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AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT PAPER

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PROJECT
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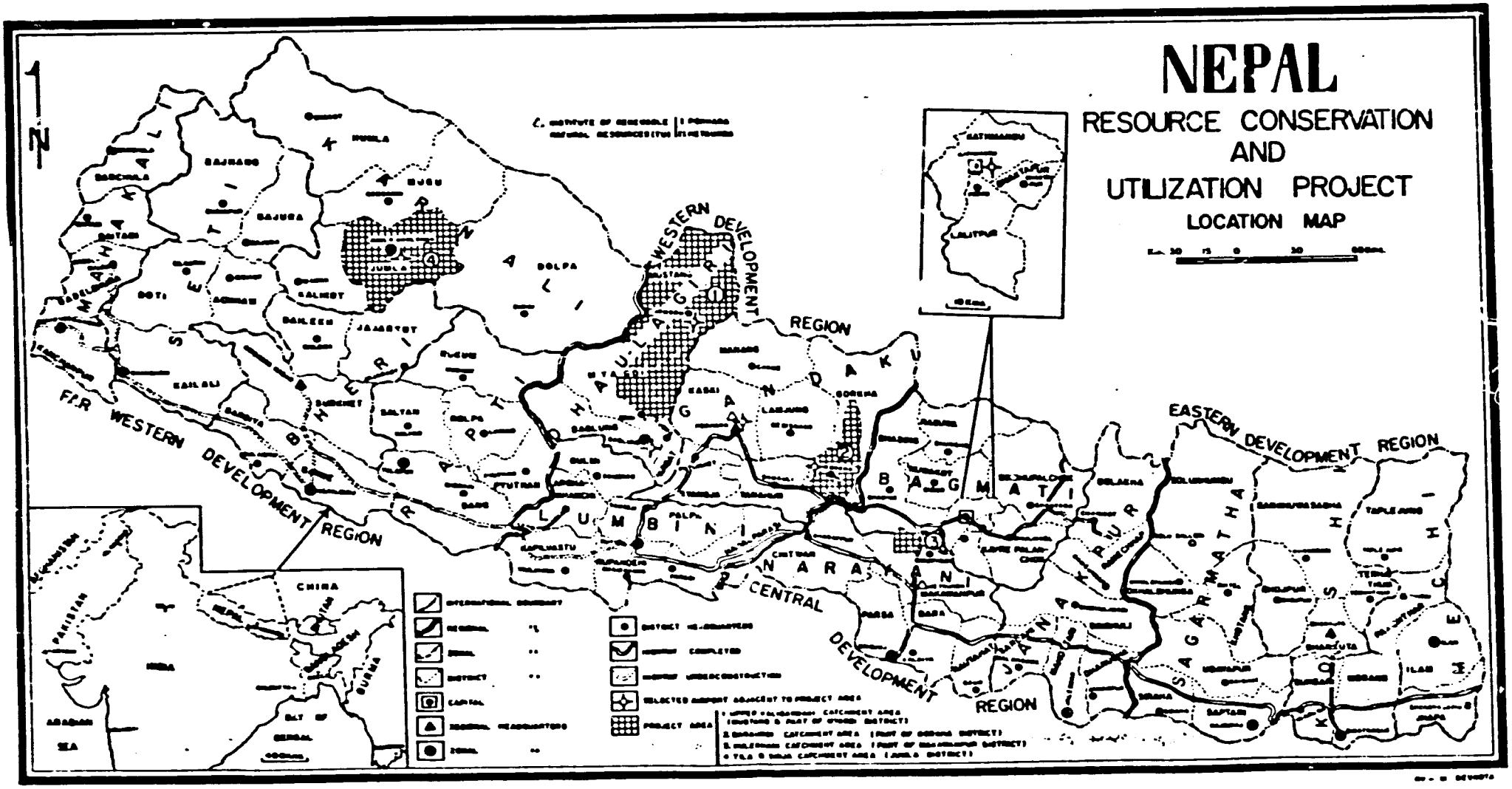
MAP



APROSC AUGUST, 1979

APPENDIX C

SOILS AND GEOLOGY OF KULEKHANI, DARAUNDI, MIDDLE UPPER AND UPPER KALIGANDAKI (MUSTANG AND MYAGDI) WATERSHED AREAS

Prepared by: APROSC

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The Soil Survey and Geological Team of the Resource Conservation and Utilization Project (APROSC) for various project areas was composed of the following personnel:

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All the figures are attached at the end of the report.

