers.

IIIP1. High Ridges of Mahabharat Lekh Land System.

This land system occupies the upper slopes of the main Mahabharat Lekh ridge in far western Nepal. This is a very heavily forested land system, with agriculture over less than 5 percent of the area. The major intrusion here is the Dhangarhi-Dandeldhura road. This road will be a source of sediment in streams for a long time. Forest management opportunities exist here that should be evaluated.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIP1a	25	30-60	80	10	10	low	1	3	2	3
IIIP1b	45	70-100+	90	0	10	low	1	4	3	5
IIIP1c	30	70-100	70	10	20	low	1	4	4	5

IIIP1a. Upland Surface, oak - chir pine.

These are intricately dissected north facing slopes. The internal relief is low compared to adjacent lands, giving the unit the appearance of a remnant surface. The landtype is cut by some rather deep ravines. The elevational range is 1800 to 2800 meters. The slope gradients are 30 to 60 percent. The soils are deep loams and sandy loams over clay loams. The vegetation is a complete cover of oaks (Q. semecarpifolia, Q. lanuginosa) and chir pine.

This landtype has nearly a 100 percent forest cover. No landslides or other evidence of erosion were noted. Road cuts here would undoubtedly cause landslides.

IIIP1b. Canyon Slopes, chir pine.

These are slopes of canyons cutting into the Mahabharat Lekh uplands. They are very steep (70 percent to over 100 percent), long, shallowly dissected and straight. The rocks are granites. The soils are shallow to moderately deep, fine, gravelly sandy loams. The vegetation is an open chir pine type with a grass ground cover.



2.52 Part of the Far Western Mahabharat Lekh Region (IIIP).
Canyon Slopes (IIIP1b); and North- and South-facing
Ridge Slopes (IIIP2a/b) landtypes are shown.

These slopes are too rugged for much agricultural use. In spite of their steepness and sensitivity, there are few natural landslides. The Dhangarhi-Dandeldhura road has caused several large landslides and is the principal source of sediments. A small amount of cultivation is taking place on secondary ridge crests. This has caused landslides on the margins of the cultivated land.

The needs are for fire protection and strict control of tree cutting. The road will continue to be a problem hydrologically for several years as additional landslides come down. Agriculture encroachment here should be strictly controlled.

IIIP1c. Valleys of Headward Cutting Streams, oak.

These are the ridge and valley slopes carved by headward cutting streams on the south side of the Mahabharat Lekh. The elevation range is from 1500 to 2500 meters. Slope gradients are 70 to 100 percent. The materials are a combination of granites, granitic gneisses and schists. The soils are moderately deep, sandy loams.

The vegetation is an oak forest, Q. semecarpifolia on upper slopes and Q. lanata on lower slopes.

The unit is over 95 percent forested but cultivation on ridge points and slopes above stream level terraces is expanding. This has caused landslides. The Dhangarhi-Dandeldhura road has caused several large landslides.

The landtype has low suitability for agricultural development. Farmer guidance through regulation and extension is needed. This unit presents an opportunity for erosion control through management.

IIIP2. Lower Ridgeland Land System.

These lands are peripheral to the main high ridges of the Mahabharat Lekh described in IIIP1. This is a maturely dissected area. Some ridge tops are broad enough and sufficiently continuous to permit cultivation.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIP2a	40	70-100	80	10	10	low	2	4	3	4
IIIP2b	50	60-80	65	25	10	low- mod.	1	3	2	2-3
IIIP2c	10	5-60	30	50	20	high	3	4-5	-	1-3

IIIP2a. South-facing Ridge Slopes, chir pine - oak.

These are straight, south-facing ridge slopes. Slope gradients are 70 to 100 percent. The soils are shallow to moderately deep, sandy loams. The vegetation is an open chir pine stand. Agriculture is limited to shoulders and weak benches on the upper parts of the slope. A few landslides are visible here but the general appearance is one of stability. Ideally, soil and geologic investigations are needed to guide agricultural expansion. Fire protection is needed.

IIIP2b. North-facing Ridge Slopes, oak - chir pine - hardwoods.

These are straight to concave-shaped slopes. Slope gradients are 60 to 80 percent. The vegetation is chir pine with oak (Quercus incana) and various hardwoods.

These slopes have been terraced from stream level to ridge top in spots. Few landslides however are associated with this activity.

IIIP2c. Basin and Valley Lands, sal/chir pine.

This landtype is made up of elongated stream valley bottomlands, associated toe slopes and clusters of small valleys where streams converge. The bottomlands are discontinuous, high valley fill deposits are incised by vertical walled stream channels. Meandering streams here have cut into the toe slopes leaving steep, narrow ridge remnants. Slope gradients are 5 - 10 percent in the bottoms, and 40 - 60 percent on the toe slopes. Vegetation is a sparse sal/chir pine forest.

These valleys are isolated pockets which form the center of development in this land system. The slopes in contact with these bottomlands are intensively terraced and grazed. South facing slopes are deforested. Small landslides and gullies are common. The stream channels are in poor condition.

Gully control instruction and reforestation are probably needed. The importance of forests lands to erosion control and water supply should be made clear to the people.

IIIP3. Seti-Karnali Canyons Land System.

This land system includes the great bend of the Karnali and the junction of the Karnali with the Seti. It is a narrow group of canyons with narrow bottomlands. It is extremely rugged with few villages and most cultivated land restricted to upland basins. This area was not visited on the ground. This brief description is based on aerial photo interpretation.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IIIP3a	80	60-100	60	5	35	low	2	4	4	4-5
IIIP3b	20	20-60	20	60	20	high	1-4	3	2-3	1-3

IIIP3a. Canyon Slopes, brush - chir pine.

These are the long straight to convex canyon slopes formed by truncated spur ridges. Slope gradients are 60 to 100 percent. The elevation is 600 to 1900 meters. The relief is up to 1300 meters. The rocks are mainly schists. The vegetation is a brush type on most south aspects and heavy forest cover on north aspect slopes. Chir pine stands are common on the upper slopes here.

There is some farming in isolated patches on small benches and broad ridge crests. There are a few long debris avalanches, but because of their general lack of use these slopes appear to be in good hydrologic condition. If a dam were built here, many landslides would be expected along the water line of the reservoir.

IIIP3b. Uplands, chir pine - oak.

These are comparatively small areas of modified slopes and relief in the upper parts of the side valleys to the main canyon. Slope gradients appear to be 20 to 60 percent. These are mostly shallow basins with a northerly aspect. The vegetation is chir pine and oak. This landtype is intensively cultivated without undue impact on watershed resources. However, cultivation on ridge crests and slopes with south aspects is associated with a large number of landslides and heavy sedimentation.

An effort should be made to restrict cultivation on the more sensitive, south facing slopes. Long term protection is the most realistic rehabilitation method in abused areas. Tree planting would be helpful.

IV. Siwalik Zone.

The Siwaliks are a series of low, hogback ridges in a sinuous pattern that cross the length of Nepal. They enclose several valleys and intricately dissected outwash plains. The elevation is 120 meters near Dharan to nearly 2000 meters in the far west. The materials are Pliocene and Pleistocene sandstones, shales, siltstones and weakly consolidated gravels, sands and silts. The valleys have been cleared and are being cultivated but the ridges have about 80 percent cover of dense subtropical forests.

The Siwaliks are the first ridges of the Himalayan mountain system. The Ganges plain is at their southern foot; the Mahabharat Lekh, the southern edge of the Middle Mountains, contacts them on the north.

Although the Tharu have long occupied these lands, clearing and settlement began on a large scale after malaria began to be controlled in the 1950's. The valleys are nearly completely cultivated. Most of the ridges remain in forest because coarse textured, stony, shallow soils, and steep slopes make them unsuitable for cultivation. Ridge crest saddles, and a few of the more gentle slopes are being farmed however. Agriculture is particularly common on the ridges in eastern Nepal where cultivation is associated with some very large landslides. Agriculture seems to be expanding on the Siwalik ridges with an accompanying increase in soil erosion. This is a trend that needs to be monitored and perhaps controlled. Roads here cause landslides, particularly on the dip slopes.

The Siwalik Zone makes up 13 percent of the country and is divided into three regions on the basis of regional climate, relative proportion of ridge types and presence of inner valleys. Each region consists of one to four land systems.

IVA. Western Siwalik Region.

These are the Siwalik ranges and inner valleys west of the Dang Valley. The region consists a single ridge system in its western extent and a double set of ridges to the north of Nepalgunj. It is the highest of the three Siwalik regions, with elevations up to 2100 meters north of the Bheri-Karnali confluence. This region differs also from the other two Siwalik regions by its lack of the large inner valleys (IVB) and the lack of secondary, low-land ridges formed in recent outwash (IVC). The braided streams from this region of the Siwaliks appear to be less erratic than those in the eastern regions. Here they are shorter and more entrenched than those to the east.

Summary of Region

Area 4462 sq Km

25 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush	1	2	3	4	5
70	12	18	38	30	32	0	0

Location: Southwestern Nepal. Mahakali Zone districts are: Dandeldhura and Kanchanpur; Seti Zone district: Kailali; Bheri Zone districts: Surkhet and Bardia. Surkhet is the principal town in the region. The region includes the lower drainages of the Karnali and Bheri Rivers. Secondary rivers are the Puntara Gad, Rangun Khola and the Thuli Gad.

Elevation/Relief: Elevation from 300 to 2100 meters; maximum relief is 1400 meters.

Climate: Subtropical monsoon. Mean annual precipitation is 1500 to 2000 mm. According to Köppen's classification this is a subtropical monsoon climate, with maximum temperature before the rainy season (Cwag).

Geology: The materials are sandstone, conglomerates and siltstones of the Siwalik series. The structure is that of hogback ridges with the beds dipping to the north at 50 to 60 percent.

Vegetation: Mainly chir pine - oak (Q. incana, Q. lanata) forest with rhododendron, Lyonia sp and Inula sp Sal forest with Terminalia tomentosa is in the valleys. A hygrophytic tropical forest reaches into the mountains from the Terai in some valleys.

People: Brahmin, Chhetri and occupational castes with Tharus and Magars. The population density of the districts here is moderate, 40 - 70 people per square kilometer. Based on crops it is low to moderately low at 3 - 6 people per hectare.

Comments: For management purposes, one should give attention first to small portions of this heterogeneous region, mainly the back slopes of the Siwalik ridges, IVA1c, and the valley bottomlands part of IVA2b. Most of the remaining areas are in natural condition. As in most regions, grazing management is the single most pressing need.

Division: Two land systems were recognized. One is of a complex valley, the other is a ridge system. The many kinds of landscapes in IVA2 could be separated only in a very general way. Understanding of this region would benefit from more detailed examination.

IVA1. Main Ridgeland Land System.

This land system consists of the somewhat curving main ridge blocks that extend the length of the region. It forms the front slopes of the hills above the Terai.

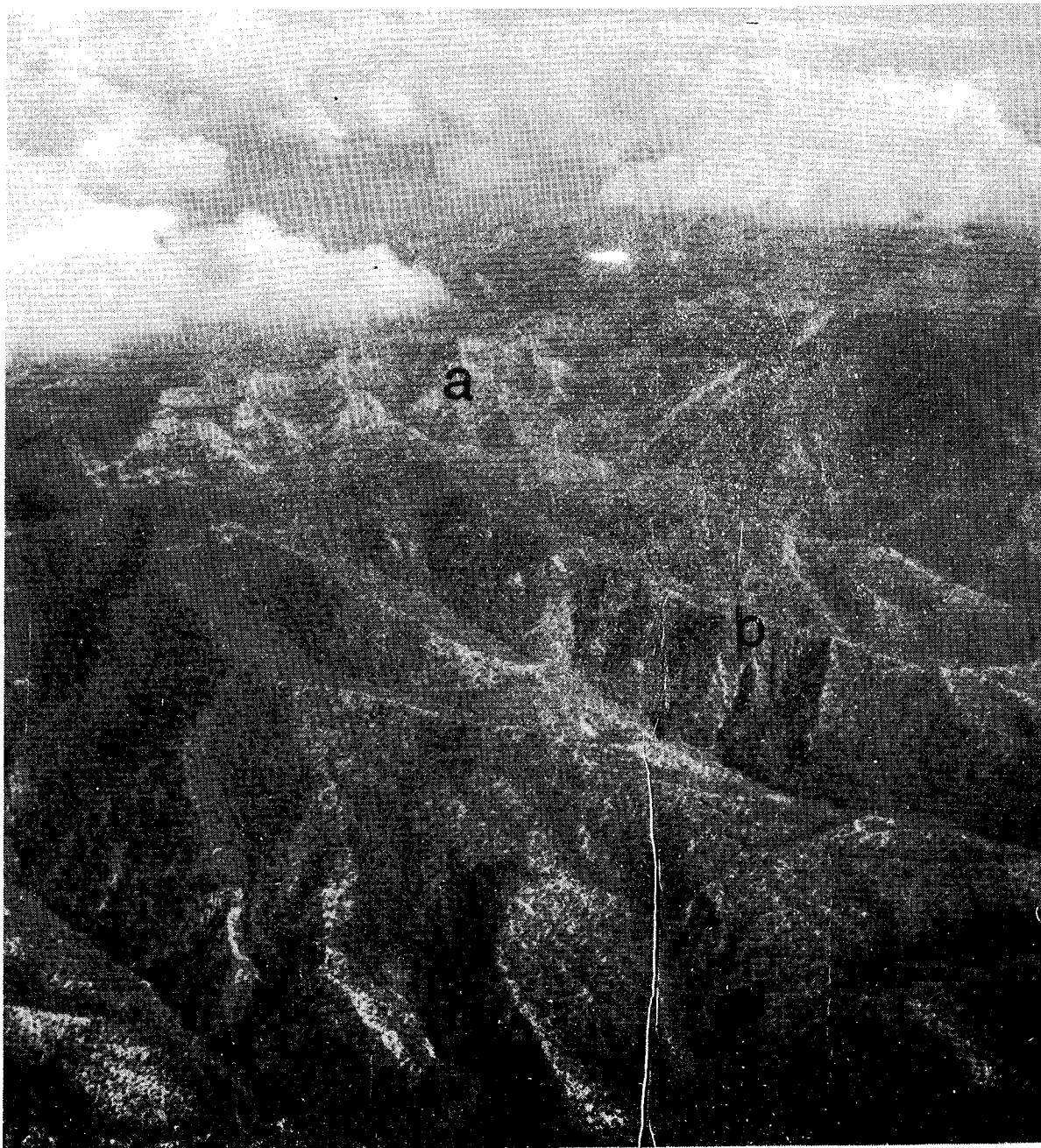
Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IVA1a	20	70-100+	80	-	20	low	1	5	5	5
IVA1b	30	40-70	90	5	5	low	1	3	3	4
IVA1c	50	30-70	70	10	20	mod.	2	4	3	2,5

IVA1a. Scarp Headlands, chir pine/oak.

These are the upper, south facing slopes on the main ridge of the Siwaliks. They form the steep headlands of the series of parallel valleys of southward flowing streams. The elevational range is 1200 to 2100 meters. The slope gradients are 70 percent to over 100 percent. Cliffs, long rubble slopes and raw landslide scars are conspicuous. Headward cutting streams have stripped the rocks here of soil, leaving multilayered outcroppings. The soils where present are shallow, sandy loams or gravelly sandy loams. The vegetation is a chir pine/oak forest.

These slopes are the sources of the braided streams that extend across the Terai from the base of the Siwaliks. The erosion here is natural. There is a little grazing but no man-caused deforestation. The Dhangarhi-Dandeldhura road has caused a few small landslides, but most landslides here are part of natural erosion processes and therefore cannot be stabilized.



2.53 Main Ridgeland (IVa1) of the Western Siwalik Region. Landtypes shown:
(a) Scarp Headlands; and (b) Siwalik Secondary Ridges.

IVAlb. Siwalik Secondary Ridges, chir pine - mesophytic tropical forest.

This is a series of parallel, maturely dissected, V-shaped ridges and valleys that extend to the south from the axis of the main Siwalik ridge for 2 to 8 kilometers. The slope gradients are 40 to 70 percent. A narrow, discontinuous, high terrace is on the outer margins of these slopes. There are a few high benches on the upper slopes. The soils are moderately deep, gravelly and cobbly sandy loam and loamy sand. The bench soils are deep loams. Boulders and other colluvial debris cover the slope. The vegetation is a sal/Terminalia spp forest. Cover is conspicuously less dense in convex positions.

Agriculture is limited to a few upslope benches. The landtype is nearly completely forested. Large landslides are common on the slopes near the heads of the valleys. Gullies and rills (apparently natural) are visible under the forest cover. The forage is too sparse and the surface too rough to have much grazing potential.

The Dhangarhi-Dandeldhura road has caused surprisingly few landslides. The rills and many gullies, landslides and thick rubbly mantle appear to be natural. Removal of vegetation cover would cause a large increase in soil movement.

IVAlc. Backslopes, chir pine - sal.

These are the northward dipping back slopes of the Siwalik range. As considered here, they reach from stream level to the crest of the main ridge. They are crossed laterally by several minor canyons but their general appearance is that of a sloping slab. At their western end, they consist of several imbricated surfaces, giving the appearance of a shingled roof. The slope gradients are 50 to 70 percent in the west, and 30 to 50 percent at the eastern end. The canyons of the Puntora Gad and the Thuli Gad are at the base of these slopes. Gradients here are over 100 percent. The materials are sandstone of the Siwalik series with thick (20 meters plus) layers of rubbly, young, sediment accumulations. This latter material occupies the more modified topography. The soils are reddish, moderately deep loams and clay loams. Open mature chir pine with oak (Q. incana) stands cover much of the unit. A sal/Terminalia sp forest is present at lower elevations.

Agriculture is in isolated upland saddles and on slopes with less than 40 percent gradients. All but the steepest slopes appear to be grazed. The chir pine stand is intact but there is little reproduction. A few gullies and patches of bare ground were noted.

It would seem that the mature forest could be safely logged if provisions were made for regeneration and protection of the site. Forest fire is a problem. Agriculture is expanding. Great care is needed in selection of sites for cultivation. Grazing is responsible for most signs of site deterioration. The canyon slopes have some large landslides on their eastern extent.

IVA2. Bheri Khola-Karnali Valley Land System.

The land system encloses the Bheri Khola and the Karnali river within the Siwaliks. It is a complex system that varies longitudinally as well as transversely. On-the-ground observations were minimal with most information coming from overflights and aerial photograph interpretations.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IVA2a	30	40-70	50	20	30	mod.	3	3	3	1-4
IVA2b	50	5-20	60	20	20	mod.	3	2	3	1-3
IVA2c	20	0-5	75	15	10	low	1	1,5	3,4	1-4

IVA2a. North Ridge, brush - sal.

This northern ridge merges with the Mahabharat Lekh in much of its eastern extent. In the western part of the landtype it is undercut on the north side by the Karnali. It is separated from that river by steep, heavily forested north-facing canyon slopes. The ridge has a broad convex top in its western end. The south facing slope reaches to the basinland along the bottom of the valley. Slope gradients are 40 to 70 percent. The ridge top is broad and has slope gradients of less than 10 percent. The geologic materials are sandstones of the Siwalik group. The soils are reddish, loams and clay loams. The vegetation is mostly a sal type with mixed hardwoods on north aspects.

The ridge tops and north facing slopes are cultivated. In the east, small benches and pockets on the south face are cultivated. Most of the unit is grazed. Forest cover is broken. Landslides associated with grazing are present.

Guidance in selection of sites for farming is needed. Tree planting would be of value.

IVA2b. Basinlands, sal.

This is a rather broken, heterogeneous unit. It ranges from the broad, flat lands of Surkhet valley to a network of low hills cut by deep gorges. Slope gradients are generally in the 5 to 20 percent range. The geologic materials are reddish sandstones with claystone. Much of the area consists of deep sediment deposits. The soils are shallow to deep, loams and sandy loams. The vegetation is a sal type.

Land use varies with roughness of the terrain. The Surkhet valley and a broken string of bottomlands along the Bheri are completely cultivated. The western end of the unit is mostly in sal forest. The entire area appears to be grazed.

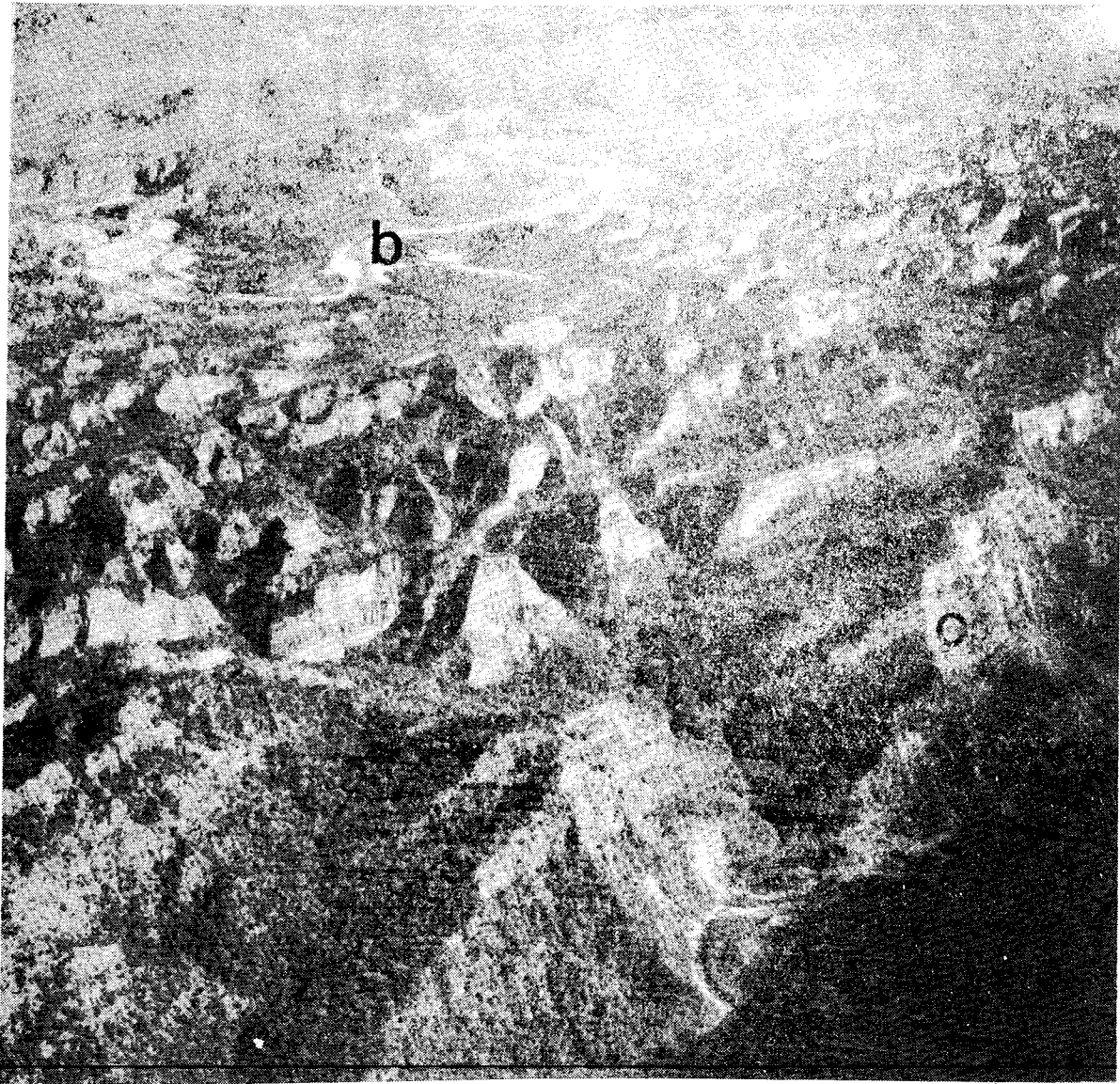
There is considerable bare ground here, including areas under sal forest. A low, red sandstone outcropping along the margin of valleys produces lands prone to serious erosion. More study is needed to evaluate the erosion problems and the opportunities for further development.

A study of sal management would be helpful here.

IVA2c. Gorges, Terraces and Flood Plains, sal/khair.

This landtype lies along the south side of the land system between the basinlands and the north foot of the Siwalik ridges, landtype IVA1c. It is a complex of benches, cliffs, terraces, steepwalled gorges and flood plains. The materials are alluvial deposits and sandstones. The vegetation is a sal/khair/sissoo type.

Some extensive terraces are cultivated. Most forest land is intact. A detailed study is needed to plan irrigation and agricultural development, and to design flood protection practices.



2.54 Basinlands (IVA2b) and Gorges (IVA2c) in the Bheri Khola-Karnali Valley Land System (IVA2).

IVB. Central Siwalik Region.

This is a large region, reaching from near Nepalgunj to the upper Rapti Valley near Hetauda. It is composed of five lines of ridges and six enclosed valleys, including the Dang, Rapti and Chitawan Valleys. In addition to sharing a similar physiography, the lands here have been subject to rapid agricultural expansion over the last 25 years.

Summary of Region

Area 8371 sq Km

46 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush	1	2	3	4	5
58	32	10	50	13	32	0	5

Location: The Banke district of the Bheri Zone; the Dang district of the Rapti Zone, small parts of the Kapilvastu, Rupandehi, Arghakhanchi, Palpa and Navalparasi districts of the Lumbini Zone; and the Chitawan and Makwanpur districts of the Narayani Zone. Towns here are Tulsipur and Bharatpur. It is drained by the Narayani, Rapti and Babai Kholas.

Elevation/Relief: Elevation is about 100 to 1000 meters. Maximum relief is 300 meters.

Climate: Subtropical monsoon. The mean annual precipitation is 1000 to 1800 millimeters. The classification according to Köppen's method is subtropical monsoon, with the maximum temperature before the rainy season (Cwag).

Geology: Siwalik sandstone, siltstone, conglomerates and recently deposited sediments from these rocks. The structure, as in other parts of the Siwalik, is a series of angular, hogback ridges with beds dipping to the north at 50 to 100 percent.

Vegetation: A mesophytic tropical forest on the front slopes with Shorea robusta, Casearia tomentosa, Buchanania latifolia and Anogeissus latifolia. A sal forest with Terminalia spp. is in the inner valleys and chir pine on the upper ridge slopes. Most of the flat land is cultivated.

People: Tharu, Brahmin, Chhetri and occupational castes, Magar and Sunwar. Population density is low at 3 people per hectare of crop. It is moderate at 62 to 132 people per square kilometer of land.

Comments: Two landtypes dominate the erosion control needs in this region: IVB2a in the Dang Valley, and IVB3a along the north side of the Rapti

Valley. Careful and time consuming observations are required to devise effective measures to counter the erosion in these two places.

Division: The region can be divided into two kinds of lands: ridges and valleys. Five lines of Siwalik ridges divide and enclose three major Inner Siwalik valleys: the Dang, Rapti and chitwan. The following descriptions will treat the ridges as one land system and each of the valleys as a land system. In reality the use and condition of the ridges and the valleys are interdependent.

IVB1. Siwalik Ridges Land System.

The central Siwalik ridges have the same hogback form as do ridges in other Siwalik regions. However they are something of a transition between the regions on each side. For example, they are lower than the ridges in the west but higher than those in the east; the development of secondary, spur ridges is stronger to the west and weaker to the east; the difference in vegetation between north and south aspects is more pronounced in the west, less so in the east.

The natural erosion pattern in the central Siwalik ridges is worth mentioning. The stretch of the Siwaliks north of the Terai (Region VB) is a single ridge, the only ridge section in this region not enclosing a valley. The erosion here is similar to that found in the Siwaliks to the west, i.e. high rates of natural erosion in the form of exposed soils, with rock, gullies and landslides caused by headward cutting streams. Elsewhere, landslides are conspicuously scarce, even on the cut-over ridges on the northwest side of Chitawan valley. Sheet, rill and gully erosion however is common on the spur ridges and toe slopes of the Siwaliks surrounding the Rapti and Dang Valleys. Badlands are formed by advanced erosion in the toe slope here.

For the most part, the ridges are in a single line where the most meaningful subdivision for descriptive purposes is based on aspect. The area east of the Dang and Rapti Valleys is unique in Nepal in that here there are five tightly packed lines of Siwalik ridges. The width of the ridges here is 25 kilometers rather than 5 to 8 kilometers as it is in most places.

The following are descriptions of the typical ridges, based on aspect.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IVB1a	40	50-70	80	0	20	low	1,4	4	4	5
IVB1b	60	30-60	90	5	5	low	1	4	3	3,5

IVB1a. South-facing Slopes, sal.

These are the steep scarp slopes of the Siwaliks. Slopes gradients are 50 to 70 percent. Relief varies from 100 to 300 meters. A secondary ridge system is cut into these slopes. The materials are sandstones, conglomerates and shales. Rock outcrop is exposed on the main ridge crests and headlands. Rubbly colluvium covers most slopes. The soils are shallow to moderately deep, loamy sands and sandy loams. The vegetation is mostly a sal forest type. Some other trees are Anogeissus latifolia and Terminalia tomentosa. Chir pine is on the upper slopes and in convex positions.

The area is grazed. Some ridge crests show signs of abuse. The secondary ridges on the north side of the Rapti Valley are severely eroded. Landslides are in the heads of secondary drainages and on side slopes in the central part of the region. These appear to be natural. Roads crossing these slopes cause some major landslides.

The unit is in excellent hydrologic condition except as noted. The local people have not exerted pressure through firewood collection or grazing. A few minor exceptions were seen. No attempt has been made to clear these lands for cultivation because of their steep slopes and coarse textured soils. Some logging has taken place on the north side of the Chitawan valley with surprisingly little erosion. The most beneficial use of these lands would be in watershed protection because of their critical position above the highly valuable, populated agricultural lands at their base.

Low toe slope are present. These are covered with outwash cobbles and have deep reddish, gravelly loam and clay loam soils. Unlike most of the landtype, they have received heavy use and are in poor condition in many places. In Chitawan valley there are some heavily forested, detached segments of the Siwalik ridges.

IVB1b. North-facing Slopes, sal.

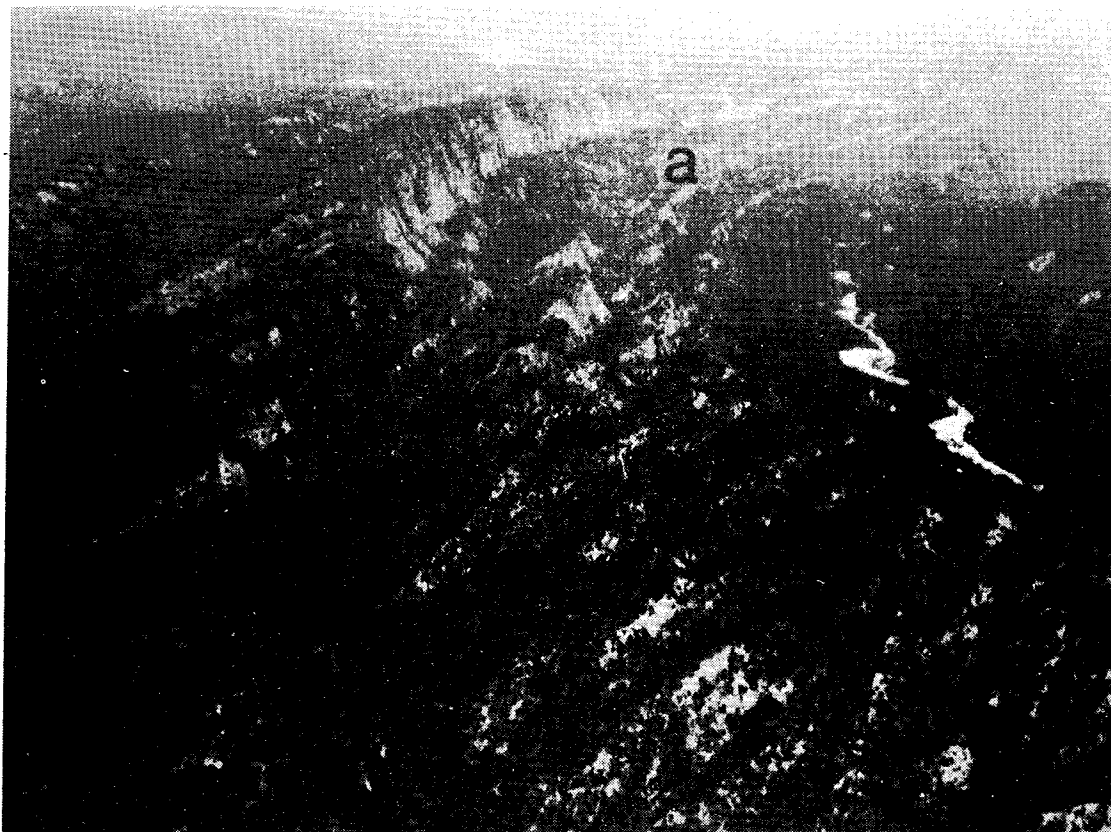
These are the north-facing, dip slope side of the Siwaliks. Many of these slopes have an internal pattern of micro dip and scarp slopes giving them in profile the appearance of a saw.

Included with this landtype are the terraces and bottomlands. Such lands usually occupy narrow back valleys. Unlike the bulk of the landtype, these inclusions are usually cultivated. Except for some stream bank erosion, there is little erosion.

There is a weakly expressed internal, parallel drainage pattern. Slope gradients are 30 to 60 percent. The soils are moderately deep to deep sandy loams over loamy sands. There is no rock outcrop but large colluvial boulders are common. The vegetation is a sal forest community. Some additional species are Terminalia tomentosa, Embllica officinalis, Adina cordifolia and Bauhinia vahlii.

A few patches of agriculture are found in this unit on low relief uplands. The lower slopes are grazed excessively in places. Roads here have caused slumps in their cut slopes. There are some narrow, torrentlike drainage bottoms crossing these slopes.

These are sensitive slopes. Great care should be used in extending agricultural land and in locating roads.



2.55 Siwalik Ridges (IVB1) showing landtypes (a) South-facing Slopes and (b) North-facing Slopes.

IVB2. Dang Valley Land System.

This large valley in south-central Nepal was cleared for agriculture following the control of malaria. Although it is very productive agriculturally, it presents one of the most dramatic examples of man-caused erosion in Nepal. The solution to problems here can be a gauge to measure the commitment and effectiveness of erosion control programs throughout the country. Three landtypes were recognized.

Land System Summary

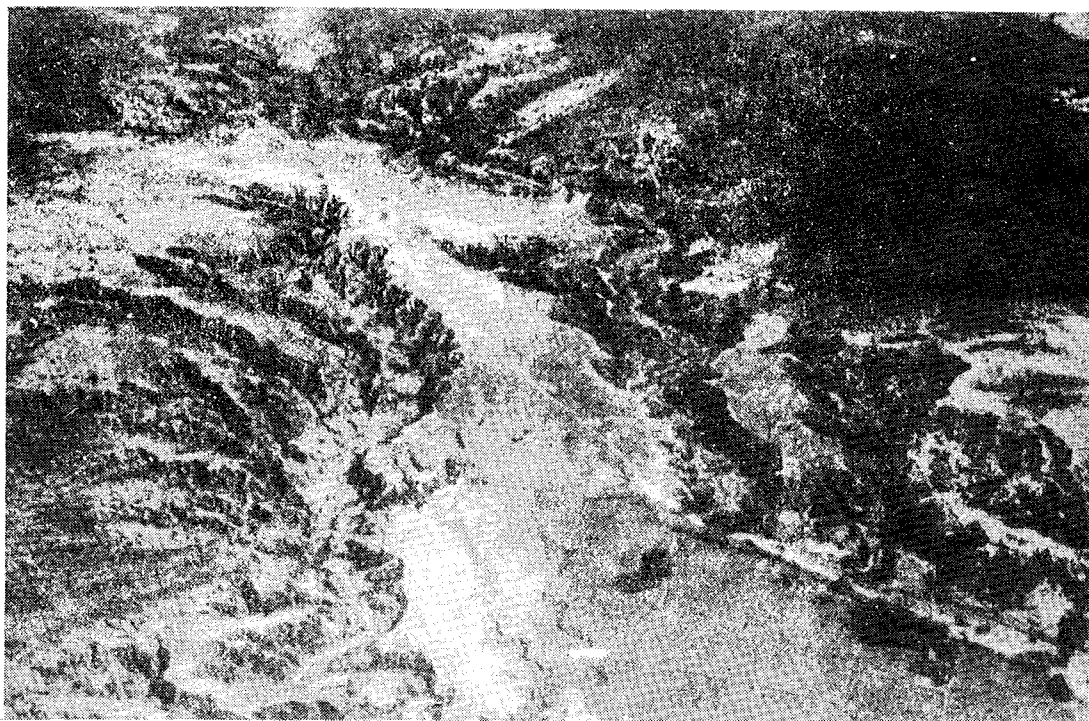
Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IVB2a	20	5-20	50	20	30	mod.	5	2	3	3
IVB2b	60	2-5	0	90	10	high	1,4	1	2	1
IVB2c	20	1-3	0	90	10	mod.	2	1	2	1,2

IVB2a. Toe Slopes, sal.

These are at the base of the adjacent Siwalik ridge slopes. Included here are isolated hills and high terrace remnants. Slope gradients are 5 to 20 percent on the valley floor and 10 to 40 percent on the adjacent Siwalik slopes. This unit forms a discontinuous belt that circles the entire valley. The materials are reddish and grayish sandstones and shales, with the outwash from these materials. Soils are shallow to moderately deep, reddish (5 YR), loams and sandy loams. The vegetation is an open sal forest cover. The lower slopes are cultivated.

This unit is conspicuous for its poor hydrologic condition. Gully erosion is rampant, having converted parts of the landtype to badlands. These eroded conditions underlay the tree cover in many places. This seems to be an area with very sensitive soils being intensively grazed and picked over for firewood.

Under natural conditions small areas of erosion could be expected. With use, the soils seem to dissolve. The magnitude of the problem is such that only a concentrated, long term effort can restore these lands. The first step should be an intensive study to determine the exact causes of erosion, and to experiment with various approaches to rehabilitation including rest and protection, with and without plantings and seedlings. Check dams should be tried as part of this experiment but the extent of the problem make it beyond the scope of mechanical methods alone.



2.56 Headward cutting gully systems in the Toe Slopes of the Dang Valley (IVB2a), one of the "hot spots" of erosion in Nepal.



2.57 A ground view of some of the erosion in the Dang Valley Floor (IVB2b).

IVB2b. Valley Floor, agriculture.

This is a gently sloping (2-5%) surface composed of multiple terrace layers of outwash and fan materials. At least five levels of natural terraces are visible. The surface is dissected by a series of broad drainageways crossing the valley from north to south. The streams in these drainageways enter the westward flowing Babai Khola at the south edge of the valley. The material is outwash of gravel to clay size. The soils are deep, reddish (2.5 YR - 7.5 YR) silt loams and clay loam over clays and silt loams. The landtype is nearly completely cultivated or converted to pasture.

Much of this landtype is in good condition. Headward-cutting gullies however have turned the margins into badlands. A kind of rounded gully erosion is eating its way into these terraces on their lower side. The rate of gully extension is unknown but it is conceivable that without prompt action the entire Dang valley could be converted to a badland.

There is an urgent need for unraveling the erosion process here to arrive at a solution. It is obvious however that irrigation water use must be strictly controlled and that eroded land needs to be protected from grazing. Some protected spots of erosion are supporting good grass cover. Use of grasses as a stabilizing agent should be one line of investigation. Check dams could be another effective erosion control tool.

IVB2c. Bottomlands, cultivated.

These are flat lands laying adjacent to the major streams that cross the valley from north to south. The stream channel is braided during monsoon but meanders within the braided flood plain during the remainder of the year. The slope gradient is 1 to 3 percent. The materials are recently deposited sediments from sandstone, schists and shales. The soils are shallow to deep sands to sandy loams over loams and sands. Nearly all the landtype, including recent sand deposits, is terraced to produce crops or pasture.

Bank erosion is a problem, but because of the flood peaks indicated by the braided channel, it is a problem that has to be lived with. Otherwise, this landtype is in comparatively good condition.

IVB3. Rapti Valley Land System.

This narrow valley is the smallest of the inner Siwalik valleys considered to be land systems. It is open ended on the west where it is in contact with the western Terai. Three landtypes, based on source of materials, are recognized here.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IVB3a	10	5-30	60	10	30	low	5	2	3	2,4
IVB3b	70	1-3	40	50	10	high	1,2	1	1	1
IVB3c	20	5-20	50	40	10	mod.	3	2	3	2

IVB3a. Northside Siwalik Toe Slopes, sal/khair.

The Siwaliks ridge on the north side of the Rapti Valley is a rugged scarp slope. This landtype is at the base of this scarp. It is a low relief, undulating, intensively dissected series of benches which form the toe slopes to the main Siwalik ridge.

The toe slopes are part of the Rapti valley floor and are formed in sandy and silty outwash from the Siwaliks. Natural erosion has carved deep, narrow ravines through part of this benchy land. In places erosion has reduced the bench to discontinuous, rounded outcroppings. The slope gradients are 5 to 30 percent. The soils are gravelly, silt loam and loamy sands. The vegetation is an open forest of Shorea robusta, Terminalia tomentosa, Adina cordifolia, Anogeissus latifolia, Syzygium cuminii and Acacia catechu.

These lands are heavily grazed and are in poor condition. The only remedy is to bring the grazing under control.

IVB3b. Bottomlands, sal/khair.

Whereas the previous landtype was formed in outwash from the Siwaliks, this is in materials brought into the valley by the Rapti River. The line between the two kinds of deposits is abrupt, including cliffs where the Siwalik toe slopes have been truncated by the Rapti. These bottomlands are flat except for the slight entrenchment of the stream channel. Low terraces are within the bottomlands. The soils are deep, silt loams and near the river, loamy sands. The vegetation is a forest type with a wide range of subtropical deciduous trees: sal, Terminalia tomentosa, T. belirica, Adina cordifolia, Acacia catechu, Lagerstroemia parviflora, Zizyphus spp, Carissa carandas, Aegle marmelos, etc. Much of the unit toward the eastern end of the valley is cultivated.

This relatively new land appears to be highly productive. More forest land can be expected to be cleared for cultivation. The erosion problems so prevalent in the Siwalik Toe Slope landtype are absent here. The river appears to occupy a stable channel.

IVB3c. Southside Siwalik Toe Slopes, sal/khair.

This is a wide strip of land on the south side of the valley consisting of low relief, gently sloping (5-20%) toes of dip slopes and high terraces formed in outwash from the Siwaliks. Like the benches on the north side of the valley, these are not cultivated but do receive heavy grazing pressure, causing erosion. Grazing management is the only response to this problem.

IVB4. Chitawan Valley Land System.

Most of this large valley has been recently cleared and is now one of the most productive agricultural areas in Nepal. From an erosion control view point, Chitawan valley does not present the challenges encountered in the Dang and Rapti valleys. This valley, like the Dang, consists of a series of fans and terraces. Three landtypes were recognized here on the basis of their relationship to current drainage patterns.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IVB4a	30	2-10 10-30	70	30	0	high	1	1	1	1,3
IVB4b	60	1-5	10	90	0	high	1	1	1	1
IVB4c	10	1-3	60	20	20	mod.	1	1	1	3

IVB4a. Terrace and Valley Land, sal.

This landtype is in the northwest part of the valley and consists of a locally high (maximum relief: 50 meters) series of terraces near the foot of the Siwaliks. They are dissected by a parallel series of broad, north-south valleys. The terrace surfaces are flat to undulating. The stream valleys have one to three terrace levels. Slope gradients are 2 to 5 percent. The sides of the valleys slope at 10 to 30 percent with occasional vertical bluffs. The soils are deep, reddish (2.5 YR - 7.5 YR) sandy loams and silt loams. Soil structure is strong. The vegetation is a subtropical forest with sal, Terminalia spp, Adina cordifolia, Lagerstroemia speciosa and Butea monosperma. The valleys are mostly cultivated.

Land use to date has created a somewhat striped pattern with strips of cultivation along the streams that cut through blocks of forest land. The streams here are in braided channels although the full channel is occupied only during monsoon. The higher terrace surfaces are not

cultivated because of a lack of water but they are grazed. In places grazing and trampling has eliminated all ground vegetation.

There is some streambank cutting here that could be prevented with well located structures. Grazing needs should be studied as a step toward development of a grazing management plan.

IVB4b. Central Chitawan Valley, cultivation.

This landtype occupies the bulk of the valley. It is an outwash plain with several levels. The Narayani crosses the landtype in an incised flood plain. The slope is 1 to 5 percent. The materials are deposits from the Siwaliks and from the Middle Mountains. The soils are generally deep, silt loams and sandy loams. Gravels are present in scattered low ridges. There is one remaining belt of natural forest. Species composition is similar to that described for IVB4a.

This is agricultural land. The surface is flat so erosion is not a problem except on the southern edge where gullies are cutting into the surface of the plain. An on-the-ground investigation is needed to determine the cause and cure of the erosion.

IVB4c. Bottomlands, riverine forest - elephant grass.

This is along the south side of the valley and includes the lowlands of the Rapti and Narayani rivers. Its southern edge is the base of a low range of Siwalik hills along the Indian border. The area consists of the flood plains of these large rivers and the slightly higher ground at the base of the Siwaliks. Much of this latter area is periodically flooded. Numerous old channels and meander remnants are filled with water. The soils are deep, loamy, fine sands. The forest cover includes Salmalia sp, Mallotus sp, Acacia catechu, Zizyphus spp.

There is little cultivated land here but encroachment pressure is high. Except for bank erosion along the main rivers, erosion is almost non-existent. Protection and management will undoubtedly be controlled by the needs of Chitawan National Park, which is the most interesting feature within this landtype.



2.58 Bottomlands (IVB4c) in the southern part of the Chitawan valley. This is part of the Chitawan National Park.

IVC. Eastern Siwalik Region.

This region of the Siwaliks consists of a main ridge system at the foot of the Mahabharat Lekh, a series of alluvial river valleys lying parallel to these ridges, then a zone of intricately dissected low ridges. This is the lowest and most heavily forested of the three Siwalik regions recognized. The landscapes here are more rounded than those in other regions and the extensive maze of jungly low relief ridges is unique to this region.

Summary of Region

Area 5354 sq Km

29 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush	1	2	3	4	5
77	11	12	15	50	35	0	0

Location: The region is in the southern tier of districts reaching from the Narayani Zone to the Mechi Zone. Towns in the region include Hetauda and Chisapani. The principal rivers here are Kankai, Bering Khola, Balan Nadi, Kamla Nadi, Murin Khola and the upper Rapti. In addition, the region is crossed by the Sapt Kosi and the Bagmati.

Elevation/Relief: The elevation is 150 to 1200 meters. The relief is low, usually less than 200 meters in any single valley.

Climate: Subtropical monsoon with 1500 to 2300 millimeters of precipitation. This region is wetter than the Terai to the south. The Köppen classification is subtropical monsoon with maximum temperature before the rainy season (Cwag).

Geology: The geologic material is grouped under Siwalik sediments. These are Pliocene to Recent sandstones, mudstones, siltstones and unconsolidated or weakly cemented strata of clay, sand and gravel outwash. The harder, older rocks are in beds tilted in a northward direction at 40 to 80 percent.

Vegetation: The vegetation is a group of subtropical and tropical forest types where Shorea robusta, Terminalia spp, P. roxburghii and Lagerstroemia sp are major components. The bottomlands are mostly cultivated but support elephant grass and khair-sissoo forests in places.

People: The original people here were Tharus. With the expanding agriculture, Hindus, mainly Chhetris and Brahmins from both central Nepal and the Terai, have probably become the dominant groups. The population density is low in the upland land units and high in the river valleys.

Comments: This complex group of land units is at the juncture of the densely populated, flat lands of the Terai and the mountain lands of central Nepal. This region of the Siwaliks appears to be coming under very heavy pressure. Deforestation and cultivation appear linked to many large landslides. Forest clearing for cultivation is occurring rapidly. Detailed classification of these lands for agricultural suitability is needed to guide development.

Division: This region, because of its distinct patterns of gradational subunits, and the intricate dissection of these subunits into a detailed mosaic of ecological landtypes, will be treated as a single land system. The landtypes are themselves composed of a detailed, repetitive pattern of land units too small to treat separately.

IVC1. Eastern Siwalik Land System.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
IVC1a	25	20-60	90	5	5	low	2	3	4	4,2
IVC1b	35	40-80	80	5	15	low	3	4	3	4
IVC1c	15	2-10	30	50	20	high	1	1	2	1-2
IVC1d	25	30-70	90	0	10	low	1,3	3	3	5

IVC1a. North Boundary Ridge, sal.

This is a continuous, cresta-like ridge with a steep, short south face and a longer more gradual north slope which abutts against the toe of the Mahabharat Lekh. A secondary ridge system has developed on much of its south face. The elevation is 200 to 1200 meters with 20 to 60 percent slope gradients. Soils are shallow to moderately deep, gravelly loamy sands. The vegetation is tropical forests composed of sal, *Meliosma* sp, *Lagerstroemia* spp. and *Anogeissus* sp. The landtype is dominantly forested but benches, upland pockets and more gentle slopes are cultivated. Brush covers less than 10 percent of the area. Due to overgrazing and tree cutting, erosion is occurring in places. Large landslides were noted in this unit near the Sapt Kosi Valley. The steep slopes and coarse textured, stony soils make it necessary to maintain a good vegetation cover. This can be a flood source area. Deforestation should be prohibited except under controlled conditions. Roads through this landtype would be subject to severe landslide hazard.

IVClb. Finely Dissected Lowlands, sal/chir pine.