CHAPTER I

INTRODUCTION

Over the past fifteen years, the area of Nepal's forests has been reduced by about two-thirds. This deforestation is in direct response to the needs of a bargaining population for additional farmland and, even more critically, for fuel. In addition, overgrazing of cleared lands, fires set to increase the growth of grasses, and continuous cropping with insufficient restoration of nutrients to farmland, has resulted in serious soil erosion, destroying the basis of rural livelihood and having widespread impacts on potential hydroelectric development, on transportation networks, and on flooding regions throughout the North Indian plateau.

In addressing this complex problem, the RCUP is providing for long-term resource inventory and monitoring to assess environmental damage and the success of the RCUP in improving the situation. A soils and geological reconnaissance of the RCUP project area has already been carried out to provide a basis for the design of the early project activities. This is considered an interim measure, pending the publication of the report of detailed resource inventories.

CHAPTER II

SOILS AND GEOLOGY OF KULEKHANI CATCHMENT AREA

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I. PHYSICAL AND ENVIRONMENTAL FEATURES

Location and Extent

The Kulekhani catchment area is located southwest of Kathmandu Valley in and around the Mahabharat ranges in Makawanpur District, Narayani Zone of Central Nepal. The catchment area, measuring about 18 km from east to west and 12 km from north to south, lies between 85° 2'46" and 85° 16'15" east longitude and 27° 33'25" and 27° 41'13" north latitude. The surveyed area comprises 212 sq. km. There were about 30,000 inhabitants in this area in 1971, with a projected population of 36,000 in 1979. The average density of the population in the area is 172 people per square km. The elevation of the area varies from 1200 m at the bank of Kulekhani khola at Ipa Ukhubari to 2400 m at Simbhanjyang.

Climate

Only two weather stations, Daman and Markhu, are operating within the Kulekhani watershed. Data from these stations reveal annual precipitation values of between 1500 and 2500 mm respectively. The records indicate that about 80 percent of the rain falls in the months from June to September. Most of the remainder falls in the pre-monsoon (April-May) and post-monsoon (October-November) periods. Winter is a distinctly dry period. All precipitation falls as rain except some snowfall in the highest elevations.

Daman temperature records show seasonal fluctuations in mean monthly temperature between 5.6°C in January and 17°C in June. Summer mean maximums reach 23.5°C, whereas winter mean minimums drop to -1.5°C. Relative humidities reach about 60 percent in winter-spring, climbing to 91 percent during the monsoons (Department of Irrigation, Hydrology and Meterology, 1977).

This data indicates that the lowland climates of Kulekhani are subtropical monsoonal, becoming temperate at higher elevations in the surrounding mountains.

Physiography and Drainage

Most of the Kulekhani catchment area is drained by the Kulekhani River, which is one of the tributaries of the Bagmati River. The Kulekhani River originates about 5 km west of Palung. Gathering tributaries from the north, the river flows about 10 km eastward to Tasar, then turns southeast meandering toward Kitni, about 7 km south-southeast of Tasar. For the last 9 km between Kitni and the confluence with the Bagmati, the river takes an east-southeast direction.

The Kulekhani project area can broadly be grouped into two physiographic units namely Mahabharat Lekh and Midland.