These are intricately dissected, gently sloping basins and dip slopes with entrenched and braided stream channels. The elevation is 200 to 600 meters. Slopes are up to 80 percent within the intricately dissected portion of the landtype. The soils are variable - shallow to deep, sands to clay and silt loams, depending on local materials and slope position. Natural vegetation is mostly a sal/chir pine type. Although it is mostly forested, small areas are cultivated and grazed.



2.59 North Boundary Ridge (IVCl a) of the Eastern Siwaliks. These are the north-facing dip slopes in the lower valley of the Bagmati River, and are the most extensively cultivated lands in the Siwaliks.

The high, natural erosion rate is accelerated by even slight use. This is the major source of braided streams which flood and deposit materials in the Terai. These are forested natural badlands where only small areas can be safely cultivated or logged. Protection is needed. The wildlife resource here should be surveyed. It is possible that wildlife preservation would be a valuable use for this land.

IVC1c. Cresta Ridge, chir pine/sal.

These are discontinuous hogback ridges along the southern edge of the Siwaliks. The elevation is 200 to 1000 meters. The soils are mostly shallow, gravelly, loamy sands. The vegetation is mainly chir pine and sal with some stands of Terminalia tomentosa and T. belerica, Eugenia sp and Lagerstroemia sp. This unit joins abruptly with the Terai at its southern margin. It forms the southern edge of a shallow basin containing the finely dissected lowlands and the bottomland complex.

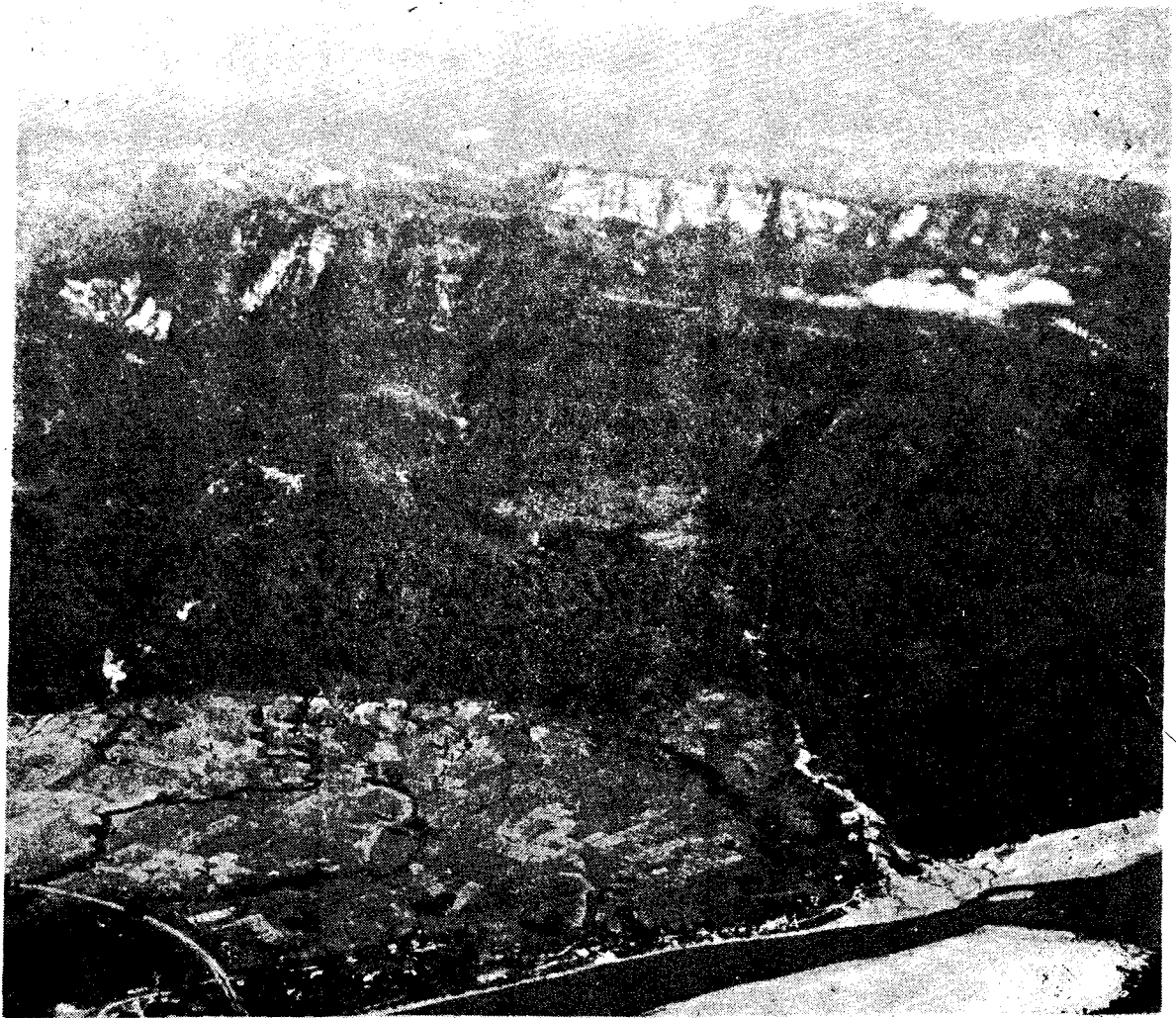
IVC1d. Bottomland Complex, sal - elephant grass.

These are benches, terraces and flood plains of inner Siwalik river valleys. There are some bluffs and inter terrace break slopes. The elevation is 200 to 400 meters. Slopes gradients are 2 to 10 percent. The soils are deep, loamy sands to clay loams, generally stone free. Many "red" soils with weak soil structure are present. The vegetation is mostly sal forest lands which are now cultivated. Pasture lands and elephant grass are on some flood plains and low terraces. Rubbly, braided stream channels cross the unit.

This is the only landtype in this region of the Siwaliks which is well suited for agriculture and road building. Problems encountered here however, include flooding of lowlands, streambank cutting and gully erosion. A detailed flood hazard zone map should be made. Surface runoff must be strictly controlled. Additional irrigation development would be beneficial.



2.60 Finely Dissected Lowlands (IVC1b) of the Eastern Siwalik Region, with Bottomland Complex (IVC1d) above. This is part of the Trijuga River valley. The North Boundary Ridge (IVC1a) is also shown. The numerous landslides appear to be natural.



2.61 Cresta Ridge Landtype (IVClc) in the Eastern Siwalik Region.

V. Terai Zone.

This is a portion of the Ganges Plain within Nepal's boundaries. It is bounded on the north by the first ridges of the Siwalik Zone and its southern boundary is the Indian border. As mapped here, it covers 21,800 square kilometers, about 15 percent of the country. It is a plain with a gentle southern slope of less than 1 percent. It is composed of mostly silt and clay-size alluvial materials. The Bhabar however, is an irregular band of fans and outwash gravels along the upper edge of the Terai Zone. The elevation is from about 100 meters in the far east to 300 meters in the west. The climate is subtropical. The Terai was originally covered by a continuous forest but agricultural development has reduced this to discontinuous blocks and strips. The gravelly Bhabar belt has remained in forest for most of its extent.

A very large number of streams enter and cross the Terai. Zollinger (1979) has classified these streams according to origin: originating in the Siwalik Zone, the Middle Mountains, and streams that begin in China. The Siwalik group is by far the most abundant, numbering over one hundred streams. Only six streams are in the latter two classes, including three of the major streams of the Central Himalayas: the Sapt Kosi in the east, the Narayani in the middle of the country, and the Karnali in the west. These three rivers are presently underdeveloped in Nepal but have great importance both as assets and liabilities to Nepal and to India. Most of the Siwalik streams are ephemeral and many are absorbed in the Terai, entering the ground water aquifer from their channels or from fields as irrigation water. The channels of nearly all the streams are braided in their upper reach, then meander after moving across the Terai a considerable distance. The full potential of the water resources, both surface and ground, has not been realized. The floods on the Sapt Kosi and numerous Terai streams are major challenges to land use in Nepal.

Since malaria was controlled about 20 years ago, the Terai has experienced an invasion of land hungry settlers from the hills and to some extent from India. The population was about 4 930 000 in 1971. Today it is estimated at 6 000 000. The accompanying loss of forest land is a major concern of His Majesty's Government of Nepal. Because, in Nepal most of the best land for agriculture is situated in the Terai, it appears inevitable that the migration trend will continue.

From a soil and water conservation view point, the major need is that forested land unsuitable for agriculture, such as that in the Bhabar, be identified and left as forest, and that development plans be made to minimize the impact of flooding and stream channel change on settlements, farm land and structures.

VA. Western Terai Region.

This is part of the Gangetic plain in southwestern Nepal.

Summary of Region

Area 5694 sq Km

25 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush	1	2	3	4	5
29	62	9	100	0	0	0	0

Location: It lies between the Nepal-India border and the Siwalik range in the following districts: Mahakali Zone - Kanchanpur; Seti Zone - Kailali; Bheri Zone - Bardia and Banke. The Mahakali River, which is also the international boundary, is on the western edge. The Karnali crosses the region at a midpoint location. The Rapti and Babai Kholas cross through its eastern section. Mahendranagar is the principal city in the west. Nepalgunj is in the eastern part of the Region.

Elevation/Relief: Elevation is from 150 to 300 meters. Very low relief with a slightly undulating surface.

Climate: Subtropical monsoon. Precipitation is 1200 to 1700 mm. According to Köppen's classification this is a subtropical monsoon climate with the maximum temperature before the rainy season (Cwag) with leanings toward a slightly drier, steppe climate (BSw). The area is noted for hot summer winds. Northwest winds in the winter bring occasional rain storms.

Geology: These are Gangetic plain deposits with recent outwash from the Siwaliks along the northern edge and fluvial deposits from a meandering Mahakali in the southwestern corner of the country. The Karnali has deposited a large delta of rubble in the middle of the region.

Vegetation: A Terai tropical sal forest with Shorea robusta, Butea frondosa, Anogeissus latifolia, Lannea grandis, Aegle marmelos and Acacia gageana. Much of the forest has been converted to agricultural land.

People: Tharu is the principal indigeneous group. Others are Brahmins, occupational castes, Muslims, Magars, Thakuris and Newars. Population densities are low for people per hectare of crop (2-3) and moderate for people per sq Km of land at 44.

Comments: These appear to be rather stable landscapes. There seems to be a clear demarcation between lands suitable for agriculture and those that are not. The exception to this is along the base of the Siwaliks where agricultural expansion onto fan deposits and terraces may be removing

an important buffer zone between the hills and the plains. Gullying appears to be taking place on these sites.

Divisions: A single land system consisting of three landtypes is described here.

VA1. Western Terai Land System.

The area is essentially a plain surface with shallow relief due to past and present stream patterns. Subunits based on type of deposition could probably be differentiated. For purposes here, three landtypes are described.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
VA1a	10	3-10	90	10	-	low	1	1	1	2
VA1b	85	2-5	20	70	10	high	1	1	1	1
VA1c	5	3-10	70	20	10	mod.-high	1	1	1	2

VA1a. Bhabar, sal.

These are the slopes at the base of the Siwaliks consisting of fans, outwash and terrace remnants. They are incised by streams coming from valleys in the Siwaliks. Slopes are 3 to 10 percent with interterrace faces nearly vertical. The materials are comparatively recent sands to boulder size deposits originating in the Siwaliks. The soils are shallow to moderately deep, sandy loams and loamy sands over cobbly substratum. The vegetation noted at one site included species of Acacia, Anogeissus, Butea, Schleichera and Mallotus.

This is a forest-dominated landscape with agriculture making inroads on finer materials between drainageways. The outer boundary of this unit is indicated by its line of continuous forest cover. The streams crossing the unit are confined to fairly narrow, steep sided drainageways. Although the area is probably grazed, slight site deterioration in the form of heavy trailing and loss of ground cover was noted in a few flights over the area.

The question pertaining to the Bhabar tract throughout Nepal is whether it is suitable for agriculture, and where the boundary between suitable and unsuitable lands is located. A detailed soil survey would be useful here. Those lands marginally suited or unsuited for farming should

be identified and kept as forest. The Bhabar is an important buffer and groundwater recharge zone between the Siwaliks and Terai. Deforestation here leads to increased flooding and spreading out of the braided streams which originate in the Siwaliks and then cross through this landtype.

VALb. Central Belt, subtropical deciduous forest.

This is the Terai proper. It consists of a flat to gently sloping surface that extends the width of the Ganges basin. This landtype has a cross-wise or lateral pattern of alluvial flat lands interspersed with strips of "micro-ridge" lands. The flat lands are cultivated and the micro-ridge lands are forested. The pattern of north-south belts found here is unique in the Terai. To the east, longitudinal belts (east-west) are parallel to the foot of the Siwalik. It should be noted that in spite of extensive forest lands here, nearly all the suitable land is already being cultivated.

The live streams are braided in their upper stretches and meander in their lower stretches. They mostly occupy incised channels. The Karnali is the exception to this but even its great power is defused by its spralling, braided pattern. The soils are universally deep and range from sands to clays in texture. The soil pattern is dictated by the depositional history.

The natural vegetation is a forest with sal (Shorea robusta), sissoo (Dalbergia sissoo), khair (Acacia catechu), nim (Azadirachta indica), mahuwa (Madhuca indica), simal (Salmalia malabarica), kadam (Adina cordifolia) and bot dangare (Lagerstroemia sp) as the major species.

About 60 percent of this landtype is cultivated. Agricultural suitability and productivity is a function of surface form, soil type and availability of water for irrigation. A small percent of the area is in waste land. Such areas are strips and spots adjacent to streams, along roadways and in abandoned fields. These areas are bare, rutted or have a sparse cover of brush or weeds. Shallow gully erosion is common on these sites. Some wind erosion has been noted in the flood plains of major rivers and from fields during fallow periods. Heavy trailing was observed in forested areas. This is evidently the result of community herding practices.

The soil and water conservation problems are comparatively minor. Attention however must be given to channel stabilization; encouraging planting of wind breaks; protection and maintenance of forest cover next to braided stream courses, and management of the forage resources. The degraded agricultural lands can be reclaimed by putting them back into agricultural production. Protected tree plantings should also be experimented with on such lands. Research is needed to determine the effect of cropping and irrigation practices on the nutrient status and productivity of soils. The effect on soil fertility of the use of manure for fuel would be one aspect of this investigation.



2.62 A village in the Western Terai Land System (VA1). Note the margin of the Bhabar (VA1a) in the upper part of the picture and the lighter colored wasteland.

Flooding appears to be less severe here than in the more eastern segments of this zone.

VA1c. Recent Alluvial Lands, subtropical deciduous forest.

A small but distinct segment of the region is on young river deposits. Such lands are a maze of old channels. The largest extent of this kind of land is along the south western corner of the region. The Mahakali has evidently shifted its course to the south leaving a section of its old flood plain. Singhphur Wildlife Reserve is in this area. The surface is undulating to benchy. Wet and dry spots are common. The soils are loamy sands and sands. The vegetation is a sal forest. There are pockets of agriculture here but most of the area is in forest.

Given the usual fragile nature of sandy soils, study is required before the forest lands are converted to croplands. It is likely that forest is the most valuable use of most of these lands, especially on the drier sites.

VB. Central Terai Region.

This central block of the Terai is bounded by the Siwaliks on its north, east and west sides, and by the Indian border on its south side.

Summary of Region

Area 4143 sq Km

19 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush	1	2	3	4	5
22	72	6	100	0	0	0	0

Location: Lumbini Zone - Kapilvastu, Rupandehi and Nawalparasi districts. The principal towns here are Butwal, Bhairahawa and Taulihawa. The region is crossed by the Banganga and Tinau Kholas.

Elevation/Relief: The elevation is 100 to 300 meters. Relief is very low. The land slopes at about 10 to 20 meters per kilometer toward the south.

Climate: Subtropical monsoon. The precipitation is 1400 mm on the southern border to 2500 mm at the foot of the Siwaliks along its northern edge. It is classified according to Köppen's system as subtropical monsoon with the maximum temperature before the rainy season (Cwag).

Geology: Gangetic Basin sediments with more recent deposits of sediments from the Siwaliks and Mahabharat Lekh.

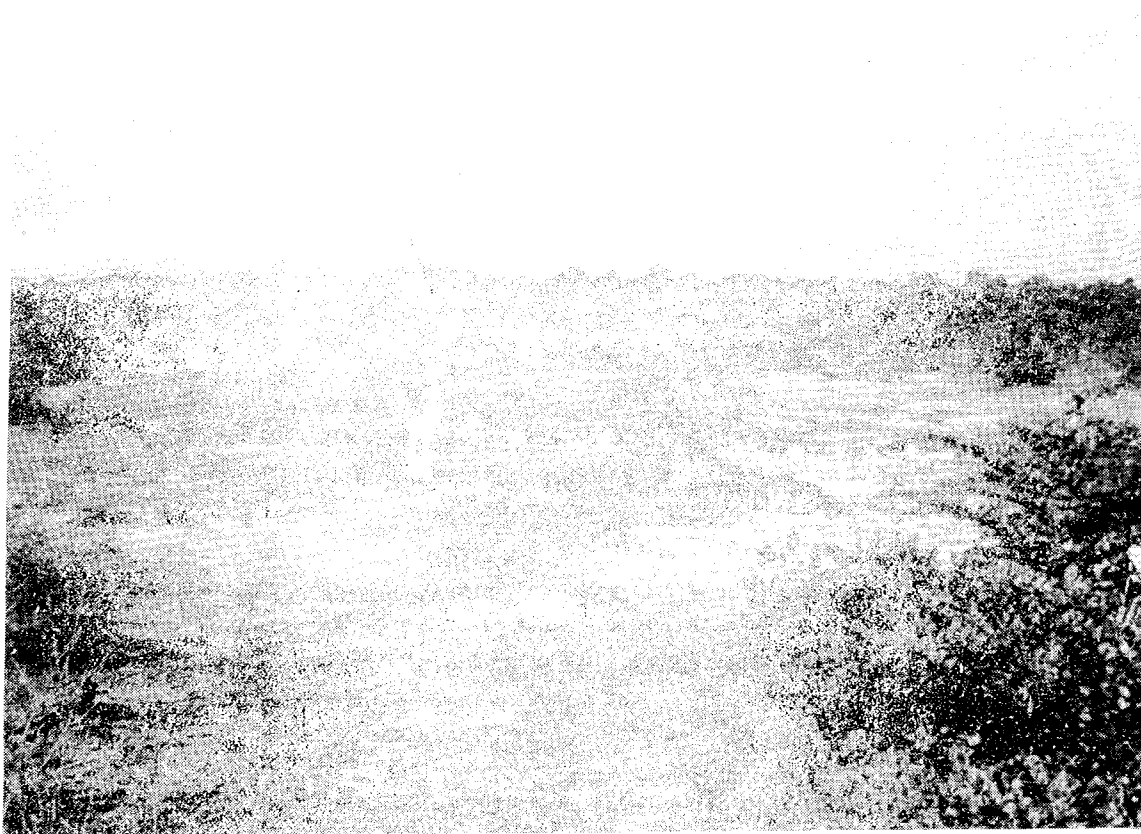
Vegetation: A Terai tropical sal forest. In addition to sal (Shorea robusta), the principal genera here are Terminalia, Bombax, Acacia and Dalbergia.

People: Tharu with Brahmin, Thakuri and occupational castes. Population density is one of the lowest in the kingdom at 3 people per hectare, based on cropland. It is high to very high (117-205) per square kilometer based on total land area.

Comment: The watershed condition here is excellent. Two situations however require attention. There are open bare gullied land areas near roads and drainageways. Although such areas are a minor part of the region, they should be examined in detail to determine their cause and rehabilitation. Land ownership may have a role here.

The second problem is with cut-over land on shallow soils. Some of these lands appear to be unsuitable for agriculture and very difficult to get forest regeneration established. The result is that soil present now is being eroded and an open-brush cover is taking over. Forest lands should be studied to predict probable consequences of logging and to make plans for site regeneration.

Division: The region was treated as one land system with two landtypes.



2.63 A cut-over area in the Central Terai Land System (VB1) where erosion has occurred due to excessive grazing.

VB1. Central Terai Land System.

Land System Summary

Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
VB1a	20	2-10	70	20	10	low	1	1	1	2
VB1b	80	1-4	10	85	5	high	1	1	2	1

VB1a. Central Bhabar, sal.

This is a broken, irregular zone next to the foot of the Siwaliks. It consists of terraces, undulating lowlands and outwash slopes. Slope gradients are 2 to 10 percent. Materials are a mixture of outwash sands, silts and gravels from the Siwaliks. Some terrace escarpments show these deposits to be over 50 meters thick. The soils are fine sands, loam and silt loams. Many are very red. The vegetation is a sal forest with Terminalia sp, Mallotus sp, Clerodendrum sp and Syzygium cuminii.

About 40 percent of this unit has been converted to farm land. All of the forested area is heavily grazed. The silty soils are highly erodible. Dense trail patterns were noted in places.

Study is needed to identify and map lands suitable for agriculture development before the remaining forest has been destroyed. Zoning of river valleys would limit flood damage. Special protection must be given to bridge sites here. Grazing should be controlled. The forage resource and needs must be studied as a basis for a grazing management plan.

VB1b. Central Terai, subtropical sal/Terai forest.

This landtype forms the bulk of the region. It is a plain crossed by meandering streams. Slope gradients are less than 2 percent. The soils here are mostly deep, silt loams over silty, clay loams. The vegetation was originally a sal forest. Except for some broken fingers of forest reaching into the plain from the Bhabar, this landtype has been converted to agriculture. There is bare, gullied waste land along some of the streams and roads, though this appears to occupy less than 1 percent of the area. Cut over forest lands have been excessively grazed, resulting in considerable soil erosion and impeded natural regeneration.

For most of this landtype, the concern should be for maintaining or improving agricultural production through improved soil fertilization and irrigation practices. There must be an effort to follow up

treatment of cutover land more rapidly with either planting, and/or strict control on grazing. The alternative appears to be conversion of forest lands to waste lands. The patches and strips of waste land may be large sediment producers because of their proximity to streams. These lands should be studied to determine their capability and conservation needs. Plantings of trees or grasses, followed by protection and management is probably needed. There are many opportunities for tree planting here. An increase in tree cover, in groves and in rows would provide wind protection, firewood and shade. Conservation traditions of tree planting and small erosion control structures need to be encouraged.

VC. Eastern Terai Region.

This region is a segment of the Ganges plain in southeastern Nepal. It is a great, sloping surface crossed laterally by numerous rivers. It is the most productive agricultural region in Nepal.

Summary of Region

Area 11962 sq Km

55 percent of Zone

Cover Types - Percent			Watershed Condition classes Percent of Region in each				
Forestry	Agriculture	Brush	1	2	3	4	5
13	83	4	100	0	0	0	0

Location: The region covers the southern parts of eleven districts, from Jhapa to Parsa. The principal towns here are Biratnagar, Jhapa, Bhadrapur, Janakpur and Birgunj. The Sapt Kosi crosses the landtype. Other rivers here are the Mechi along the eastern border, the Bering, the Roluwa Nadi, the Kamala, the Bhauhi Nadi and the Bakeya Nadi. The streams originating in the Siwaliks are ephemeral or have greatly reduced flows during the dry period.

Elevation/Relief: The elevation is 100 to 300 meters. The relief is very low. There is a slight southerly aspect. Slope gradients are less than 3 percent.

Climate: Subtropical monsoon. Precipitation is 1300 to 2400 mm with the higher rates along the inner part of the Terai. The area is noted for its hot, wet monsoon season. The climate is classified according to Köppen's method as a transition between a subtropical monsoon with maximum temperatures before the rainy season (Cwag) and tropical, dry winter savanna climate (Awg).

Geology: Gangetic basin materials with alluvial fill. The northern part has recent outwash deposits from the Siwaliks.

Vegetation: The original cover was dense subtropical forest composed of Terminalia spp, Adina spp, Schleichera trijuga, Dillenia spp, Eugenia jambolana, Salmalia malabarica and Shorea robusta.

Over three-fourths of the forest has been cleared for agriculture. The remaining forest is mostly in the Bhabar along the foot of the Siwaliks.

People: The Tharus were the original people here. The region is now heavily populated by Brahmins, Chhetris and occupational castes. Newars are prominent in the towns. The population density on a unit of land basis, is moderate to high at 60 to 300 people per square kilometer. Based on area of crops, the density is low at 2-3 people per hectare, one of the lowest in Nepal.

Comments: Minimizing the impact caused by flooding is the major conservation need here. Classification of and planning for lands now forested are additional needs. Zollinger (1979) classified and mapped the rivers of the Terai as a first step in this task. There are some cultivated, dune-like areas that need investigation to determine the importance of wind erosion.

Divisions: The region has only one land system which has been divided into two landtypes: the Bhabar section of the Terai at the base of the Siwaliks and a strip of the Terai proper along the southern boundary of Nepal. This is undoubtedly an over simplification of these vital and complex lands.

VC1. Eastern Terai Land System.

Land System Summary

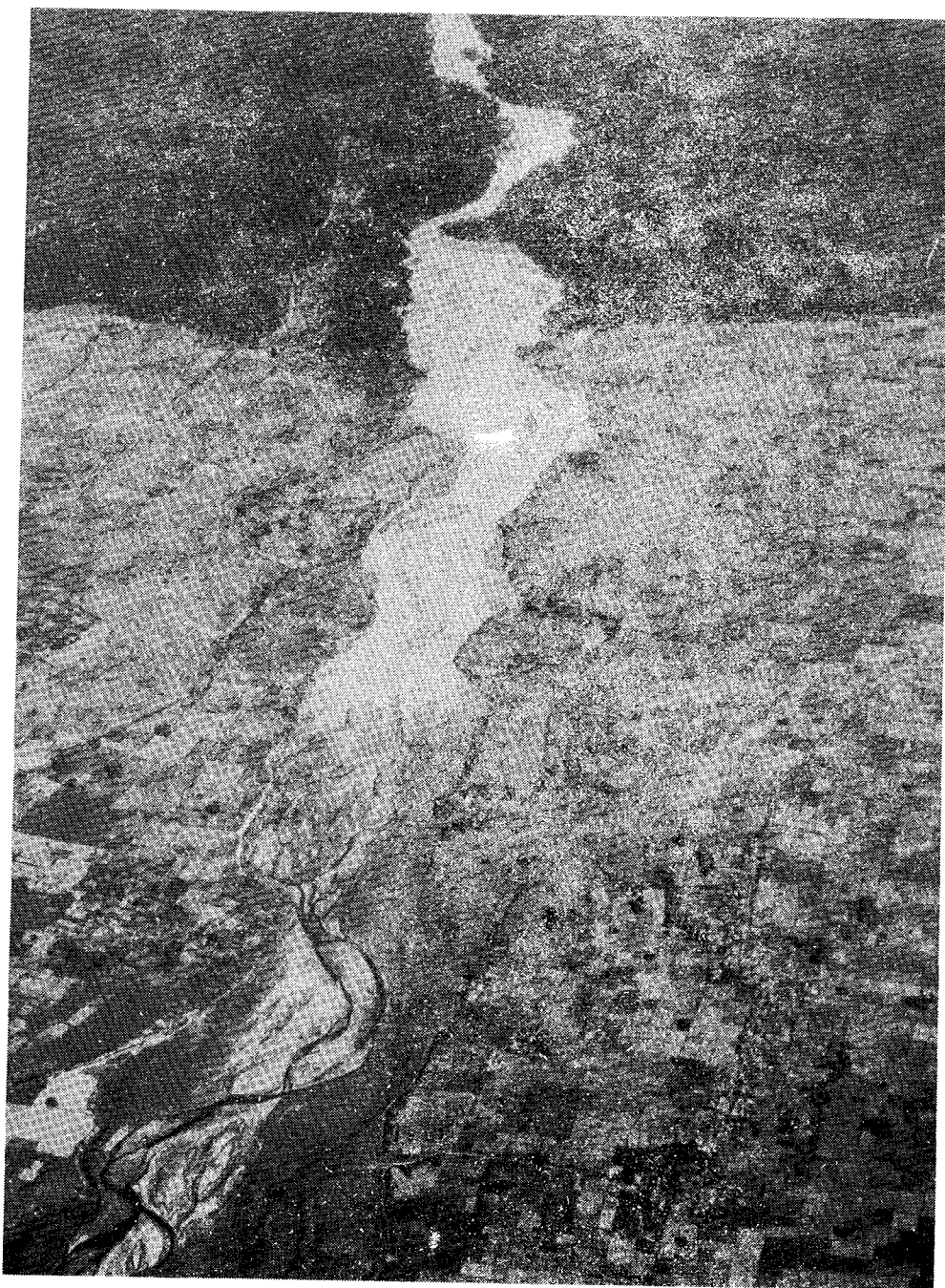
Landtype Symbol	Area (%)	Slope gradient (%)	Land Use (%)			Pop. Den.	Wsh. Con.	L.S. Haz.	Eros. Haz.	Terr. Suit.
			For.	Ag.	Br.					
VC1a	10	10	80	20	0	mod.	1	1	1	2
VC1b	90	1-5	5	90	5	high	1	1	1	1

VC1a. Bhabar Land, sal.

These alluvial plains, outwash fans and river bottomlands are at elevations from 120 to 300 meters and have slope gradients of 3 to 10 percent. They form a belt at the base of the Siwalik foot hills. The soils are moderately deep to deep, loamy sands and are gravelly in places. The vegetation is mostly a sal forest but also includes Terminalia spp , Adina sp , Salmalia sp and some grasslands. This is a transition area between the solid forest of the Siwaliks and the pure agricultural lands of the central Terai. The area is mainly degraded forest. Parts of it are in the process of being converted to agriculture. Gullies, dry channels near streams, and braided stream channels cross this area from the Siwaliks. This landtype has some of the last of the Terai forest land. The coarse textured soils indicate that most of this area would be poor agricultural land.

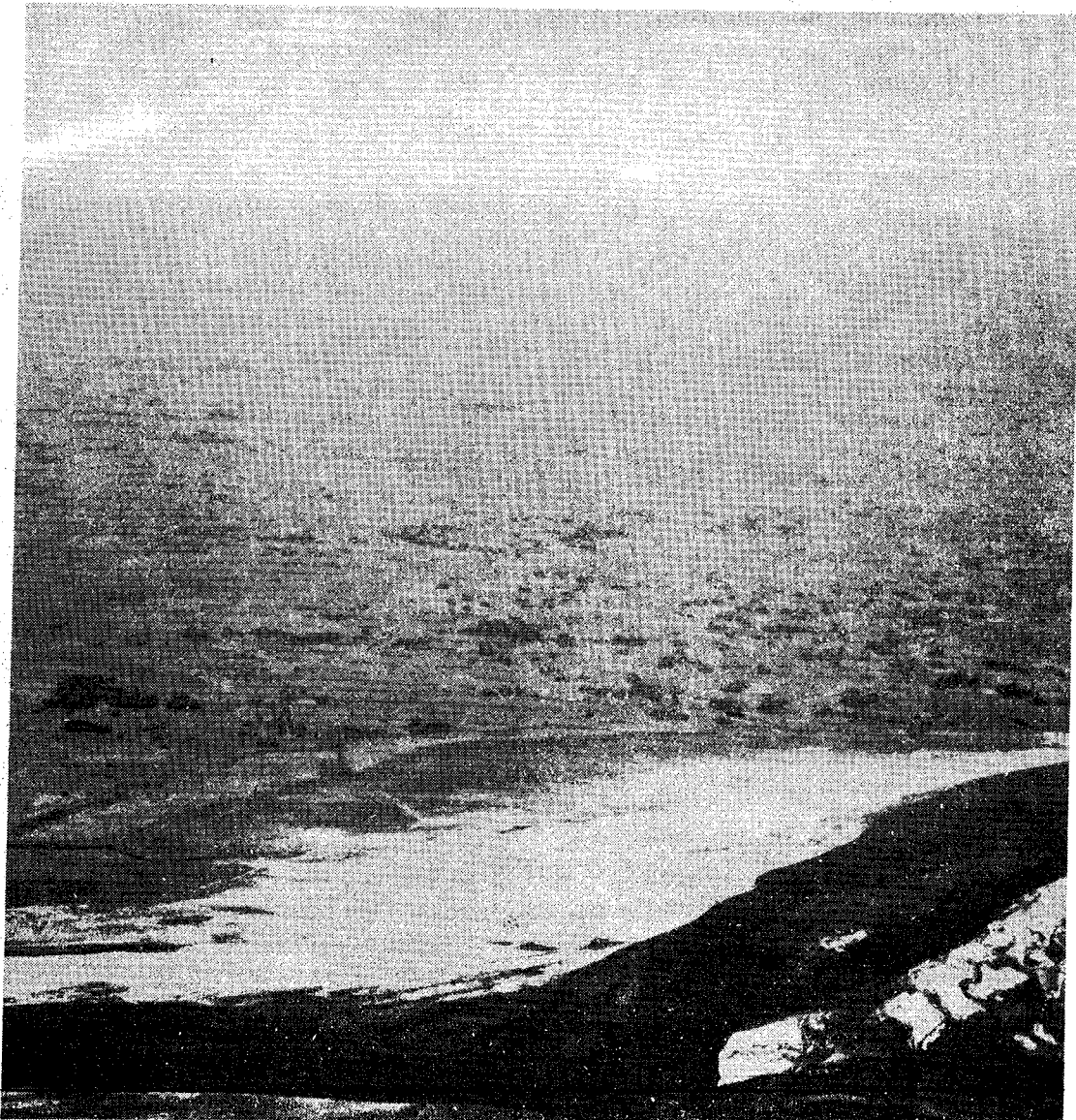
VC1b. Terai Land, cultivated.

These alluvial plains at 100 to 200 meters have 1 to 5 percent slope gradients. The soils are deep, stone free, silt loam, sandy loam and clay loam. The vegetation was originally sal forest but now it is nearly completely cultivated. The low gradient slopes are responsible for this area's good watershed condition. Some flooding by streams, poor drainage in places during monsoons and a few wet lands in abandoned



2.24 The Upper Valley Land System (IID2), Trisuli River canyon with the Canyonlands (c) and River Terrace (d) landtypes.

stream channels are problems. Much of the water that leaves the Siwaliks enters the ground in the Bhabar or the upper part of this landtype. It is believed to reappear in the lower part of this landtype, creating what was, in its original condition, a swampy area. Most land use problems require agronomic solutions. Wind erosion, which occurs in a few places, requires detailed study. Teaching of practices which maintain or enhance soil fertility is needed. The effect of prolonged application of synthetic fertilizer should be investigated.



2.65 A braided stream entering the Terai. Note the general broadening of the channel as the stream leaves the forested area and abrupt change from braided to meandering form.

Part 3. HOW THE INVENTORY WAS MADE

A land system approach was used to make the inventory. This consisted mainly of identifying, mapping and describing units of land thought to have uniform physical characteristics important to watershed management.

The inventory process is outlined under the four headings: Preliminaries, Mapping, Information Collection/Descriptions and Interpretations.

1. Preliminaries.

These are the several tasks needed to get the inventory launched in the field. The first of these tasks was the conception of the inventory in the project document for FAO/UNDP/Department of Soil and Water Conservation Project NEP/74/020, Integrated Watershed Management, Torrent Control and Land Use Development.

The project document defines the inventory and specifies the approach as: "... a first, broad reconnaissance of the country's land degradation and erosion problems and the extent of forest destruction, using a land system approach."

It describes the purpose of the inventory, "... to identify major problem areas of erosion, landslides, torrents in upper catchment, etc. and land degradation problems and also serve to point out where more specific data or surveys will be needed. This serves as a first step for an inventory of land use and as a basis for future planning of land use", (page 7 of Project Document, NEP/74/020).

The project document also identifies the staffing requirements, time allocation and financing needed to make the inventory. With the acceptance of the project document by all parties, the first step in executing the inventory was taken by recruiting the staff. The following is a listing of inventory staff members:

- DeVon Nelson - Team leader for the inventory with training in forestry and soils and 15 years' experience as a soil scientist for the Forest Service in the United States.
- Peter Laban - A Dutch Associate Expert who is a soils graduate and had experience in an FAO forestry project in Senegal.

As counterpart staff we had:

- B.D. Shrestha - A 1974 geology graduate with experience in the Department of Hydrology and Meteorology in groundwater.
- G.P. Kandel - A 1977 forestry graduate from Dehra Dun Forestry College, India. Work on the inventory was Kandel's first assignment.
- N.P. Paudel - Same as Kandel. Mr. Paudel worked the first year on the Inventory before leaving to work for the Department of Forests.

The staff was assembled by August 1977. The first pre-field work task undertaken by the inventory staff was to review the information need. The following aspects of the information need were treated:

- a. Kind - The major information need was for "watershed condition". It was the pattern of watershed condition that was to be the basis of a "master plan" for soil and water conservation in Nepal. It was soon recognized that this would have to be expanded to give some insight to the cause of erosion as guidance to its remedy. Erosion condition class alone would not be enough. It was decided that data on soils, topography, vegetation, geology, climate and land use would also have to be collected.
- b. Intensity of Information - A reconnaissance is "a preliminary survey usually executed at a relatively low cost," (Schwartz, et. al. 1976). Classes (an ordinal scale) rather than quantitative figures (interval scale) for condition and natural resources are used. There is not a standard scale for inventory intensity using a land classification approach. Practical constraints on intensity of data collection were provided by time of information need, crew size and mapping medium.
- c. Timing - The inventory was to be completed within two years and the contracts for the principal foreign staff members were written accordingly. Unfortunately, delays in approving and filling positions, and transfers, made a solid block of two years' duration for the entire crew impossible.

A second pre-field task was the collection of mapping materials and information on the natural resources in Nepal.

The mapping medium was black and white, band 7 (near infrared) 1:500 000 Landsat imagery. Satellite imagery was used because it provided the only complete photograph-like coverage of Nepal when the inventory began. Small scale aerial photography has since become available for about 60 percent of the country. This, along with a limited amount of Skylab photography, false color landsat imagery at scales of 1:250 000, 1:800 000 and 1:500 000; and band 5 black and white, 1:500 000 imagery, have been used as supplementary mapping tools. The attraction of the 1:500 000 scale was that it reflects the intensity of our field work and that the 1:500 000 map on a mosaic of the imagery is a convenient size for display. Band 7 shows the physiography (the principal mapping criterion) vividly. Appendix 1 has a list of the imagery used and an index map to the imagery.

Information on the natural resources was accumulated and was used in mapping and describing the land units. The informational working tools we found particularly helpful are given in References.

2. Mapping.

Using the land system approach (as required in the project document), the country was sequentially divided into categories of greater refinement. The result of this work is a four-tiered hierarchy of land units within which

watershed conditions and management needs, along with descriptions of the basic natural resources and the land uses, were made. The final map is at the land system level on the mosaic of black and white satellite imagery.

The four levels in the mapping hierarchy used are Zone, Region, Land System, and Landtype. Each term could be prefixed with "ecological" to emphasize the perspective sought in the inventory and to distinguish it from administrative units. These units were defined in the introduction to the land unit description section.

The primary criteria for land unit delineation were physiographic. The rationale for use of physiography was that it is mappable on the satellite imagery and that the pattern and intensity of man's activities in a mountainous environment are controlled mainly by physiographic features of the land. This assumption should be qualified to say man's "agricultural" activities are controlled by physiography. Road-building, commercial and defense developments are less rigidly linked to regional physiographic differences. An effort was made to identify areas of land degradation related to these latter developments in a "hot-spotting" approach. A list of seriously eroded areas called "hot spots" which are not tied directly to the land units identified was made based on ground and air observations.

The physiography was supplemented by other land features as mapping criteria. As indicated, mapping criteria varied by mapping level and geographical location.

The mapping process began with preliminary mapping at a zonal level on a mosaic of 1:800 000, color satellite imagery. The purpose of this preliminary mapping was general orientation to the landscapes in Nepal and planning field transects.

Secondary mapping was made on individual sheets of 1:500 000, black and white, band 7 Landsat imagery. These delineations were at zone, region and land system levels. Zonal lines were based on the preliminary mapping lines as modified to reflect changing zonal concepts and information from air and ground transects. Regional boundaries were drawn, discussed, field checked and removed and redrawn before being accepted. The question asked in deciding the validity of a line was, "Would the land areas separated be treated differently for watershed management purposes?" This process was repeated for the land systems separated within the regions. A final review of the regions and land systems was made to see if any could be grouped without loss of information. A question at this stage was, "Do we have enough information to maintain the unit as a separate entity?" Additional ground or air data was collected if our informational base was weak. If the answer was 'no' and we did not have time to collect more information, the line was removed.

The final map was made by transferring lines from the twelve individual sheets to a mosaic of the field sheets covering the entire country. The mosaic was made photographically at a 1:500 000 scale. The names of the principal rivers, peaks and cities were drafted onto the base map. The national boundary and geographic co-ordinates were added using the Tactical Pilotage charts made by the United States Defence Mapping Agency. Charts H-9A,B,C and D, numbered respectively: 439, 438, 553 and 552, were used.

Mapping criteria used for different mapping levels

Mapping Level	Mapping Criteria
Zone	Zones are strongly related to elevation. Many land features correspond to elevation zones. The independent variables are climate and geologic structure and the dependent variables are geomorphic process and resulting landforms, vegetation and land use. Criteria varied by zone, e.g. the Transition Zone and the Siwalik Zone contrasted visibly on the satellite imagery because they were forested and adjacent zones were not.
Region	Criteria for separation of regions were related to the character of the zones. Regions in the Terai and Siwalik Zones were separated on the basis of regional climate as it varied in an east-west direction; the western regions are driest, the eastern regions wettest. Regions in the Middle Mountain Zone were separated by differences in drainage pattern and density, and relief. Transition Zone regions were separated by degree and pattern of dissection: abrupt or irregular margin, linear or circular configuration. The High Himalaya Zone regions were separated on relief, degree of dissection and regional climate.
Land System	Criteria varied by zones and regions. Generally degree of development and land forming processes were used to separate land systems within a region.
Landtype	Most common criterion was slope position, but landform, slope gradient and vegetation type were also used.

3. Data Collection/Land Unit Descriptions.

There were four sources of information used to identify, describe and make interpretations of the land units.

- a. Literature - The most useful sources are listed in References. Information was sought on the physical and cultural characteristics of the land throughout the duration of the inventory. Much of this information merged to form a general background for the inventory work. Some information was used directly in the text of the report. Dobremez's (1970 through 1979) vegetation maps and descriptions are examples of

direct use. The identification and mapping of most of the zones is treated in the literature (Karen 1960, Thapa and Thapa 1969, Hagan 1971). No literature source however recognized a Transition Zone. Although it is quite voluminous, literature is a major problem because of the lack of central library facilities in Nepal. Information tends to be scattered through the bookselves of projects, donor groups, government agencies and individuals. One of the first tasks of people beginning projects in Nepal is an obligatory round of the ongoing projects and departments to get literature or leads to literature. The Integrated Watershed Management Project became a key stop for many people trying to get their feet on the ground because of the scope of our informational search and field experience.

- b. Aerial Transects - Approximately 44 hours of overflights were made for the purposes of getting acquainted with the Nepali landscape, gathering information on the condition and use of the land, identifying and confirming land unit boundaries, and photographing the landscape. An additional 28 hours was spent flying to drop-off points for beginning treks, or from pick-up points at the end of treks. Notes on land features, land uses and conditions were made in notebooks and on cassette tapes with varying degrees of satisfaction. The biggest problem was keeping oriented in the rugged Nepali landscape.

To get more out of our flight time, we devised a method in which we carried 1:250 000 color, or 1:500 000 black and white satellite imagery in the plane. Representative square kilometer plots were selected, plotted on the satellite imagery, and described from the air using the form shown in Figure 3.2.

The data on these forms were summarized by land systems. The biggest problem with this approach was that landtypes could not be identified rapidly enough to relate our plot data to landtypes and therefore most plots were rounded by regions and land systems. The data collected in this manner were valuable as "ground truth", a basis for interpreting the various tonal patterns on the satellite imagery. We flew in a Pilatus Porter STOL (short takeoff and landing), seven-passenger aircraft at about 130 Km per hour. Elevation above the terrain varied from 2500 meters in the flat Terai to less than 100 meters when crossing ridges in the hills.

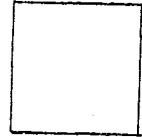
- c. Remote Sensing - This was mainly the visual interpretation of unenhanced satellite imagery. Nearly all of the land features used to make land unit delineations were visible on imagery. The following land and land use features were visible on the imagery of 1:250 000 and partially on 1:500 000.

Physiography

1. General surficial characteristics, e.g. flat or hilly,
2. Patterns of landforms,
3. Drainage density and pattern,
4. Relative relief,
5. Elevation - related zones,

Figure 3.1 Example Flight Description Form

Symbol*



NATURAL RESOURCE INVENTORY DATA COLLECTION FORM

ECOLOGICAL REGION

DATE _____

1. Sample Plots

No.	Region	Agr.	For.	Brush	Cond.	Remarks

* Rectangles were marked so they could be related to specific flights.

6. Cloud patterns at different seasons,
7. Snow cover at different seasons,
8. Lakes, rivers, glaciers.

Vegetation

1. Forest Cover,
2. Forest cover changes over time,
3. Wet lands.

Land Use

1. Cultivated land,
2. Road locations, partially.

Earth Disturbances

1. Flood zones of larger rivers,
2. Large landslides.

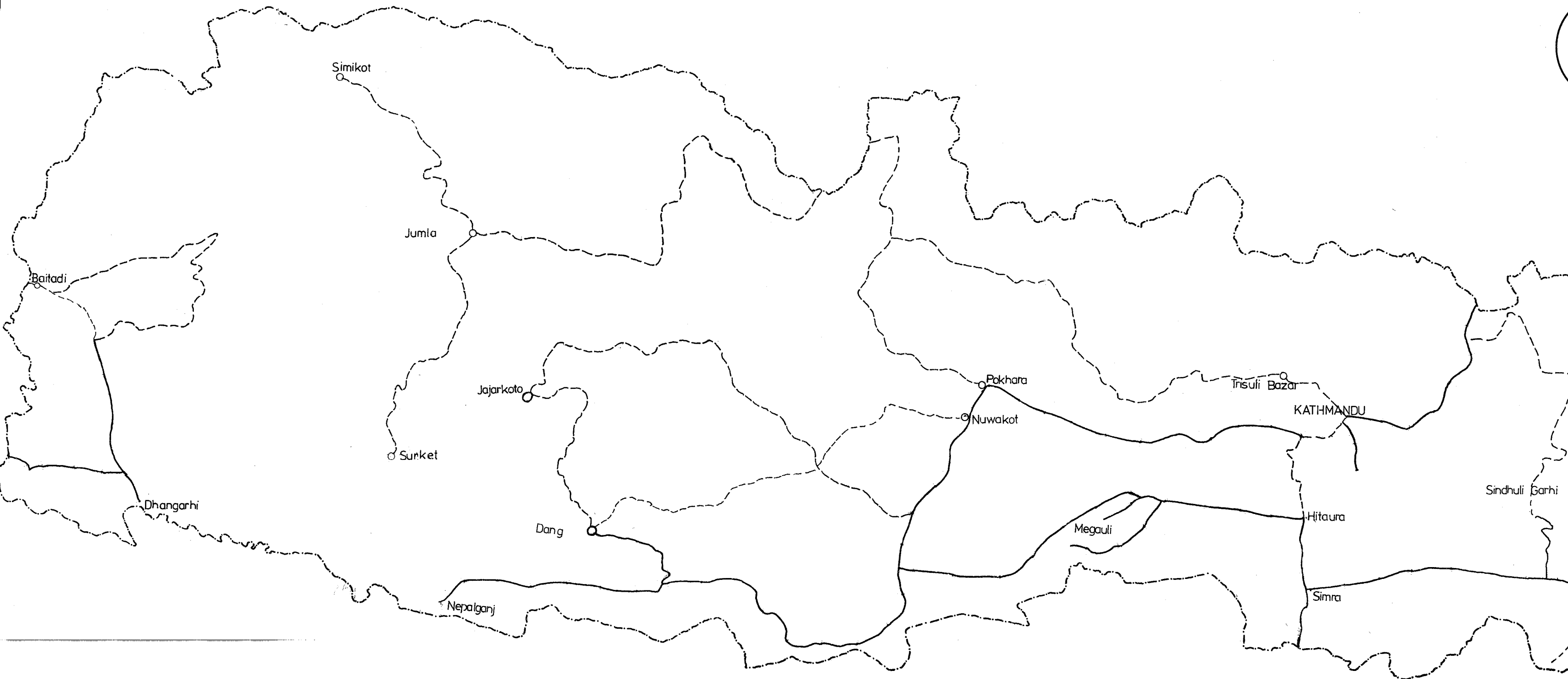
The landslides are not shown with sufficient consistency to permit direct mapping. Land features reflecting regional climatic differences were not visible. Delineations of regions in the Siwalik and Terai Zones had to be made arbitrarily to show approximate zones of major precipitation rate classes.

Remote sensing was a means to identify and delineate land units at the zone, region and land system levels. Landtypes could not be identified or delineated on satellite imagery. Landtype delineation would have required a scale of 1:100 000 or larger and was therefore beyond the scope of this inventory. Landtypes were identified in field transects and by spot checking 1:50 000 aerial photographs. They were therefore described but not mapped in this inventory.

- d. Ground Transects - Routes used to make these transects are shown in Figure 3.3. The transects followed established trail routes or roads. As indicated in the map of these transects, most were made on foot. The usual practice was to fly to a STOL landing field in the hills and walk to another landing field or to a road end where the party would be picked up. The field party generally consisted of the staff leader or his assistant, one or two Nepali counterparts, and two to four porters. The trek from Jumla to Jomosom through Dolpo and Mustang was an exception where we had a Sardar, a cook and 20 porters. The treks lasted 8 to 30 days and covered 50 to 300 miles.