Mahabharat Lekh: Mahabharat Lekh, known as middle or "less" Himalaya, is situated south of the Kulekhani River. The whole range rises from 884 to 2590 m. The Mahabharat range is very rugged, steep and has minimal soil development and productivity, resulting in a sparce human habitation. The lithology of the Mahabharat Lekh consists mainly of metamorphic rocks of marble, gneiss, schist and quartzite and also has massive granitic intrusive rock. A warm temperate climate supports evergreen oak forests at lower altitude, yielding to mixed broad leaf and rhododendron forest with increasing elevation. The upper part of the Lekh has good forest cover, but in the lower slopes the forests are being heavily cut and are badly depleted.

Midland: The northern part of the project area, north of the Kulekhani River, comes under the Midland Region. This region attains almost the same elevation as that of the Mahabharat range but its terrain and geological composition are quite different. It is gentle in slope and consists of soft rocks (schist, phyllite, limestone, etc.) and has a favorable agro-climate. Soils are fertile and support intensive rice cultivation with ample water supply, especially in the valleys and adjoining terraces. All of these factors have contributed to a dense population in this region.

Natural Vegetation

Based on altitudinal zonation, the native vegetation of Kulekhani Catchment area can broadly be grouped into sub-tropical (1200-1800 m) and temperate forest (1800-2400 m) categories.

In the sub-tropical forest category, the vegetation identified are *Pinus roxburghii*, *Lagerstroemia parviflora*, *Lyonia ovalifolia*, *Berberis asialica*, *Castanopis indica*, *Querces incana*, *Impereta cylindrica*, etc. *Shorea robusta* is found only in very few places. Temperate zone forest consists mainly of *Pyrus ovalifolia*, *Rhododendron arboreum*, *Prunus cerasoides*, *Ficus nemoralis*, *Barberis asialica*, *Pinus excelsa*, *Lyonia ovalifolium*, *Schima wallichhii*, *Quercus sermicarpifolia*, *Quercus incana*, *Quercus glauca*, *Castanopsis indica*, *Castanopsis taubalaris*, *Myrica nagi*, *Pyrus pashia*, etc.

Land Use

Out of the total 212 sq. km. of the project area, the area under forest, cultivated land, pasture and others are estimated to be 104, 82, 21 and 5 sq. km. respectively (APROSC 1979). A description of each land use type follows:

Forest: Fortynine percent of the project area is covered by forest. As

already pointed out, sub-tropical and temperate forest areas include shrub and brush, encroached forest, steep and rocky areas and commercial forest.

Pasture: Pasture land comprises 10 percent of the project area. The natural pasture units are scattered throughout the catchment area.

Agriculture: Agriculture covers about thirty-nine percent of the total project area. Cultivation is mainly carried out on bench terraces. The Valley of Tistung, Palung and Sikharkot are under intensive cultivation, rice being the main crop in terms of area and production. Maize, millet, wheat, potatoes, and mustard follow in importance. Other crops such as sugarcane, barley, soybean, and a wide range of vegetables are grown on a small scale. Rice is grown in the Kulekhani Catchment area up to 1800 m. Below 1600 m., double cropping is practiced; the main summer crops being maize and millet followed by either mustard or wheat during the rabi (winter) season. Between 1600 m and 2200 m. a two-year cropping sequence of maize followed by millet and wheat is the common pattern. Above 2200 m., only one crop per year of either wheat, barley, potatoes or maize is grown. The crop grown and the intensity of land use are influenced to a large extent by the availability of water.

Others: Water areas, roads and trails, rock outcrops, settlements, etc. cover two percent of the project area. Major areas of human settlement are in Tistung, Palung, Kulekhani and Chitlang.

II. GENERAL NATURE OF THE SOILS

A. Methodology

Mapping and Classification of the Soils: The soil survey was done on a broad reconnaissance basis with the primary objective of identifying and recommending the inventory needs for investigation and planning sectoral projects. The field work was carried out from December 13th to 28th, 1978 and then from January 6th to 17th, 1979. A topographic map (Sheet No. 72 E/2) with a scale of 1:63,360 was used as the base map. Traverses of the area were made on foot and by vehicle. Because of the time constraints for field surveying, major emphasis and reliance was placed on aerial photo-interpretation for both preliminary studies of physical features and as a basic aid in plotting the boundaries between map units. Soils were examined in soil pits and notes on topography, vegetation, geology and other physical features were recorded on field sheets and on air photos. Forty pits were dug in the entire project area.