The purpose of the treks was to gather information on the erosion problems and the natural resources. Landtypes were identified. Premapped regional and land system boundaries were examined. Descriptions were made ~~periodically in each land system~~ passed through. The land systems were identified by the combination of landtypes noted in the vicinity. Sites of descriptions were usually prominent points where large areas could be viewed, often after passing through the described landscape for some distance. The descriptions were a summation of observations made enroute.

Transect Routes Used In National Inventory Of Watershed Condition



Relationships were sought among condition indicators, land uses and physical characteristics. Hypotheses relating land use and natural land features to watershed condition were made, tested, rejected, modified or accepted on the basis of field observations. One person described the process as "continuous integration." We recorded these relationships, and basic resource and condition data on description cards.

Figure 3.3 shows the information on the field description card we developed for the inventory. The classes used to describe various land features recorded on the form are given in Part 2.

Figure 3.3 Example field description card

Date _____	ELU _____
Location _____	
Landform _____	
Topography Slope _____	Aspect _____ Elev. _____ Relief _____
Geology Material _____	Dip _____ % Fract. _____ Proc. _____
Soil Texture _____	Colour _____ Depth _____ Stoniness _____ % Rock _____ %
Vegetation Type _____	Cover _____ Key Spp. _____
Landuse: Kind _____	% Kind _____ % Kind _____ %
Population Density _____	Groups _____
Wshed. Cond. Indic. _____	

ELU = Ecological Land Unit

An attempt was made to gather information from the local people on various aspects of watershed condition, to assess their perception of the problem and its causes. This effort involved interview of local officials. A colorful badge was given to local dignitaries as a token of appreciation for their cooperation.

The field trips were an essential part of the inventory process. In addition to collection of data, it gave the field party a sense of the magnitude and complexity of the erosion problem in Nepal. This "feel" for the problem and the land was difficult to convey, but an attempt was made to weave it into the land unit descriptions in the inventory report.

Descriptions based on field observations, remote sensing and literature were made of each zone, region, land system and landtype for the inventory report. Brevity and clarity were attributes sought. Repetition was avoided as much as possible, but information in lower, more detailed units was included in higher level unit descriptions in a condensed form to convey a knowledge of the land and its problems to persons not reading the land system and landtype descriptions.

4. Interpretations.

Descriptions and guidelines for making the four interpretations we used follow.

The guidelines were not used as an ironclad rule. There was inevitably a degree of subjectivity in making these rankings. The guidelines use more than one factor; where interpretation of different factors would lead to different class values, the "poorer" class was generally used. This is based on the idea that one land feature can have a limiting influence or control of land use. Again, application of this rule was made with discretion.

Class values for land features used in making these interpretations are given in Part 2.

- a. Watershed condition: This is the principal interpretation made in the inventory. As previously defined, it is the state of soil erosion in an area in comparison with the soil erosion estimated for that area under natural or "well managed" conditions. Watershed condition class was determined by comparing the existing amount of erosion with an estimate of the natural erosion. The natural erosion estimates were based on observations in undisturbed part of the landtype where possible. Since these are somewhat rare, the following Table 3.1 was used as a guide to watershed condition classification.

Ground Cover includes herbaceous vegetation at ground level, litter or coarse material (gravel, cobble, etc.) which effectively absorbs and protects the soil from rain impact and inhibits surface flow of water. Use of this factor is based on the assumption that natural vegetation cover in Nepal is over 95 percent. This of course will not hold in much of the High Himalayas or in the rain shadow valleys in the Mustang-Dolpo areas. Other class values were used in these areas.

The rill and gully property is based on the assumption that this type of erosion is generally man-caused.

Landslide is a general term used to cover a wide range of mass movements: debris avalanches, landslides, debris slides, slumps, mud-rock flows, etc. The ratio is based on numbers of these mantle disturbances. Size is also a consideration however. Where there is a significant difference in the size of man-caused versus natural landslides the larger landslides were counted as a multiple of a "natural", base size landslide.

Table 3.1 Watershed Condition Classification

Factor	Watershed Condition Class				
	1	2	3	4	5
% Ground cover	more than 95	90-95	85-90	80-85	less than 80
Rill and gully erosion	absent	absent	present	present	present
Landslides, ratio of accelerated to natural	less than 1.2	1.2-1.5	1.6-3.0	3.1-5	more than 5
Stream channel cond.,					
a. bank erosion	none	slight	moderate	Weak-braiding pattern	braiding, aggraded bedload
b. % bank vegetation	more than 60	30-60	10-30	none	none

Stream channel indicators may apply to watershed conditions outside the ELU in which they occur. This estimate is made for perennial and ephemeral streams. There may be a continuum between gullies and steep, ephemeral stream channels.

The five classes of watershed condition are defined in Part 2.

- b. Landslide Hazard: The term "landslide" is used here for all forms of mass movements of the earth's mantle. The types of mass movements in Nepal vary by ecological zone and slope location. Debris avalanches and earth flows are the most common form in the Middle Mountains and Mahabharat Lekh. Mud flows, slumps and rock falls are most common in the Siwaliks. Rotational block slumps occur in some terraced areas. The criteria outlined in Table 3.2 were a guide selected as hazard class for this wide range of mass movements. This was used as a guide, not an arbitrary key to classification. Many slopes with gradients over 50 percent for example are quite stable, as indicated by a lack of existing landslides, stable road cut slopes, heavy vegetation cover etc. Such slopes were placed in a higher, more stable category than the guide might suggest.

Table 3.2 Landslide Hazard Classification

Land Characteristics	Landslide Hazard Class				
	1	2	3	4	5
Slope gradient class	1	2	3	4	5
Bedding plane/subs -	Dip is away from slope surface		Dip is with slope surface		
Landslide occurrence: Number per square kilometer	Absent	3 or less	4 to 8	9 or more	

The guide was supplemented with observations on slope position and geologic materials. The most sensitive slope facets were those in contact with streams of water, i.e. toe slopes. These were also the steepest, and frequently the most heavily grazed. The result is a very high incidence of landslides. The steep slopes between river terrace levels also have a high number of landslides. This is due to the high intensity of land use in adjacent lands; steep, often nearly vertical slope gradients; unconsolidated materials, and frequent occurrence of springs on these slopes. Materials were also considered in predicting landslide hazard. The sensitivity of materials to landslides is shown in Figure 4.7. Generally, the less consolidated materials have the greatest number of landslides. These include shales, phyllites, gravelly lacustrine deposits and lacustrine and outwash materials.

- c. Soil Erosion Hazard: This is an index of the vulnerability of land area to soil loss by splash erosion if the vegetation is removed. It was applied to untterraced areas. Its criteria are a minimum number of factors that (1) were obtainable in the intensity of the inventory and (2) that have high significance to the erosion process. Table 3.3 shows the guidelines used to determine soil erosion hazard.

A soil with a complete ground cover of litter, coarse material or herbaceous vegetation is assumed to be fully protected from splash erosion. If one or more of these covers is disturbed by man's activity, grazing, cultivation or logging for example, then the exposed soil will erode at the rate controlled to a large extent by the factor in the guideline.

Soil texture assumes that soil loss by splash erosion is more rapid in coarse soils than fine soils.

- d. Terrace Suitability: This is an estimate of the suitability of sloping areas for constructing terraces for cultivated crops. The outslope, where used, is assumed to be less than 5 degrees.

Table 3.3 Soil Erosion Hazard Classification

Factor	Soil Erosion Hazard Classes				
	1	2	3	4	5
Soil texture class	2,4	1,5	3	6	6
Slope gradient	1	2	3	4	5
Relief Class	1	2	3	4	5
Slope aspect	N	E,W	E,W	S	S
Revegetation rate (years)	1	1-2	3-4	over 4	over 4

Table 3.4 Terrace Suitability Classification

Factor	Terrace Suitability Classes				
	1	2	3	4	5
Slope gradient class	1,2	3	4	4	5
Soil depth class	1	2	3	4	5
Surface rock class	1	2	3	4	5

Slope gradient is the principal limiting factor. It affects the width of terracing and height of inter-terrace slope. This factor becomes more critical as soil depth decreases.

Soil depth is critical because of the excavation required for terracing.

Surface rock is a modifier that impedes terrace construction and use. It has a limiting influence on specific sites.

Part 4. SUPPORT INFORMATION

This section presents information on four types of background information used to make the land unit descriptions.

1. Climate.

Climate in Nepal is controlled by the monsoonal winds and the physiography. The monsoonal winds result from an inland low pressure developing in the summer and are accentuated by a northward migration of air from the southern hemisphere. These are south to southwesterly winds which carry moisture from the Indian Ocean to Nepal. The wet season is from June through September. Figure 4.1 illustrates the monsoonal pattern of rainfall exemplified by Kathmandu. Rains brought by these winds are characterized by being strongly seasonal, quite variable in amount and torrential at lower elevations. These rains begin early (in April) and end late September in eastern Nepal. The general precipitation pattern is for diminishing amounts and duration as one moves toward the north and west.

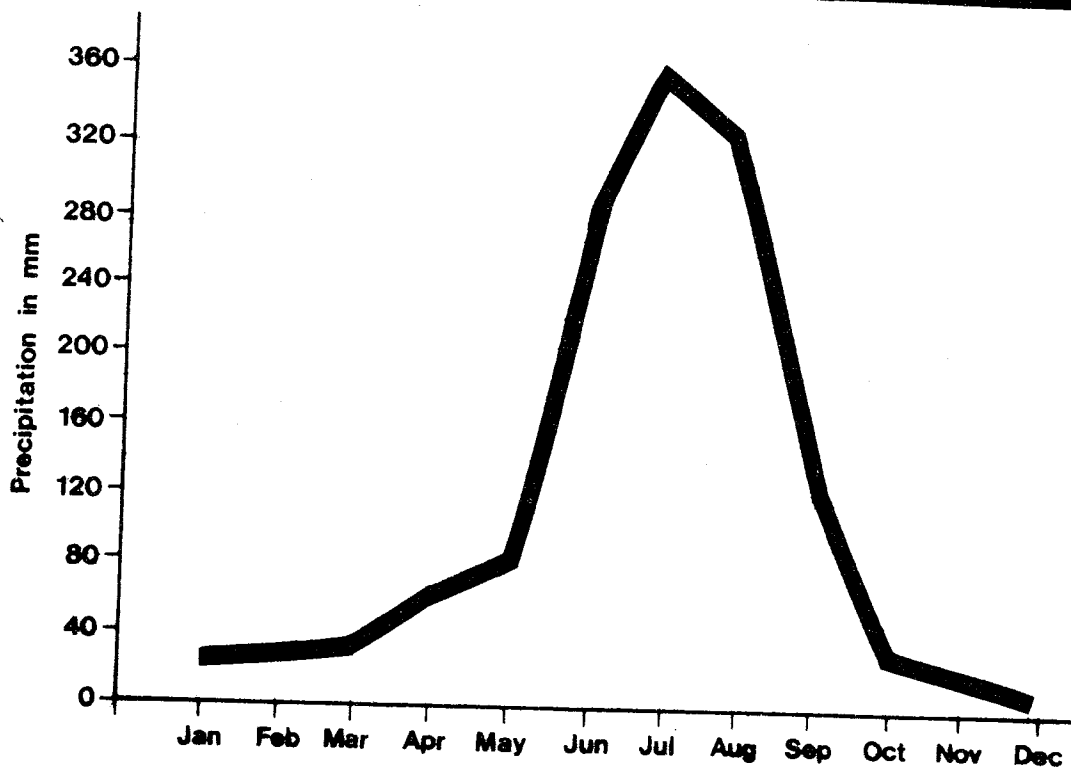


Figure 4.1 Mean Monthly Precipitation, Kathmandu, Nepal, Source: H.M.G

There is a winter "monsoon" resulting from west winds from the Arabian Sea area. This is most strongly expressed in western Nepal where up to 10 percent of the annual precipitation comes during the winter months. A distinct bi-modal precipitation pattern results (Whiteman, 1978).

Physiography has both a regional and local effect on climate. The major climatic zones are controlled by elevation. The annual snowline is at about 2000 meters and the permanent snowline, above which lies 15 percent of the country (Sakya and Thapa, 1977), is at 4700 meters. According to Stainton (1972) there is a continuous summer cloud level at about 2700 meters which shrouds the high peaks. Crops do poorly above this elevation in most of Nepal. Stainton also noted that precipitation intensity decreases with increase in elevation and that in the higher parts of Nepal (above 3000 meters) misty drizzles are a major form of precipitation.

Regional climate is strongly influenced by the mountain ranges. The luff and lee effect is visible both in the Himalayas and the Siwalik-Mahabharat ranges. A classic rainshadow is created by the High Himalayas. The often cited example is between Pokhara with 347 cm of average mean annual precipitation in front of the Himalayas, and nearby Jomosom in the Kali Gandaki Valley behind the Annapurna Himal with 29 cm of precipitation. A somewhat weaker pattern exists in relation to the Siwalik-Mahabharat ranges.

The orographic effect of mountain ridges has been noted by the higher precipitation at stations at the foot of the mountains, both Himalayas and Siwaliks, than at stations at greater distance from the mountains. Biratnagar and Dharan are an example of this: 168 cm MAP at Biratnagar, 30 Km south of the foothills; and 236 cm MAP at Dharan at the base of the Siwalik hills.

Domros (1977) describes many valleys in the Himalaya Mountains as being exceptionally dry because both day and night time breezes ascend. This causes locally heavy precipitation from thunder showers on the slopes and ridge tops but maintains a dry, nearly desertlike valley bottom. Cloud patterns on satellite imagery made during the monsoon verify these observations. One result of such a pattern is a significant under-estimation of annual precipitation because most precipitation recording stations are in valley bottoms.

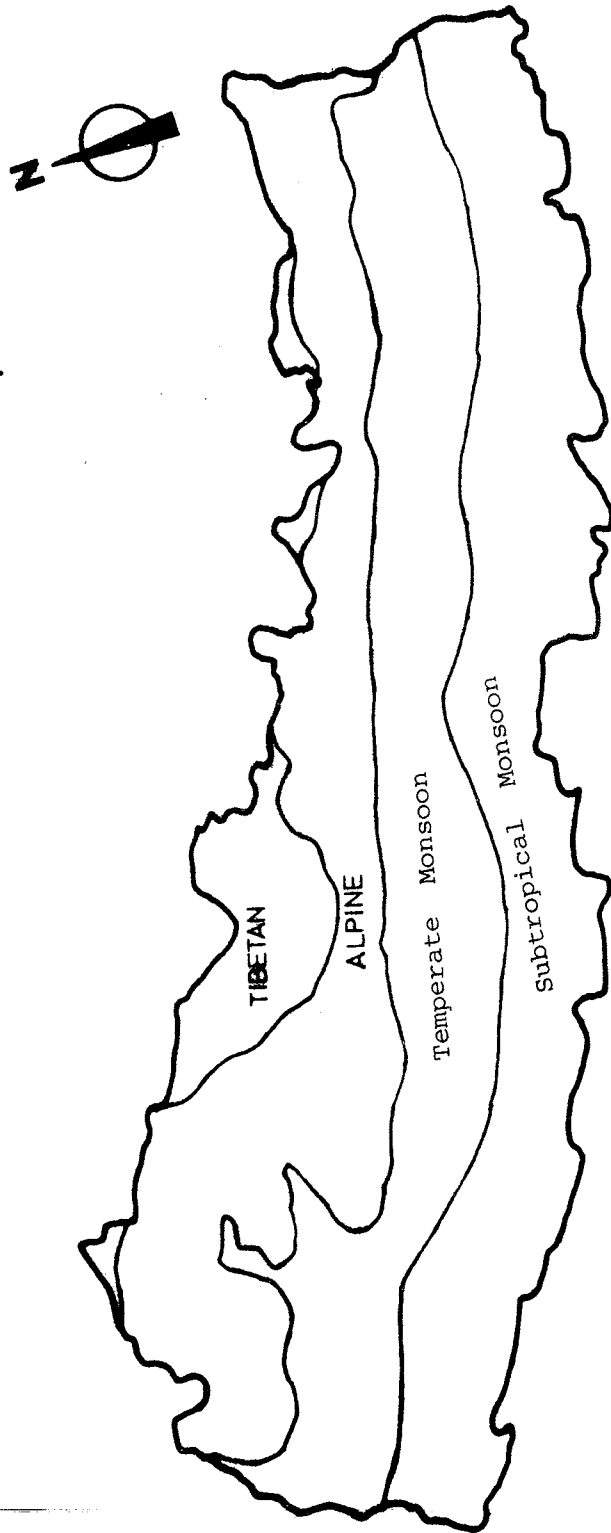
The local climatic pattern is also strongly influenced by slope aspect. The south slopes have a higher rate of insolation, resulting in higher evaporation rates. This in turn is reflected in the greater sparsity of vegetation on south-facing slopes in comparison with north-facing slopes. The difference in vegetation between north and south slopes becomes more vivid as one moves from east to west.

Two classifications of climate were used in connection with the inventory. A general classification of regional climate of types is shown in Figure 4.2. The following are descriptions of these types in Nepal. Monsoon Asia by Robinson (1967) was the source for this classification.

a. Robinson's Climatic Classification.

Subtropical Monsoon - The Terai and associated inner valleys are areas of strong seasonal change. The mean annual temperatures are over 21°C . The hot season, from June to September, has temperatures in the 25°C - 32°C range. Rainfall is monsoonal with about 110 cm in the West and 200 cm in the east (Thapa and Thapa, 1969). The dry season, October through May, is also a period of westerly winds. Winter night time temperatures in some of the inner valleys drop to 5°C .

Figure 4.2 Major Climatic Zones in Nepal



Scale 1:4.5 million

Temperate Monsoon - The central part of Nepal has warm, wet summers and cool, dry winters. This is the largest climatic region in Nepal. It is distinguished from the subtropical monsoon region by having lower temperatures and humidity levels. Night time winter temperatures can dip to below 4°C.

Alpine - This climatic region begins at 4000 meters. Its upper limits are over 8000 meters, although that above about 5900 meters could be better characterized as Arctic. Generally, this region comprises the northern tier of districts in Nepal. The short summers are cool with freezing a possibility every night. Summer is a time of continuous cloudiness. Peaks are usually visible briefly in the mornings. The winters are cold and snow storms are common. Most passes are blocked by accumulations of snow and avalanche hazards are high.

Tibetan - This region is in the rain shadow of the Himalayas. Precipitation is less than 500 mm. The Mustang-Dolpo area in north-western Nepal is the best representation. Summers are cool and winters are cold. Great temperature differences occur between sun and shade and night and day.

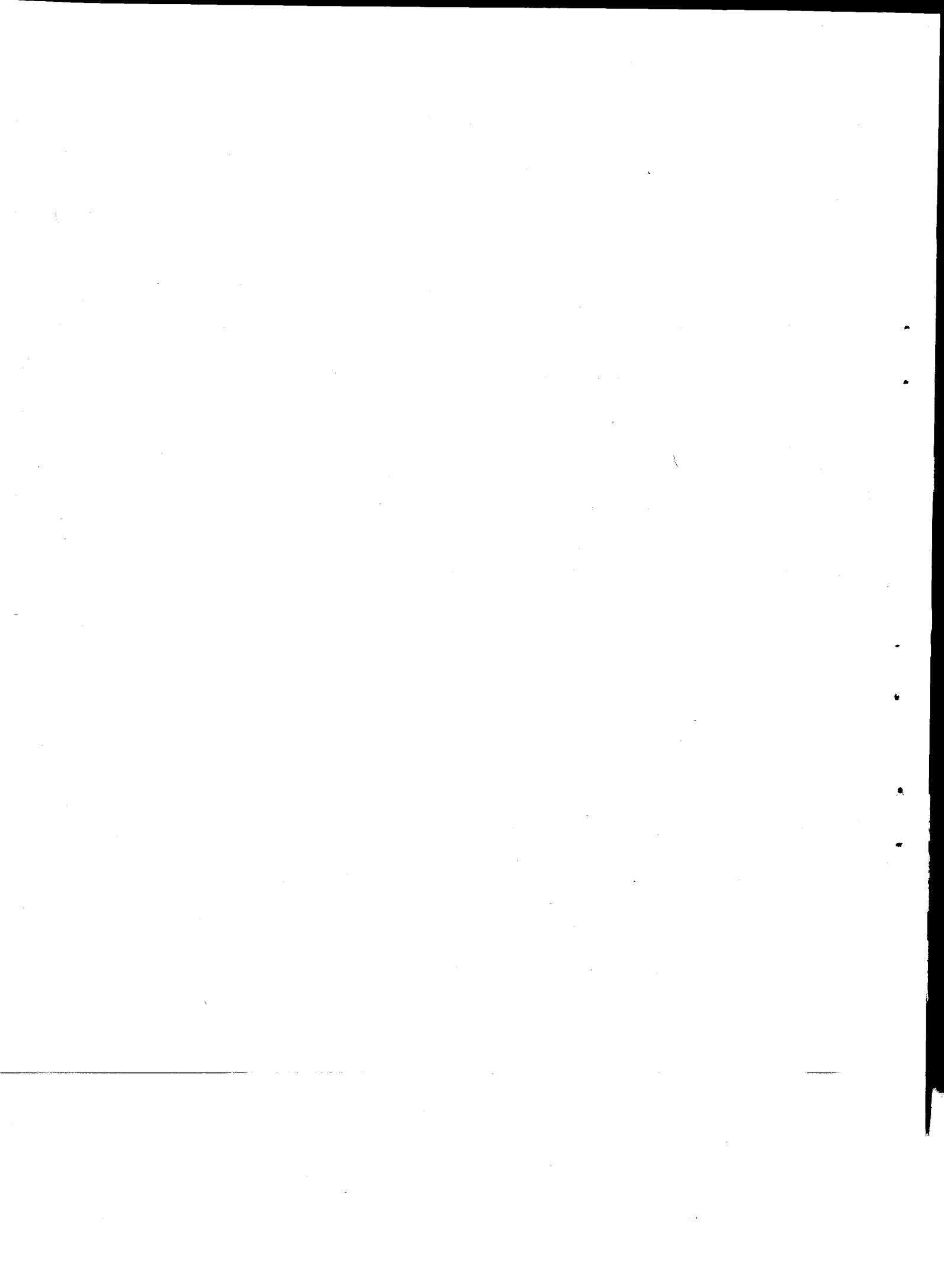
b. Köppen's Climatic Classification.

A second climatic subdivision of Nepal has been established according to climatic group and subgroups as defined by Köppen*. Although Köppen's classification is more commonly associated with continental areas, it is used here because (1) Nepal, even though a small country, does have a continental range of climates, (2) it is an objective system that can serve as a starting point for quantitative grouping of climatic regions in Nepal.

The classification aims to relate climate to vegetation, but attempts also to provide an objective numerical basis for defining climatic types in terms of climatic elements. Temperature and precipitation are used as the two important parameters because air temperature and precipitation are the most easily obtainable surface weather data requiring only simple equipment and a very elementary education to make observations. Figure 4.3 is a Map of Climates according to this classification scheme.

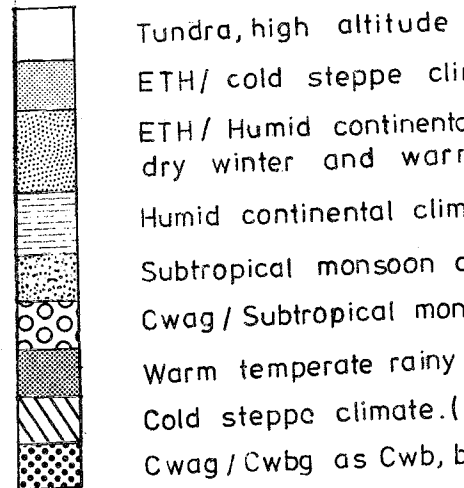
The effect of evaporation has been roughly taken into account by forming an expression that depends on precipitation as well as on temperature. The symbols of the principal climatic groups and types in the Köppen's classification are as follows:

* Köppen and Geijer: Handbuch der Klimatologie, Vol. 1,C



Climatic classification of Ecological Regions.

Legend



Scale : 1 : 1,500 000

Climatic Group	Symbol	Climatic type	
		Dry period	Degrees of dryness and cold
Tropical rainy climates	A	f,s,w	-
Dry climates	B	-	S,W
Warm temperate rainy climates	C	f,s,w	-
Cold snow-forest climates	D	f,s,w	-
Polar (snow) climates	E	-	T,F

f - absence of dry period

s - dry period in summer

w - dry period in winter

BS - steppe climate

BW - Desert climate

ET - Tundra climate

EF - Eternal frost

Climatic Groups A,C and D are the "tree" climates.

Using the Köppen classification, further specific climatic types have been distinguished on the basis of the rather scanty data available in Nepal. Temperature data are particularly scarce.

Climatic types in Nepal

EFH	-	Eternal snow, high altitude climate
ETH	-	Tundra, high altitude climate
Dwb	-	Humid continental climate with severe, dry winter and warm summer
Cwa	-	Subtropical monsoon climate
Cwb	-	Warm temperate rainy upland climate
Cwb ^g *	-	Same as Cwb, but with maximum temp. before rainy season
Cwa ^g *	-	Same as Cwa, but with maximum temp. before rainy season
Cwar	-	Same as Cwa, but with excessive rainfall
BSfk	-	Cold steppe climate (no specific dry period)
BSwk	-	Cold steppe climate (winter dry)
Aw ^g **	-	Tropical, winter dry savanna climate
BSw ^g **	-	Hot tropical steppe (winter dry)

* - The symbol g stands for a climate where maximum temperatures are before the monsoon, usually in May.

** - Existence in Nepal uncertain.

These climates are rather well correlated with the Ecological Zones as defined in the National Inventory. They can also be correlated with groups of Ecological Regions.

Ecological Zones and Regions with their corresponding climatic types

I. High Himalaya Zone

- EFH - The areas above the permanent snow line in regions IA, IC and ID.
- ETH - The other parts of these regions except the areas mapped as IC2, inner valleys.
- Dwb - Land system IA2.
- BSwk - Land system IC2.
- BSfk - Ecological Region IB (Dolpo, Mustang).

II. Transition Zone

- Dwb - IIB Humla-Jumla.
- Cwb/Cwa - The other ecological regions of this Zone.
The difference between Cwb and Cwa (temperatures of the warmest month lower or higher than 22°C) is determined by differences in altitude.

It is proposed to set a boundary as defined for the vegetation types. The vegetation types which have fir and upper oak forest types then correlate with Cwb. The vegetation communities with chir pine and sal correspond with Cwa.

III. Middle Mountain Zone

- Cwb/Cwa - The scarce data indicate that in the far western and far eastern parts of Nepal temperatures in May are cooler compared to those in the central parts. Therefore no "g" symbol for warmest temperatures before monsoon. The remarks for the Transition Zone apply for the difference between Cwa and Cwb here also.

This climate is found in IIIA, IIIB, IIIC, IIID, and IIIE.

- Cwbg/Cwag - The regions with premonsoon maximum temperature are as follows:

IIIC, IIID, IIIE, IIIF, IIIG, IIIM and IIIN
(Symbols III I, IIIJ, IIIK and IIIO were not used.
Same remarks for differences between Cwag and Cwbg apply as above.)

IV. Siwalik Zone

- Cwag - All regions

V. Terai Zone

- Cwag - All regions

However in VA (Southwestern Nepal) there is a tendency toward drier climates (BSw). In VC (Southeastern Nepal) the climatic trend is towards a tropical rainy climate (Awg).

- c. Climate and Erosion - There is little data to support a clear relationship between characteristics of the climate and erosion in Nepal. Domros (1977) summarizes storm intensity data but this has not been correlated with erosion. Additional storm intensity data needs to be collected to arrive at an estimate of a climatic factor, "R", in the Universal Soil Loss Equation (Wischmeier and Smith, 1965). Fetzner and Jung (1978) concluded for the Kathmandu Valley that the R value, an index of rainfall erosivity, "seems to be low". These authors also determined that the greatest agricultural problem related to erosion was insufficient soil cover on fields during the monsoon period.

The effect of climate on erosion is generally through vegetation. The most moist areas regionally or locally have the least erosion and, when disturbed, the greatest recuperative powers. Locally it was noted that the driest sites, mainly slopes with southern aspects, had the highest rate of man-caused soil erosion. This is due to the higher insolation rates here, leading to moisture stress. The south facing slopes also receive the most intensive storms. On a regional basis, sheet, gully and rill erosion above 2800 meters is uncommon because of the rarity of high intensity storms. The exception to this is in the Trans Himalayan Region (IB) where low precipitation is responsible for sparse ground cover and hence a high erosion hazard.

2. Geology.

The Geological characteristics of Nepal have a direct effect on watershed condition and were used to identify, map and describe the land units in the inventory. For most part, the geologic literature was adequate for our intensity of mapping. Figure 4.4 shows the main references used for lithologic structural information.

- a. Structural Zones - Like the climatic zones, the major geologic structural zones correspond well with the ecological zones identified in the watershed condition inventory. Figure 4.6 is a small scale map of these major zones. They are also shown on the cross-sectional sketch of Nepal, Figure 2.2.

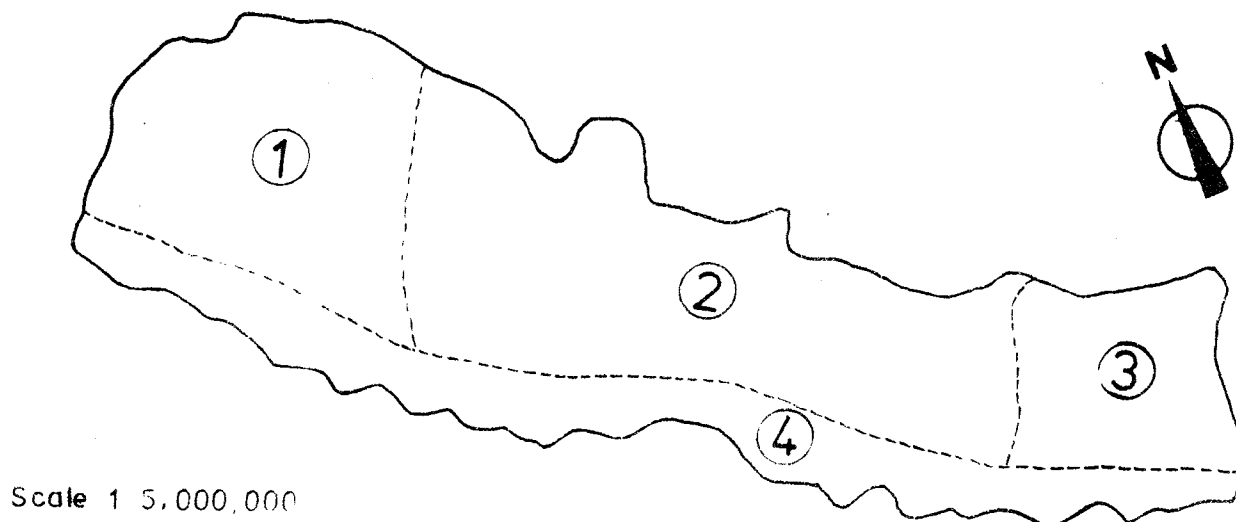
The following is an outline of the major features of these geologic zones.

- i. Indo-Gangetic plain - the Terai in Nepal.

This is a great alluvium filled basin bound by the Siwalik Hills on the northern edge and the Indian shield on the southern side. The Terai is the part of Gangetic alluvium in Nepal. The width in country is 10 to 30 Km whereas the length is 800 Km. Sediment thickness is estimated at about 1600 m.

The basin has been receiving sediments since Pliocene. Modern rivers continue to deposit large sediment loads.

Fig. 4.4 Source map for geological information.



Information Sources

1. a. Remy J. M. 1975, Geology of Nepal, West of Nepal Himalaya.
b. Reports of Department of Mines and Geology.
2. a. Hashimoto S. 1973, Geology of the Nepal Himalayas.
b. Stocklin J. and Bhattarai K. 1977, Geology of Kathmandu Area and Central Mahabharat Range, Nepal.
3. a. Reports of Department of Mines and Geology.
4. a. Sharma, C. K. 1974. Ground Water Resources of Nepal.
b. Sharma, C. K. 1977. Geology of Nepal.

The information from these references was summarized in a "Litho-Structural Map of Nepal", Figure 4.5. An enlarged version of the map with descriptions of each unit is being prepared as a separate report by Mr. B. D. Shrestha, geologist member of the inventory team.

The Bhabar, composed of boulder to sand size materials, is a zone at the base of the Siwaliks in the northern part of the Terai. This is a recharge zone for groundwater.

ii. The Siwaliks.

Lower Siwaliks consisting of fine grained, argillaceous materials.
Middle Siwaliks consisting of grey, hard, thick beds of fine to coarse grained sandstone with intercalations of mudstone.
Upper Siwaliks are composed mainly of conglomerates and pebble beds interbedded with mudstone.

LITHO - STRUCTRAL MAP
OF
NEPAL

Gr Granite
TZ Tethysian sediment Zone

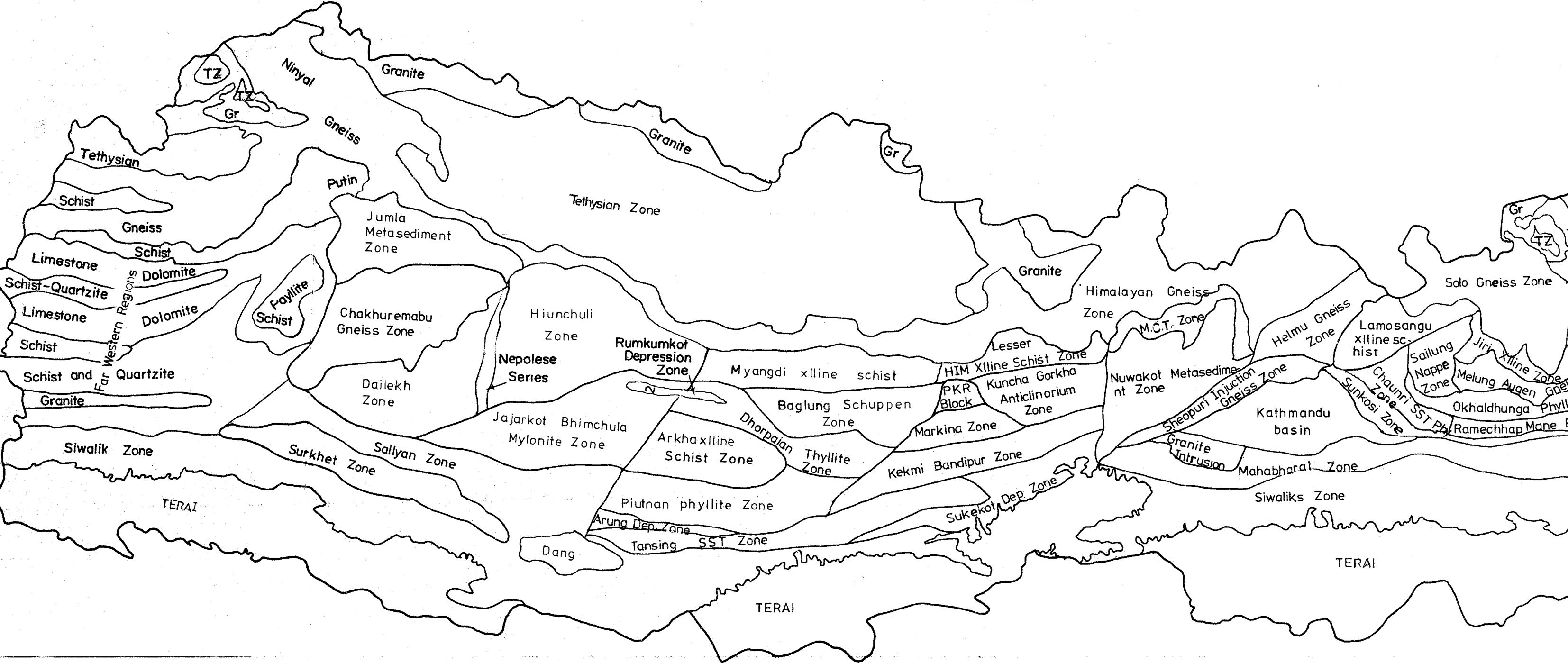
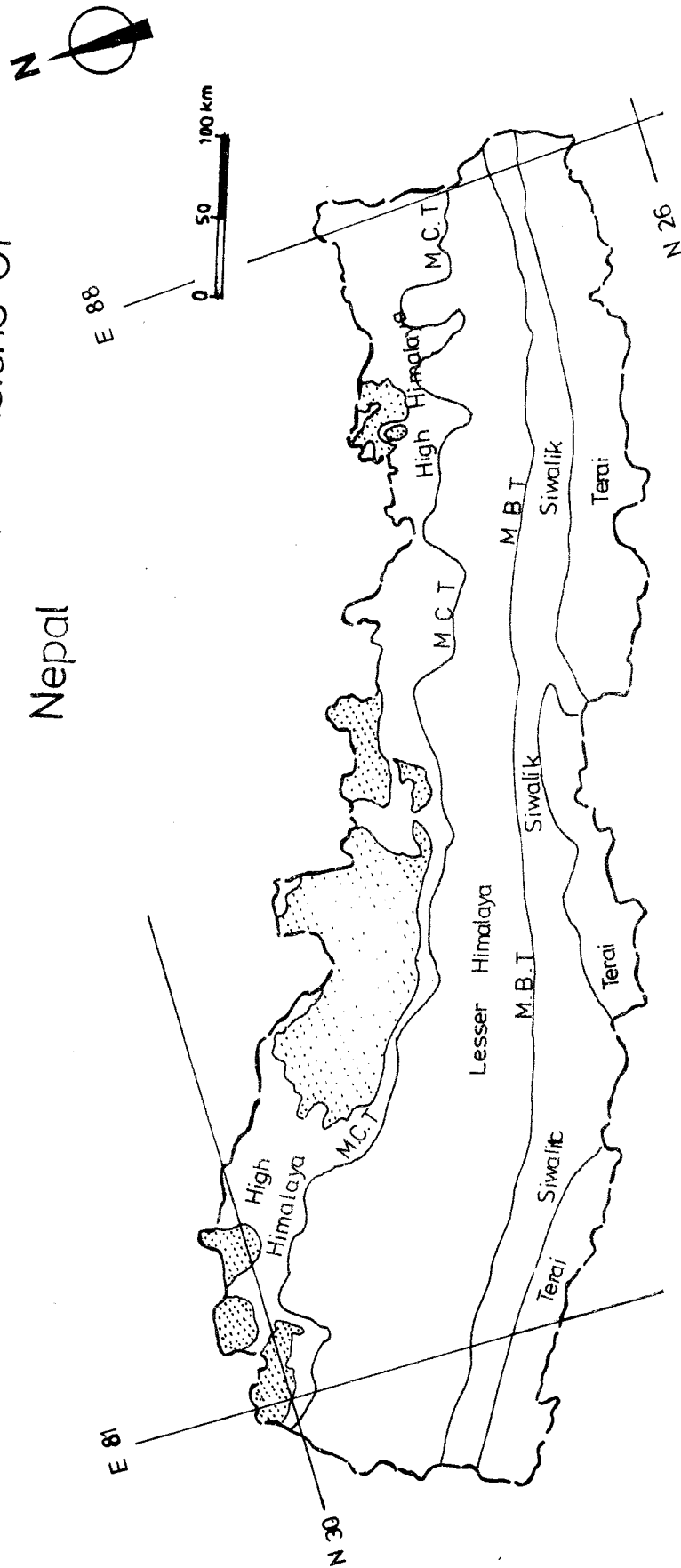


Fig 4.6
Major Geologic Structural Divisions of
Nepal



Tectonically the Siwaliks can be divided into:

The thrust Siwaliks, mainly along the Main Boundary Thrust (MBT). The folded Siwaliks, broken anticlines and synclines to the south of the Thrust Siwaliks.

The major geomorphic process here is rapid fluvial erosion. Headward cutting streams are eating into the front scarps of the Siwaliks. Meandering and braided streams in some of the lower, softer segments of the Siwaliks have sediment loads which exceed their carrying capacity. Here lateral planation is an important erosion process. Chemical weathering coupled with fluvial processes in clay and silt deposits has led to an intricately dissected landscape of narrow gorges, blade-like ridges and broad, braided drainageways.

iii. The Lesser Himalayas.

The lower Himalayas are characterized by intermittent sedimentation from the Proterozoic to Lower Permian. Breaks in sedimentation are connected with epeirogenic movements and marked by the appearance of basalt flows.

The Lesser Himalayas correspond to the Middle Mountain ecological zone in Nepal. Its northern boundary is the Main Central Thrust (Gansser 1964). The southern boundary is the Main Boundary Fault (Permian). Lithologically the zone is dominated by metamorphic rocks: phyllite, quartzite and chlorite schist. Limestone is the main sedimentary rock here. Crystalline rocks, granites and gneisses are exposed in the Mahabharat Lekh portion of the zone.

Structurally the zone is a complex maze of folds and faults. Parts of the area are described as schuppen surfaces and autochthonous zones. The northern part has a general anticlinal structure, the southern, i.e. the Mahabharat Lekh, is synclinal. Between the Kali Gandaki and the Trisuli river, there is a series of monoclinial ridges dipping to the south. Local geologic structure is a factor in soil erosion and massive earth movements. Dip slopes, sloping to the north in most of the country, are the sites of many deep seated landslides. The scarp slopes usually have shallow landslides. Figure 4.5 gives an idea of the regional structural complexity of the zone.

Mass wasting and fluvial down-cutting are the principal geomorphic processes. These are closely linked to the vegetation cover, hence the strong association between destruction of vegetation and the occurrence of landslides, debris avalanches and accelerated erosion in general. Another aspect of geomorphology that held our attention in the field are the lacustrine terraces in isolated basins and in major river valleys. These reflect periods of sediment accumulation, due to great sediment loads and/or blocked or impeded outflows. Streams have since entrenched paths through these materials, cutting steep-walled gorges and valleys. Although these

are desirable agricultural lands, the materials are very fragile. Deep gullies have cut into the terraces in places. Shallow landslides are abundant on many dissection and inter-terrace slopes.

iv. The Higher Himalayas.

This zone is about 40 Km wide and ranges in elevation from about 2800 m to 8848 m. It lies between the Main Central Thrust and the Tibetan Plateau. The materials include granite, granite gneiss, quartzite, chlorite biotite garnet schist, kyanite schist and augen gneiss.

The Higher Himalayas are characterized by continuous sedimentation from the Proterozoic to Cretaceous (Talalov, 1972). The whole area was uplifted during the early, and immediately after, the Cretaceous period. The folds of the Higher Himalayas are represented by the broad, gentle synclinoriums with a northwest-southeast trend. They are made up of Silurian-Cretaceous rocks. The space between these rocks is filled with irregularly shaped anticlines where Proterozoic, Cambrian and Ordovician rocks are exposed. The synclinoriums are complicated by minor folds, some of which are overturned and even recumbent.

The geomorphic processes are glaciation, physical weathering and mass wasting. Glaciers occupy a comparative small part of the Himalayas. They are confined to the inner valleys where they are responsible for the U-shaped valleys, long lateral moraine ridges, and heavy sediment loads in the streams. Undercutting of valley side slopes by glaciers has caused some large landslides. The lateral moraines have created a few small lakes. Thick rubble deposits on the glacial trough side slopes and in the lower valleys are poorly sorted and weakly consolidated. When disturbed by excessive grazing or down cutting streams, this material readily moves, either in surfacial soil erosion, debris slides or in large slumps. Above the valley floors, thick ice and snow deposits are slope forming agents by ice plucking, contributing water to freezing-thawing action, and by being a source of water for fluvial erosion. Avalanches, rockfall and solifluction are common mass wasting processes in the High Himalayas. Deep seated land flows and broad, braided outwash streams were noted in shales at high altitudes in the Dolpo area.

Cryoplanation, a group of mass wasting processes occurring in cold areas, is responsible for the smooth, sparsely dissected upland surfaces. Most slopes subject to cryoplanation are rounded to undulating without significant stream dissection. Rilling, stone stripes, patterned ground, severe frost heaving and extensive rubble cover are indications of cryoplanation observed in the High Himalayas and in fingers of high country reaching into the Lesser Himalayas.

v. The Tibetan Tethysian Sediments

The sedimentary rocks of the Tibetan Tethys basin extend from the highest part of the Great Himalayas northward, with the main body in Tibet.

The Tethys contains formations ranging from Cambrian to Cretaceous. They are in a synclinal basin in Tinker Zipu (Saipal), Kanjiroba Himal, Langu Valley, Muktinath basin and Larkhya basin. The characteristic features of the synclinorium are complicated structures with thrust folds, thrust faults, fractures and reverse folds.

Hagen (1969) describes the Tibetan sediment zone in Nepal as the Tibetan marginal synclinorium. According to him, the northern flank of the Tibetan marginal range can be considered as the northern limit of the synclinoria.

The Tibetan Tethys group is mostly composed of impure limestone, dolomite and argillaceous rocks converted into low grade crystalline schists and shales.

- b. Lithology, Seismicity and Erosion - Lithology has much to do with the resistance of a landscape to degradation. Figure 4.7 is a classification of rock types in Nepal according to our estimates of their erodibility, as based on their co-efficients of strength.

The following three classes were used.

Low erodibility - Rocks with coefficients of strength of 10 to 20 (over 10).

Medium erodibility - Rocks with coefficients of strength of 3 to 10.

High erodibility - Rocks with coefficients of strength of 0.5 to 3 (less than 3).

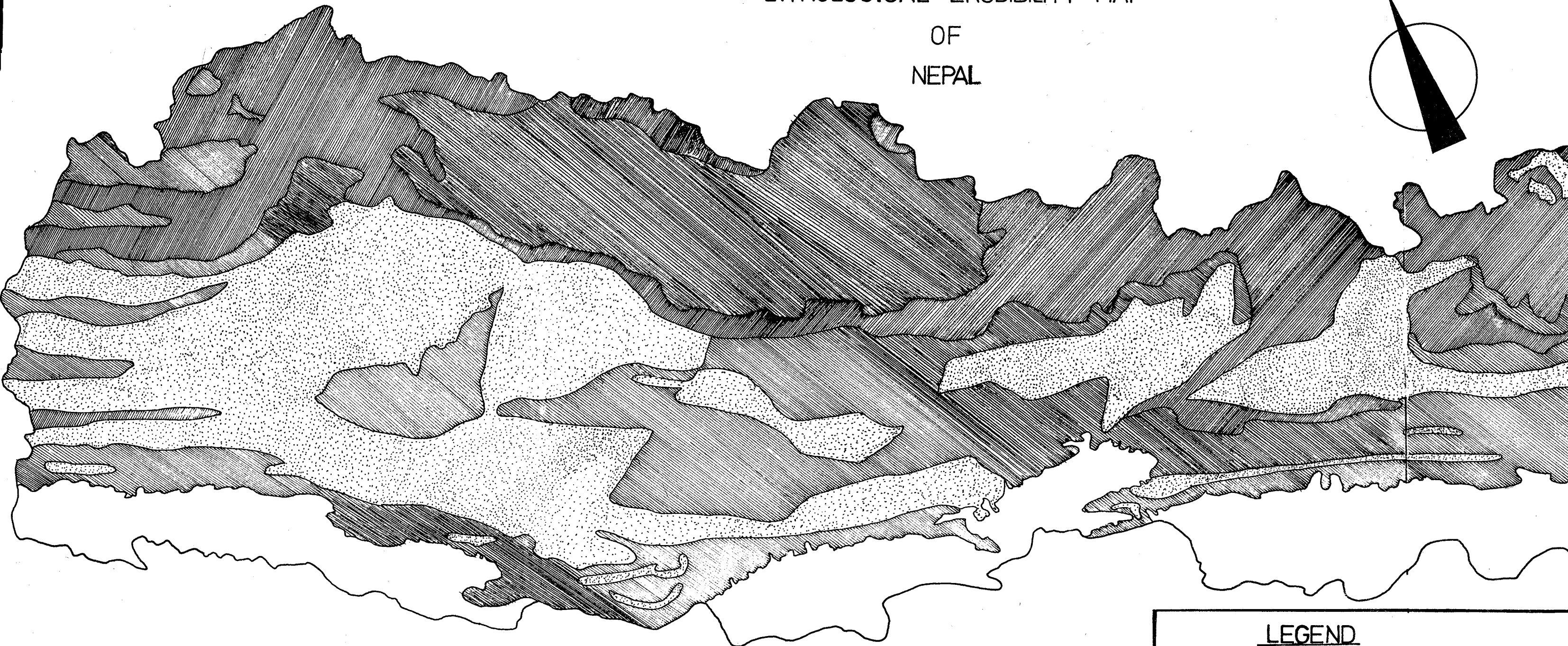
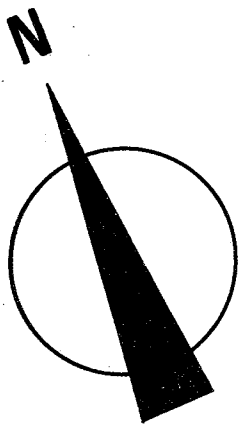
Seismicity, in relation to landslides is an unexplored field in Nepal. The large landslides along the Main Central Thrust are believed to have a seismic origin.

Available records of seismological data show that the Himalayas are in a mobile zone of seismic activity. Most geologists believe that the earthquakes here are due to block faulting rather than volcanic activity.

Because Nepal lies in a zone of seismic activity, detailed seismological study of the country is needed. Any large civil works such as roads, dams, canals, etc. in active seismic zones are endangered, and the placement of such structures can only be decided in the light of accurate knowledge of the probability of earthquakes.