The soils were tested for carbonates in the field with the help of 10

percent hydrochloric acid. Special correlation boxes developed by Charter and Brammer (Brammer, 1965) were used for soil correlation as well as for retention of a representative soil profile in the Nepalese soil museum.

Morphological characteristics are recognized by soil layers or horizons that differ in colour, texture, structure, consistency, reaction, thickness, or chemical analysis of soils. All soil profiles are compared with others in the area and classified into soil series according to the USDA system (USDA, 1975). Every soil series is given a local name, e.g., Angare series. Each soil unit is on a unique natural landscape that has a distinct pattern of soils and of relief and drainage features. A unit typically consists of one or more soils of major extent and some soils of minor extent. The unit is named for the major soils, e.g., Bisingkhel-Chhankhu. The kinds of soil in one unit can occur in other soil units but in a different pattern.

Altogether, 19 map units have been identified, four of which have been subdivided into land use phases (see Sheet No. I Soil Map 11a). The map provides a broad perspective of the soils on landscapes in the survey area. It provides a basis for comparing the potential of large areas for land use. Areas that are generally suitable for certain kinds of farming or other uses can be identified on the map. Likewise, areas of soils having properties that are distinctly unfavourable for certain uses can be located.

Because of its small scale, the map does not show the kind of soil found at a specific site. The kind of soil in any one soil unit ordinarily differs from place to place in slope, depth, stoniness, drainage, or other characteristics that affect soil management.

A description of various mapping units is given in a following section.

Land Suitability Classification[1/]: A suitability classification for agriculture, horticulture, pasture, forestry and terraceability was made based on the following criteria:

Highly Suitable (Class I):

Land having no significant limitations to sustained application of defined use, or only minor limitations that will not significantly reduce productivity and/or benefits, and will not require recurrent and minor capital inputs for production and conservation above an acceptable

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1/ This land classification is based upon the proposal by Expert Consultation on Land Classification, Wageningen, 1972 (International Institute for Land Reclamation and Improvement, 1973).

level.

Moderately Suitable (Class II):

Land having limitations which in aggregate are moderately severe for sustained application of the defined use: the limitation will reduce productivity and/or benefits and increase required recurrent and minor capital inputs for production and conservation to the extent that the overall advantages to be gained from the use, although still attractive, will be appreciably inferior to that expected on highly suitable land.

Poorly Suitable (Class III):

Land having limitations which in aggregate are severe for sustained application of the defined use and will so reduce productivity or benefits, and/or increase required inputs for production and conservation, that this expenditure will be only marginally justified.

Unsuitable:

Land having characteristics which appear to preclude its sustained use for the defined purpose in the defined manner or which would create production, upkeep and/or conservation problems requiring a level of recurrent inputs unacceptable at the present time.

B. Description of Mapping Units

1. Angare soil occurs in the western part of the mapped area on moderately steep to steep slopes. These soils are shallow, somewhat excessively drained and are made up of materials derived mainly from marble.

Altitude	About 1950 m; Exposure; Southwest.
Surface Soil	Very dark grayish brown, friable, silt loam, 20 cm. thick.
Sub-Soil	Very dark brown, very friable, silt loam. 20 cm. thick, many rock fragments.
Substratum	Hard rock *in situ*.
Other Properties	Neutral, very high in organic matter, medium in nitrogen, phosphorus and potach.
Suitability	
Agriculture	Unsuitable for farming.
Horticulture	Moderately suitable.
Pasture	Poor to moderately suitable.
Forestry	Moderate to highly suitable
Terrace	Unsuitable.
Limitations	Shallow to bedrock, many rock fragments on or near the soil surface; risk of soil erosion, moderately steep to steep slopes; wind, frost and hailstorms.