At present, there is a small seismological station at Phulchowki, Kathmandu Valley. Prior to this, one was at Chatara (not currently in

LITHOLOGICAL ERODIBILITY MAP
OF
NEPAL



LEGEND

HIGH		Schist, Broken, Sandstone
MEDIUM		Limestone, Sandstone, Dolomite
LOW		Quartzite, Granite, Gneiss
TERAI		Gangetic Alluvium

Scale:- 1:1500,000

working condition) established by the Indian Co-operation Mission. Nepal should have at least one seismograph station in each development region, and these stations must be supplemented by accelerographs and modern instruments to attain complete records of the tremors.

3. Vegetation.

The vegetation, like most other major natural resources in Nepal, is in a zonal pattern related to elevation. Figure 4.8 is a map of the major vegetation types as based on the work of Dobremez and others. Dobremez's series of ecologic maps on a 1:250 000 (two on 1:50 000) base provides the most detailed picture of the vegetation communities in Nepal. (Various references, see page 290). Reference to Dobremez.

The original vegetation in Nepal consisted of forests up to the tree line on the Himalayas. There is a zone of meadows and low shrubs between the highest tree communities and the rock, ice and snow of the peaks. The Trans-Himalayan regions, in the desertlike rainshadow of the Himalayas, has a continuous shrub cover. The forests in the Middle Mountains have been considerably altered with large areas which were once completely forested, now converted to agricultural land and brush and grass types. We found the following percentages in the four zones that were once completely forested:

<u>Table 4c-1</u>	
<u>Forest Cover by Zones</u>	
<u>Zone</u>	<u>Percent Forest</u>
Terai	19
Siwaliks	66
Middle Mountains	28
Transition	48

Our data showed that 30 percent of Nepal is forested. This is in line with the 34 percent figure reported in Agricultural Statistics for Nepal 1977, based on observations in 1974/1975.








These figures have implications for land management needs and opportunities. Obviously, the Siwalik Zone and the Transition Zone present opportunities for forest management that should be studied and followed up. These two zones are critical, sensitive watersheds for heavily populated lower lands and, like the Terai and the Middle Mountains, are areas of agricultural expansion. The rate and extent of encroachment on these more heavily forested areas is restricted by the limited suitability of the lands for farming. The high hazards here however create a risk of significant impact even with minimal encroachment.

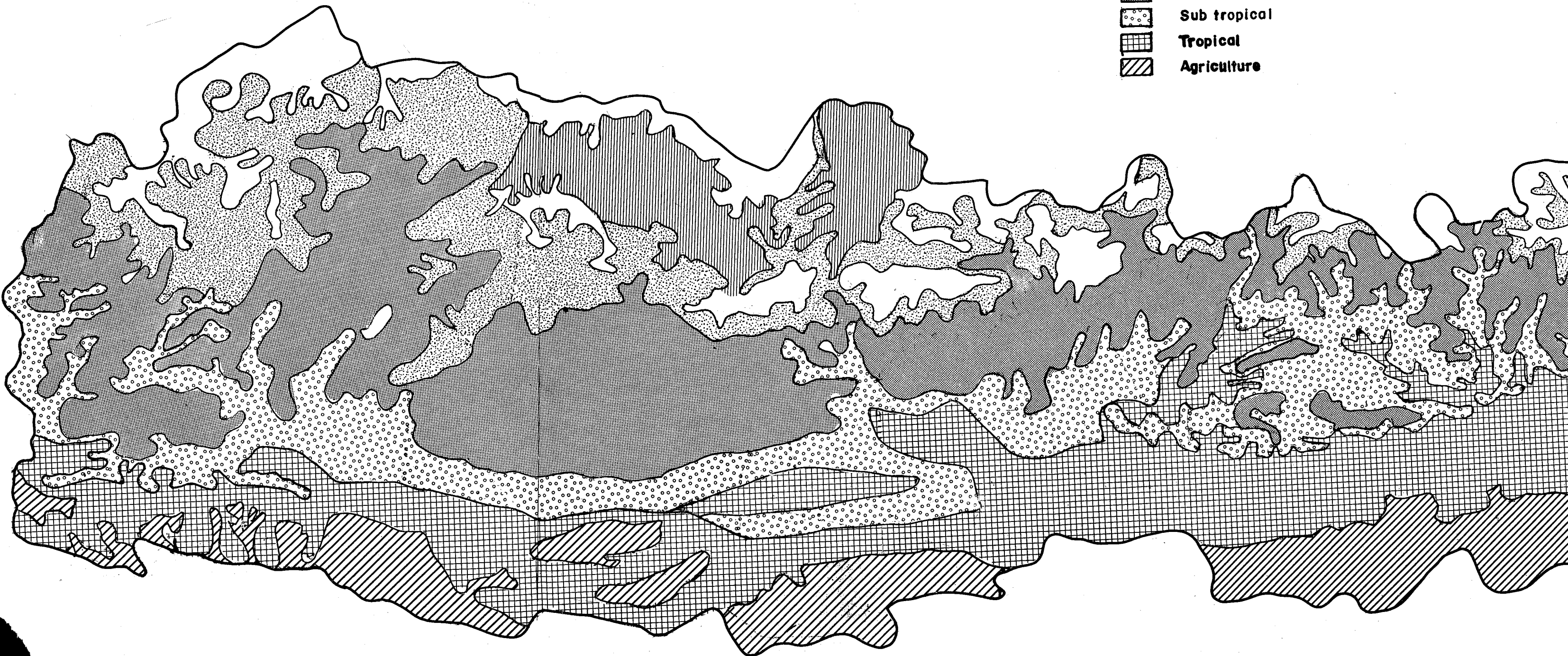
Editors' note Unfortunately the authors were unable to consider "Le Nepal Ecologie et Biogeographie", by J. F. Dobremez, (Editions due Centre National de la Recherche Scientifique, Paris, 1970).

It is suggested that persons seeking more detailed information consult this work of Dobremez particularly the lists of zones, an outline of which is included in Appendix 3, his various maps and their additional explanatory notes of each map.

VEGETATION ZONES OF NEPAL (After Dobremez)

LEGEND

-  Snow rock ice
-  Alpine and Sub alpine
-  Steppe
-  Temperate
-  Sub tropical
-  Tropical
-  Agriculture



The Terai has experienced a wave of deforestation since the control of malaria. Most of the lands thus far converted to agriculture are well suited to that use, but some, mainly on the northern margin of the Terai, in the Bhabar, had best be left in forest. A systematic classification of the remaining forest lands in the Terai is needed to avoid costly errors. Such a study would be a basis for estimating the numbers of people that can be resettled here without serious environmental degradation.

The Middle Mountain area is a zone of rapid and critical change also. The reduction in forest here is estimated at 2 percent a year, about 18,000 hectares. The afforestation program is now accelerating, but it has averaged about 1000 hectares a year. The opportunity for afforestation is great in the Middle Mountains. About 33 percent of the zone is in brush and could be planted to forests.

In much of the Middle Mountain Zone, the only forest remaining is around temples and on slopes too steep even for goats. The thoroughness of deforestation is impressive. Are parts of the Middle Mountains threatened with desertification*? In the short run they are not, because the climate and soils favor heavy vegetation.

In most brushlands in the Middle Mountains, a forest cover would return if protection or even less intensive use were given. This new forest would probably not have the species composition of the original forest. The original complex, multi-storied vegetation community which evolved with the soils and the slope in response to a particular set of geological, topographical and climatic factors has been changed by man's use to a simpler, less productive (in terms of biomass) vegetation type.

This new type is less protective of the soil because it has less crown cover, less litter cover, shallower rooting and less overall productivity. The changes brought about by the destruction of the original vegetation are changes in the site. The soils, the microclimate, the fauna, and the slope-forming processes, in addition to the obvious changes in the vegetation, have been altered. Land rehabilitation is therefore a bigger task and requires more time than simple afforestation. It also implies that there is a need for an ecological understanding of the vegetation if restoration is to be effected.

The banmara problem in eastern Nepal is an example of land degradation problems which require a knowledge of plant ecology to bring about a meaningful response. Although banmara may be an asset hydrologically because it covers overgrazed soils and is unpalatable, questions as to why it is spreading and what must be done to control it must be answered. The grazing problem in Nepal requires a knowledge of vegetation and animal husbandry that is very rare in that country. Grazing or pasture management is a skill that Nepal must have in order to be able to resolve many of the problems causing poor watershed condition.

* Desertification is taken to mean destructive, long-term degradation of the land in an arid environment.

4. People.

Demography was treated in the inventory report in terms of population density. The information for ethnic group enquiries and the literature. People of Nepal by Bista is the principal literature source. C. Jest's group delineation "Map of Annapurna-Dhaulagiri Area" was another source of information. Figure 4.9 is a map of ethnic groups in Nepal.

Population density was estimated in the field for land use types as follows:

<u>Class</u>	<u>Density</u>
Low	Less than 10 persons per ha
Moderate	10 to 80 persons per sq km
High	80 to 150 persons per sq km
Very High	Over 150 persons per sq km

These estimates were supplemented on a district basis by Land Use and Development in Nepal, a collection of papers presented at a Land Use and Development seminar sponsored by CEDA, D. C. Upadhyay, editors, August 1974.

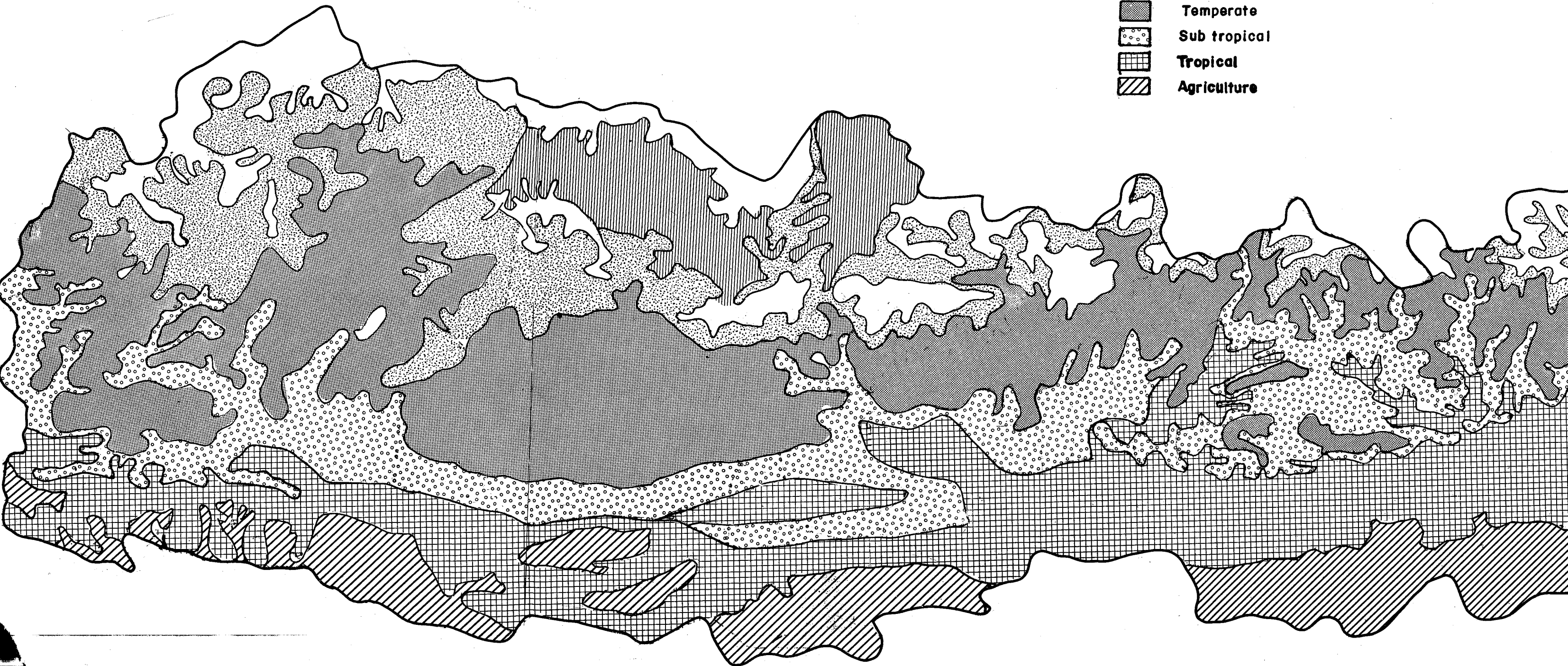
In our search for a more meaningful figure to express how population density affects erosion, we calculated the number of people per hectare of crops. Figure 4.10 is a map of this value by districts. The source of information is the Agricultural Statistics of Nepal, 1977.

We found no clear relationship between ethnic group and erosion. There is a tendency for those groups which are landowner-farmers to have higher erosion standards than groups who are primarily landlords. The relationship between population density and erosion is complex. At least population per hectare of crop are also in the most eroded areas, mainly the Terai. Moving below the district level, we found that erosion is most severe around population centers in the hills. This apparently is due to the high demand for firewood in these areas and the concentration of livestock. Indeed a typical land degradation is visible around many towns in the hills. Starting from the center, then a block of fields, next a zone of grass and brush zone, a degraded forest zone and finally, a zone of bare land. These zones circling adjacent population centers are illustrating the degradation process. The grass-brush zone and the area between the fields is usually in the poorest condition. This is illustrated in the supplemental report "Watershed Condition".

VEGETATION ZONES OF NEPAL (After Dobremez)

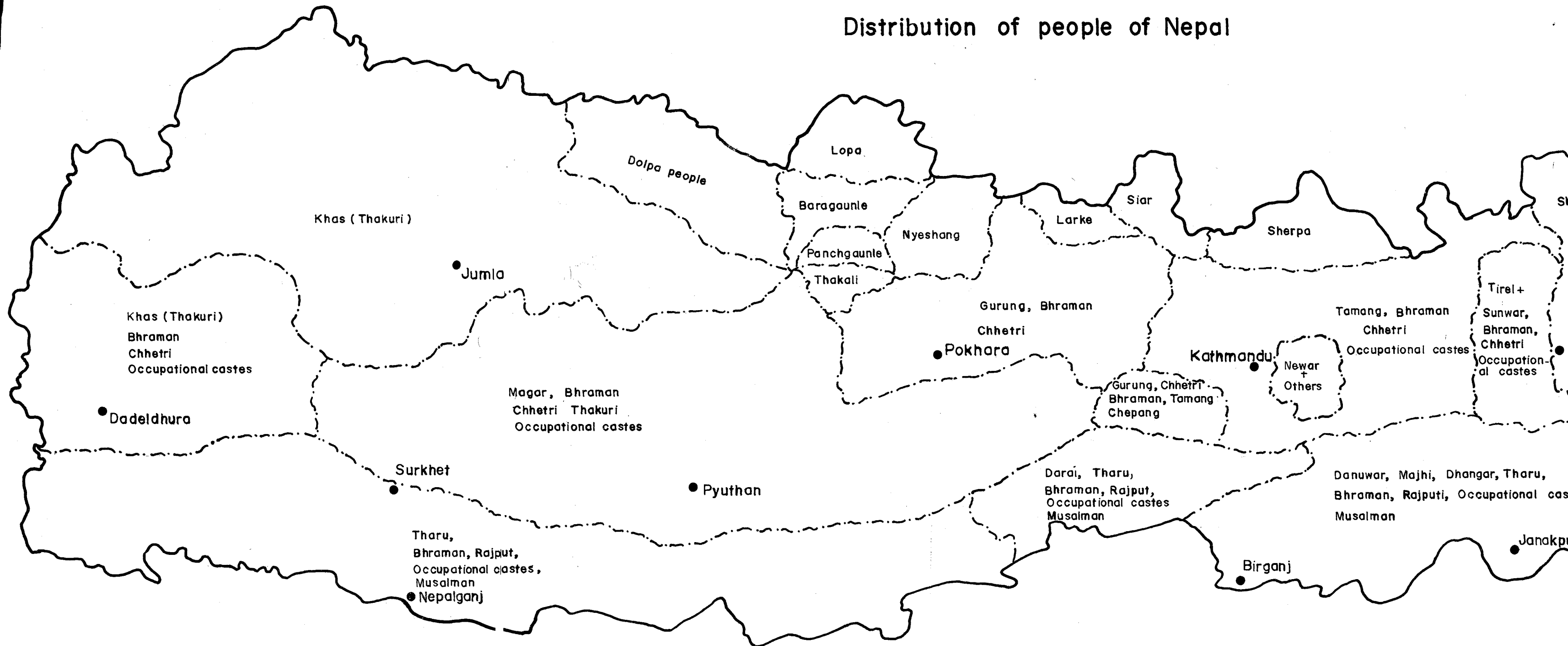
LEGEND

- Snow rock ice
- Alpine and Sub alpine
- Steppe
- Temperate
- Sub tropical
- Tropical
- Agriculture



NEPAL

Distribution of people of Nepal



Sources: 1. Population & Development in Nepal, 1974

CEDA, Edited by, DC Upadhyaya & J.V Abwva

2. Agricultural Statistics Of Nepal, 1977

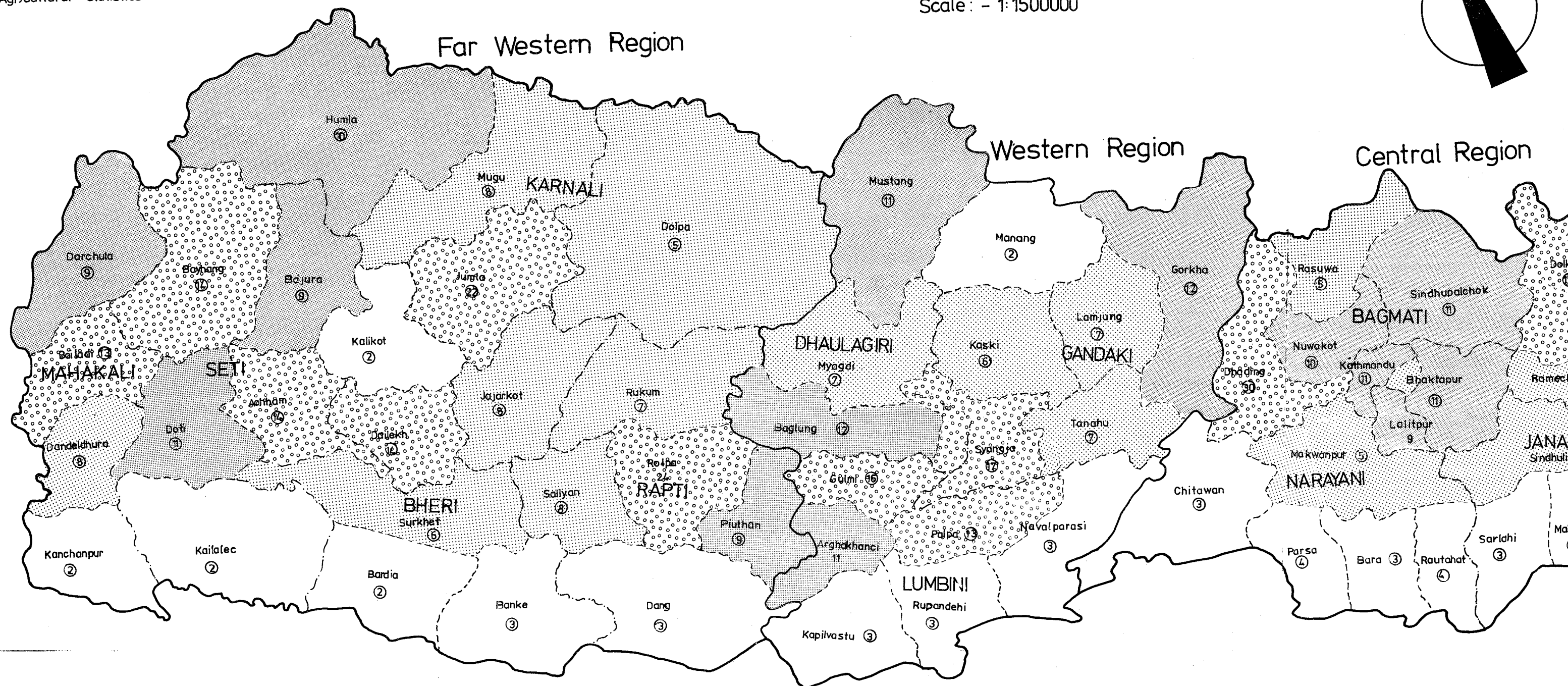
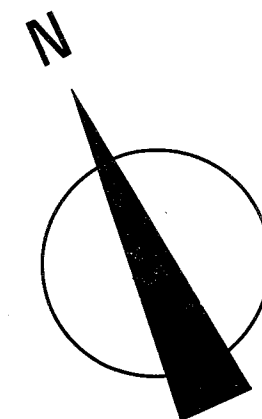
Compted & Edition By

Dept; Of Food & Agriculture,

Agricultural Statistics Division

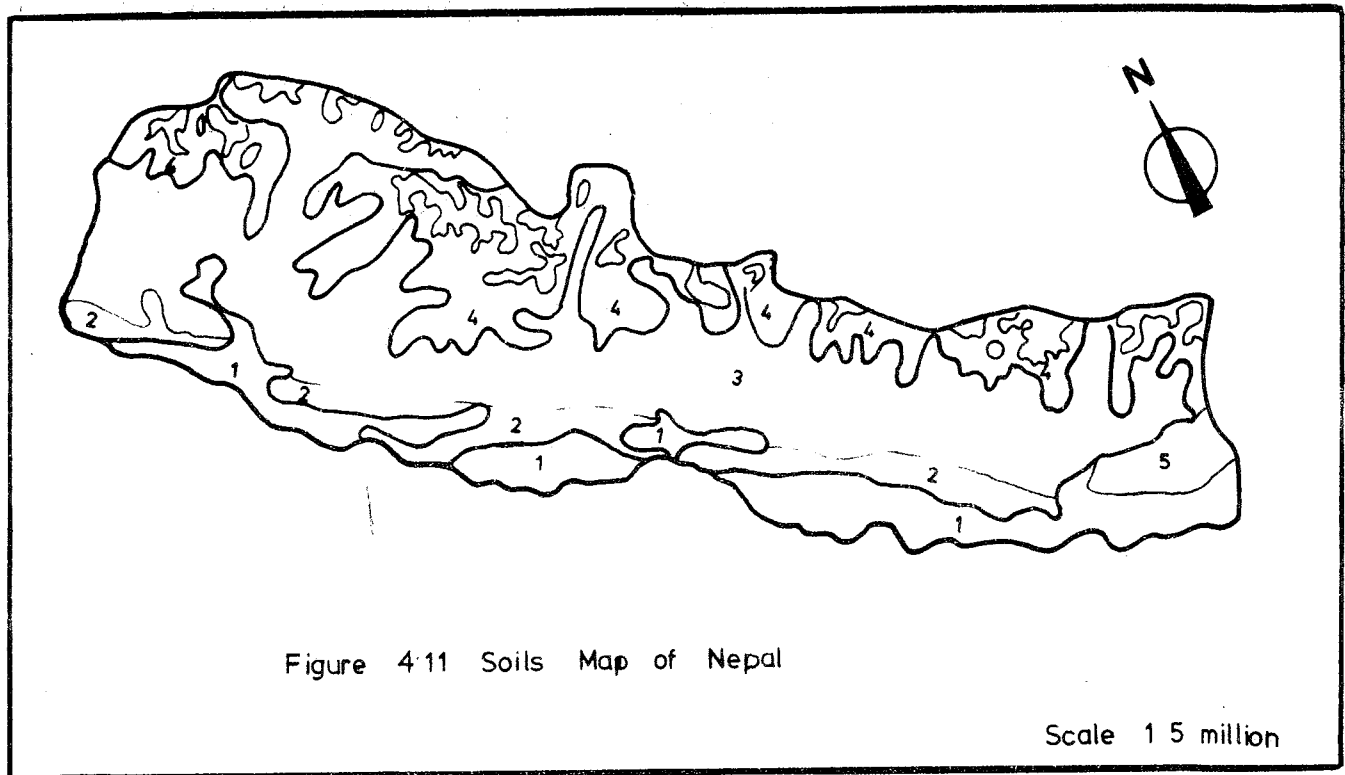
Persons/Hectare Of Crop

Scale : - 1:1500000



5. Soils.

Soil depth, texture and stoniness were described for each landtype. We did not classify soils in the field because of lack of data. Figure 4.11 is a 1:5 000 000 soils map of Nepal, taken from FAO/UNESCO's World Soils Map. This is apparently the only kingdom-wide soils map now available. The major soil types are briefly described in the legend for this map.



1. Eutric Fluvisols - Mapped in the Terai, Zone V. Weakly developed soils in recently deposited alluvium.
2. Dystric Regosols - Mapped in the Siwaliks, Zone IV. Weakly developed acidic soils with thin surface layer.
3. Dystric Cambisols - Mapped throughout central Nepal, Zone III. The most common soil. Acid soils with a non-clayey subsoil.
4. Lithic and Humic Cambisols - Mapped throughout the High Himalayas, Zones I and II. Shallow soils with high organic matter and nonclayey subsoil. Small, unlabelled inclusions here are ice fields.
5. Humic Acrisols - Mapped in southeastern Nepal. Acidic soils with a clayey subsoil and high organic matter content.

APPENDIX 1

Landstat-2 imagery used in the inventory

<u>Local Number</u>	<u>Path</u>	<u>Row</u>	<u>Date</u>	<u>Scene Identification</u>
1	155	39	10/ 2/73	1202 - 04395
2	155	40	27/ 2/75	2036 - 04283
3	154	39	16/ 3/75	2053 - 04221
4	154	40	16/ 3/75	2053 - 04224
5	154	41	16/ 3/75	2053 - 04230
6	153	40	25/ 2/75	2034 - 04171
7	153	41	25/ 2/75	2034 - 04173
8	152	40	1/ 4/75	2069 - 04110
9	152	41	1/ 4/75	2069 - 04113
10	151	41	15/10/75	2266 - 04042
11	150	41	12/ 3/75	2049 - 04001
12	150	42	30/ 3/75	2067 - 04002

Skylab Photography Available for Nepal

<u>Frame No.</u>	<u>Photo Identification</u>
180	G40 BO 91180000
181	G40 BO 91181000
182	G40 BO 91182000
183	G40 BO 91183000
184	G40 BO 91184000
185	G40 BO 91185000
186	G40 BO 91186000
187	G40 BO 91187000
188	G40 BO 91188000

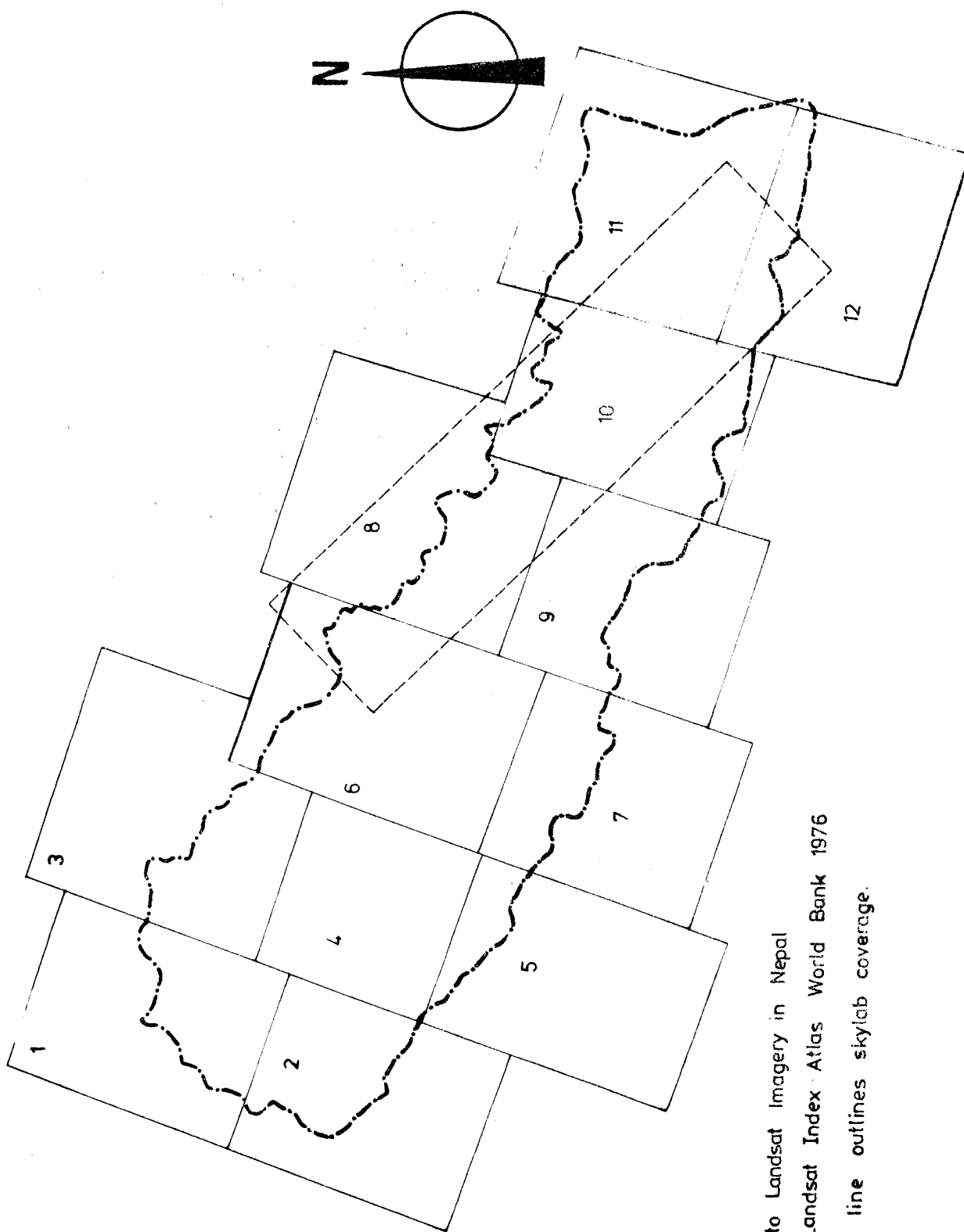


Figure A 1.1 Index to Landsat Imagery in Nepal
From Landsat Index Atlas World Bank 1976
Broken line outlines skylab coverage.

APPENDIX 2

Summary of Watershed Condition

Zone/Region/Land System	Area Sq Km	Percent of Kingdom/ Zone/ Region	Cover			Watershed Condition				
			For.	Ag.	Br.*	1	2	3	4	5
I. HIGH HIMALAYA ZONE	33611	24	3	1	96	78	16	4	2	0
A. Western High Himalayas Region	13108	39	4	1	95	100	0	0	0	0
1. High Ridgeland		95	3	0	97	100	0	0	0	0
2. Ringmo valley		5	18	12	70	100	0	0	0	0
B. Dolpo-Mustang Region	7734	23	0	1	99	49	12	38	T	0
1. Central Dolpo		15	0	1	99	2	29	43	26	0
2. Southern Dolpo mountains		15	3	1	96	70	30	0	0	0
3. Border Ridgeland		30	0	0	100	85	15	0	0	0
4. Western Dolpo Canyonlands		13	3	2	95	100	0	0	0	0
5. Upper Mustang valley		12	0	3	97	5	10	25	60	0
6. Western Mustang valley		8	0	4	96	74	13	13	0	0
7. Lower Mustang valley		7	0	4	96	100	0	0	0	0
C. Central High Himalayas Region	6671	20	3	1	96	67	27	5	1	0
1. Alpine Highlands		90	0	0	100	65	30	5	0	0
2. Inner Valleys		10	25	14	61	90	0	5	5	0
D. Eastern High Himalayas Region	6098	18	1	1	98	67	32	1	0	0
1. Inner Valley		70	1	1	98	50	50	0	0	0
2. Front Slope		30	3	0	97	100	0	0	0	0
II. TRANSITION ZONE	25134	18	48	18	34	52	42	6	0	0
A. Far Western Transition Region	2422	10	51	11	38	64	12	24	0	0

* Ice, rock, snow, meadows and brush communities.

Summary of Watershed Condition (Cont'd)

Zone/Region/Land System	Area Sq Km	Percent of Kingdom/ Zone/ Region	Cover			Watershed Condition				
			For.	Ag.	Br.	1	2	3	4	5
1. Upland Ridges and Valleys		60	77	T	23	100	0	0	0	0
2. Lower Ridges and Valleys		40	12	27	61	10	30	60	0	0
B. Humla-Jumla Region	6098	23	54	12	34	56	44	0	0	0
1. Humla-Mugu Khola		40	60	13	27	83	17	0	0	0
2. Tila-Sinja-Karnali Mountain Lands		60	50	11	39	50	40	10	0	0
C. Western Transitional Mountain Region	4504	18	38	16	46	35	42	23	0	0
1. Western Ridges		25	38	16	46	38	54	8	0	0
2. East-West Ridges		35	47	13	40	72	20	8	0	0
3. Lower Thulo Bheri Valley		20	10	28	62	10	65	25	0	0
4. Thulo Bheri Inner Valley		20	36	14	50	30	35	35	0	0
D. Central Transitional Mountain Region	5035	21	46	28	26	54	46	0	0	0
1. Central Transitional Mountain		70	37	38	25	35	65	0	0	0
2. Upper Valley		30	66	4	30	100	0	0	0	0
E. Eastern Transitional Mountains	7075	28	52	21	27	53	47	0	0	0
1. Canyonlands		70	60	5	35	75	25	0	0	0
2. Lower Main Ridge		30	65	10	25	80	20	0	0	0
III. MIDDLE MOUNTAIN ZONE	42067	30	28	32	40	14	65	15	6	0
A. Baitadi Middle Mountain Region	2635	06	33	15	52	0	88	12	0	0
1. Mahakali Riverbank		30	9	9	82	0	92	8	0	0
2. Upland Ridge and Basin		35	24	23	53	6	67	27	0	0
3. Dandeldhura Ridge		35	62	13	25	30	70	0	0	0

Summary of Watershed Condition (cont'd)

Zone/Region/Land System	Area	Percent of	Cover			Watershed Condition				
	Sq Km	Kingdom/ Zone/ Region	For.	Ag.	Br.	1	2	3	4	5
B. Dailekh Middle Mountain Region	4079	10	22	37	41	8	64	28	0	0
1. Ridge and Valley		75	21	40	39	70	30	0	0	0
2. Open Valley		25	24	28	48	22	52	26	0	0
C. Piuthan Dry Rounded Ridges Region	3612	9	21	33	46	16	55	12	17	0
1. Gulmi Convex Ridge		20	10	51	39	35	40	0	25	0
2. Gulmi Structurally Controlled Ridges		50	26	30	44	25	30	28	9	8
3. Mari Dry Hills		20	21	23	56	8	62	30	0	0
4. Sullivan Rounded Low Ridge		10	14	38	48	15	85	0	0	0
D. Baglung Middle Mountain Region	4101	10	33	27	40	27	70	3	0	0
1. Tin Bainhi Mountain		10	20	34	46	20	62	18	0	0
2. Central Mountain		70	39	23	38	53	47	0	0	0
3. Baglung Broad Open Mountain		20	16	38	46	22	63	15	0	0
E. Central Middle Mountain Region	4334	10	22	50	28	31	62	7	0	0
1. Marsyangdi Assymetrical Ridge		25	26	55	19	50	50	0	0	0
2. Chepe Moderately High Ridge		25	23	39	38	54	46	T	0	0
3. Andhi Khola Mountain		20	9	56	35	21	44	35	0	0
4. Seti Low Hills		20	18	57	25	35	65	0	0	0
5. Tanahu Low Parallel Ridge		5	77	19	4	100	0	0	0	0
6. Tar		5	2	72	26	90	10	0	0	0
F. Kathmandu Region	2252	5	5	70	25	24	28	32	16	0
1. Kathmandu valley		15	5	70	25	85	0	7	8	0
2. Indrawati Ridge and Valley		20	8	40	52	7	8	55	30	0

Summary of Watershed Condition (Cont'd)

Zone/Region/Land System	Area Sq Km	Percent of Kingdom/ Zone/ Region	Cover			Watershed Condition				
			For.	Ag.	Br.	1	2	3	4	5
3. Chautara-Dolalghat		10	19	23	58	0	30	55	15	0
4. Helambu Ridgeland		15	23	46	31	0	60	30	10	0
5. East side Trisuli River		20	18	67	15	12	40	28	20	0
6. Dhading Ridge		20	41	43	16	0	35	37	28	0
G. Sun Kosi Region	3357	8	13	36	51	11	62	14	13	0
1. Jiri-Phaphlu Upland Valleys		10	31	40	29	15	85	0	0	0
2. Charikot Ridge and Valley		40	17	40	43	25	70	5	0	0
3. Okhaldhunga- Ramechhap Ridgeland		50	6	33	61	0	50	25	25	0
H. Arun-Tamur Region	5535	14	29	40	31	4	76	20	0	0
1. Lower Sapt Kosi Basin		90	29	39	32	35	55	10	0	0
2. Ilam Ridge		10	28	54	18	40	40	20	0	0
L. Eastern Mahabharat Lekh Region	3600	8	47	22	31	0	86	14	0	0
1. Sindhuli Garhi Ridge		70	46	24	30	0	80	20	0	0
2. Far Eastern Mahabharat Lekh		30	49	16	35	0	100	0	0	0
M. Central Mahabharat Lekh Region	2800	7	21	28	51	0	66	34	0	0
1. Mahabharat Lekh Highland		60	17	37	46	0	85	15	0	0
2. Trisuli Khola Ridgeland		40	27	18	55	5	75	20	0	0
N. Western Mahabharat Lekh Region	2422	5	31	27	42	7	44	49	0	0
1. Mahabharat Lekh Ridge		40	33	24	43	0	65	35	0	0
2. Tansen Valley and Ridgeland		10	1	50	49	0	100	0	0	0

Summary of Watershed Condition (Cont'd)

Zone/Region/Land System	Area Sq Km	Percent of Kingdom/ Zone/ Region	Cover			Watershed Condition				
			For.	Aq.	Br.	1	2	3	4	5
3. Kali Gandaki Valley and Ridgeland		25	21	29	50	0	92	0	8	0
4. Surkhet Mountain Lands		25	49	19	32	30	0	70	0	0
P. Far Western Mahabharat Lekh Region	3293	8	67	15	18	50	40	10	0	0
1. High Ridges of Mahabharat Lekh		35	81	6	13	100	0	0	0	0
2. Lower Ridgeland		30	67	22	11	50	40	10	0	0
3. Seti-Karnali Canyons		35	52	16	32	5	85	5	5	0
IV. SIWALIK ZONE	18187	13	66	21	13	37	28	33	0	2
A. Western Siwalik Region	4462	25	70	12	18	38	30	32	0	0
1. Main Ridgeland		60	78	6	16	50	50	0	0	0
2. Bheri Khola-Karnali Valley		40	60	19	21	20	0	80	0	0
B. Central Siwalik Region	8371	46	58	32	10	50	13	32	0	05
1. Siwalik Ridges		50	86	3	11	70	10	10	10	0
2. Dang Valley		15	10	76	14	15	35	15	15	20
3. Rapti Valley		15	44	44	12	35	35	20	0	10
4. Chitawan Valley		20	33	65	2	100	0	0	0	0
C. Eastern Siwalik Region	5354	29	77	11	12	15	50	35	0	0
1. Eastern Siwalik										
a. North Boundary Ridge		25	90	5	5	0	100	0	0	0
b. Finely Dissected Lowlands		35	80	5	15	0	0	100	0	0
cd. Cresta Ridgeland and Bottomlands Complex		40	60	25	15	65	35	0	0	0

Summary of Watershed Condition (Cont'd)

Zone/Region/Land System	Area	Percent of	Cover			Watershed Condition				
	Sq Km	Kingdom/ Zone/ Region	For.	Ag.	Br.	1	2	3	4	5
V. TERA1 ZONE	21799	15	19	76	5	100	0	0	0	0
A. Western Terai Region	5694	26	29	62	9	100	0	0	0	0
B. Central Terai Region	4143	19	22	72	6	100	0	0	0	0
C. Eastern Terai Region	11962	55	13	83	4	100	0	0	0	0

APPENDIX 3

Vegetation Zones of Nepal, after J. F. Dobremez (1976). Note that for simplicity, facies have been omitted.

A. TROPICAL ZONE

1. Lower level
 - a. Shorea robusta and Dillenia pentagyna forest
 - b. S. robusta and D. indica forest
 - c. Riverine forest (Dalbergia sissoo and Acacia catechu)
 - d. Riverine forest (S. robusta and Duabanga sonneratioides)
 - e. S. robusta and Cycas pectinata forest
 - f. Pseudo-steppe of tall grasses
2. Upper level
 - a. Hill sal, S. robusta (Terminalia tomentosa is a common associate)
 - b. Riverine forest (S. robusta and Mimosa rubicaulis)

B. SUBTROPICAL ZONE

1. Lower level
 - a. Riverine forest (Cedrela toona - Albizia mollis)
 - b. Lagerstroemia parvifolia hygrophylous forest
 - c. Schima wallichii forest
 - d. Pinus roxburghii xerophyllous forest
2. Upper level
 - a. Alnus nepalensis formation
 - b. Mixed hardwood forest

C. TEMPERATE ZONE

1. Lower level (hill level)
 - a. Cedrus deodara forest
 - b. Quercus incana forest
 - c. Q. lanata forest
 - d. Q. lanata - Pinus wallichiana forest
 - e. Abies pindrow forest
 - f. Q. glauca forest
 - g. Q. lamellosa - Lauraceae forest
 - h. Castanopsis tribuloides forest
 - i. Q. lamellosa - C. hystrix forest

2. Upper level (mountain level)

- a. Pinus wallichiana - Juniperus indica forest
- b. P. wallichiana forest
- c. Picea smithiana - P. wallichiana forest
- d. Quercus semecarpifolia forest
- e. Mountain shrubland
- f. Lithocarpus pachyphylla forest
- g. Daphniphyllum himalayense forest

D. SUBALPINE ZONE

1. Lower level

- a. Abies spectabilis - Quercus semecarpifolia forest
- b. A. spectabilis forest
- c. Xerophyllous forest with Larix potanini
- d. Hygrophyllous forest with L. griffithiana
- e. Subalpine forest with rhododendrons

2. Upper level

- a. Betula utilis xerophyllous forest

E. ALPINE ZONE

1. Lower level

- a. Pioneer species on scree, fans and moraines
- b. Mesophytic and mesohygrophytic shrubland
- c. Alpine meadow

2. Upper level

- a. Scree
- b. Meadows on fine, homogeneous soils
- c. Formations on heterogeneous soils
- d. High altitude scattered open formations

F. STEPPE ZONE

1. Arboreal steppes a. Olea cuspidata arboreal steppe

- b. Cupressus torulosa arboreal steppe
- c. Juniperus indica arboreal steppe

2. Steppes

- a. Caragana nepalensis steppe
- b. C. brevispina steppe
- c. C. gerardiana steppe
- d. C. pygmaea - Lonicera spinosa steppe

GLOSSARY

The terms selected for inclusion in this glossary were used in the Inventory Report in a manner which may be unfamiliar to the reader. The definitions should help remove ambiguities. They are taken from the following references. Several definitions were made by simplifying, modifying, or combining the definitions in the references.

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Aretes, cols, cirques, matterhorns - alpine landforms in which ice and snow have carved sharp ridges, passes, shallow basins and peaks.

Autochthonous - rocks which have formed in situ.

Badlands - a severely eroded area with a very fine drainage network, short steep slopes and narrow interfluvies, usually unvegetated. The largest blocks of badlands are in the upper Mustang Valley and in the Dang Valley.

Benches - usually an elongated, rock-defended, flat to gently sloping surface, adjacent to a stream or on a mountain sideslope. Slopes above and below are steeper.

Bottomland - used in the report to refer to the terrace, flood plain and waterway in the lower parts of valleys.

Braided - the pattern of a stream or riverbed when the deeper channels form a lacy or reticulate network of divergent and convergent members.

Canyon - a narrow, steep-sided valley.

Condition - the state of a land area in terms of attributes pertinent to a particular resource or land use in relation to a standard situation for that resource or land use. Watershed condition is the state of an area of land in terms of those features affecting water quality, quantity and regimen in comparison with that area under pristine conditions. Divergence from the pristine state is expressed by indicators in the soil, vegetation and stream channel.

Cover (types) - refers to the broad class of material, activity or vegetation type occupying a land surface. The cover classes used in the inventory are agriculture, forest and brush. At higher elevations the brush type was replaced by ice, rock, snow and meadow vegetation types.

Deposits - soil, rock or a mixture of both that have been transported but are presently at rest. The type of deposit generally depends on the transporting agent: alluvial - water deposited; fluvial - specifically river deposits; colluvial - accumulations of gravity-moved material; glacial or morainal - deposited by ice; fluvial-glacial - ice and rivers; lacustrine - material originally deposited in lakes.

Descriptions - the section of the inventory report which presents the characteristics of the natural resources, watershed condition indicators, and management needs of the individual land units.

Deteriorated, abused - used to describe land where use impact is negative; where improper use has resulted in lowering of watershed condition.

Dip slopes - slope surfaces which lie parallel to the underlying bedrock strata.

Drainage pattern - the configuration or arrangement of streams in an area. Several types have been identified including: dendritic - tree like, the most common in Nepal; trellis - branching at right angles to the general direction of flow, parts of the Thulo Beri system; centripetal - drainages converging in a basin as in Kathmandu Valley.

Dun Valleys - valleys formed by the Siwalik ridges. Dang, Chitawan and Rapti are examples.

Entrenched - used to describe streams which have in recent times cut their channels vertically into a surface. Indicates a distinctive break in the valley slope gradient.

Erodible - materials subject to erosion, usually expressed in classes.

Erosion - the wearing away of the land surface by running water, wind, ice, or other geological agents. Detachment and movement of soil or rock fragments by water, wind, ice, or gravity.

Erosive - the capability of a geologic agent, i.e. water or wind, to cause erosion.

Flood Plain - the land adjacent to a stream or in the bottom of a drainageway that is periodically flooded frequently enough to exclude permanent vegetation.

Forbs - broad-leafed herbaceous plants.

Gorge - a narrow, very steep-sided, often vertically-walled, valley or valley section.

Headlands - the upper parts of valleys, usually where secondary streams join to form the main stream.

Impact - the expression of a land use in the environment. Impacts are usually negative, e.g. soil erosion may be an impact of excessive grazing.

Incised, dissected - the process of stream cutting or the state of a surface having been cut into by a stream.

Inner Valley - the upper parts of major river valleys behind, or within the High Himalaya Zone. Manang and the Tibrikot areas are examples.

Interpretations - the section of the report which evaluates the natural resources in a land unit for watershed condition, landslide hazard, erosion hazard and terraceability.

Inventory - the process of gathering data for future use. The document containing data on the quantity, quality, or condition of a physical resource.

Landforms - elements of the earth surface having a specific morphology and genesis.

Landscape - a land area visible from a particular point. It is not used as a mapping unit here.

Land units - a term for map units at all levels of intensity. These are described on page 2. A map unit is a conceptual device used to indicate a certain kind of land that is located by one or more delineations on a map. The names of map units appear in the legend.

Level - used here to mean a specific intensity of mapping with a particular kind of map unit, e.g. the landtype level, ecological region level.

Lowlands - used to refer to a group of landforms in the lower part of a drainage: toe slopes, stream terraces, flood plain, stream channel(s), fans, outwash plains.

Mass movements - a variety of processes by which large masses of earth material are moved by gravity either slowly or quickly from one place to another. These can be assigned to the following groups according to rate of movement - (from fast to slow) landfall, landslide, landflow, landcreep, landslump. Debris avalanche, a kind of landslide, is the most abundant form of mass movement in Nepal.

Massif - a prominent block of high mountains and associated ridges.

Materials - used in the report to refer to bedrock in a land unit.

Nappe - faulted overturned fold.

Occupational caste - The several castes that are associated with specific crafts such as shoemakers (Sarki), iron workers (Kami), etc.

Orographic storms - storms caused by the uplift of air masses as they cross a barrier, usually a mountain.

Rain shadow - the dry zone on the leeward side of a mountain system.

Reconnaissance - a preliminary survey usually executed rapidly and at low cost.

Ridge - an elongated, elevated landform which is usually triangular in cross-section. Primary ridges are the most prominent ridges and are generally aligned with the major geologic features or large drainageways. Secondary ridges are those formed by dissection of primary ridges.

Rugged - a term used to characterize land units with steep slopes, high relief, angular ridges, and/or intensive dissection.

Scarp - an exposed cross-section of bedrock or deposits, a slope that crosses the bedrock layers.

Schuppen - imbricate or overlapped structure.

Sediment - solid material, both mineral and organic that is being or has been transported by a stream either in suspension or on the stream bottom as bed load.

Shoulders - a sloping bench or area of decrease in slope gradient on a mountain slope.

Slopes - inclined surfaces with gradients over about 5 percent. Flats, as used here, are lands with slopes of less than 5 percent.

Slope position - used in the inventory report to refer to location on a lateral section of a ridge. Positions are the equivalent of slope units such as crest, upper slope, mid-slope, lower slopes.

Sod breakage - disruption of sod grass cover on a slope by trampling of animals.

Spralling - used to describe broad ridges with steeper upper and lower slopes.

Stabilize - to stop land degradation processes on a deteriorated or threatened site.

Steppe - an area with a brush and/or grass community in an arid or semi-arid environment.

Terraces - used to mean natural landforms which are elongated, flat deposits of alluvial or lacustrine materials which are above the bottom of valley. Most are dissected by streams in drainageways with very steep sideslopes. Many occur in several levels, representing different past stream or lake levels.

Terracettes, trailing - a pattern of interwoven trails on slopes caused by livestock use.

Uplands - used to refer to the upper slopes, ridge crests, the heads of drainages, benches in the higher portion of a watershed.

Vegetation types - units described in terms of major tree species which are used to describe the vegetation in a land unit.

Watershed - an area of land drained by a common stream.

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