Erosion and Landslide Hazards	This soil unit falls under moderately non-sliding territory. Soil erosion hazards class is rated as moderate and sheet erosion moderate to high.

2. Bisingkhel - Chhankhu Soil (1.63 km^2) Bi - Cn

The Bisingkhel - Chhankhu soil unit occurs in the northern part of the mapped area on rolling to moderately steep bench terraces. These soils are moderately deep to deep, moderately well drained to well drained and are made up of materials derived mainly from slate, phyllite and quartzite and occasionally limestone. Soil texture varies from silt loam to silty clay loam, and altitude varies from 1680 to 1830 m.

This unit contains 50 to 55 percent Bisingkhel and 45 to 50 percent Chhankhu soils.

Altitude (Bisingkhel)	About 1830 m.; Exposure: Southeast.
Surface Soil	Dark brown to dark yellowish brown, friable, silt loam, 10-15 cm. thick, few rock fragments.
Sub-Soil	Dark brown to dark yellowish brown, friable, silt loam, 60-90 cm. thick, few rock fragments.
Substratum	May be hard rock *in situ* derived mainly from slate, limestone and quartizite.
Other Properties	Slightly acid, very high in organic matter and potash, medium in nitrogen and phosphorus.
Altitude (Chhankhu)	1680-1830 m.; Exposure: South
Surface Soil	Brown to dark brown, very friable, loam/silt loam, 10-15 cm. thick, few rock fragments.
Sub-Soil	Brown to strong brown, very friable, silty clay loam, 55 to 95 cm. thick, few rock fragments.
Substratum	May be (a) hard rock *in situ*, (b) poorly sorted colluvial material.
Other Properties	Medium to slightly acid, very high in organic matter, high in nitrogen, low in phosphorous and high to very high in potash.
Suitability	
Agriculture	Highly suitable for maize, millet, potato and mustard; moderately suitable for wheat, barley and buckwheat; poorly suitable for rice and sugarcane.

Horticulture	Moderately suitable for lemon, lime, plum, peaches and walnut. Suitable vegetables include radishes, peas, beans and cole crops.
Pasture	Moderately suitable for forage crops.
Forestry	Moderately suitable.
Terrace	Poor to moderately suitable.
Limitations	Suffers drought in dry season, requires irrigation for good crops; moderately steep slopes, risk of soil erosion; relatively short growing season.
Erosion and Landslide Hazards	This soil unit falls under non-sliding to moderately sliding territory. Soil erosion hazards class is rated moderate and sheet erosion moderately high to high.

3. Charkhu Soil (21.34 km^2) Cr

The Charkhu soil unit occurs in the northeast part of the mapped area on steep slopes. These soils are moderately deep, well drained and are made up of materials derived from slates.

Altitude	About 2130 m.; Exposure: Southwest.
Surface Soil	Very dark brown, friable, silt loam, 10-15 cm. thick, few rock fragments.
Sub-Soil	Dark brown, friable, loam to silt loam, 35-40 cm. thick, many rock fragments.
Substratum	Weathered slate.
Other Properties	Medium acid, very high in organic matter, high in nitrogen and potash and medium in phosphorus.
Suitability	
Agriculture	Poor to unsuitable for farming.
Horticulture	Poor to moderately suitable.
Pasture	Poor to moderately suitable.
Forestry	Highly suitable.
Terrace	Unsuitable.
Limitations	Droughtiness in dry season, requires irrigation for good crops; steep topography, risk of soil erosion, many rock fragments on or near the soil surface; short growing season; wind, frost and hailstorms.
Erosion and Landslide Hazards	This soil unit is included in the moderately non-sliding to sliding

	territory. Soil erosion hazards class can be rated moderate to severe and sheet erosion moderately high to high.

4a. Chhankhu Soil, Cultivated Phase (18.05 km^2) Cn_1

This soil unit occurs in the eastern and central parts of the mapped area on moderately steep fan and bench terraces. Soils are deep, moderately well drained and are made up of materials derived mainly from phyllite, slate and quartzite.

Altitude	1830 m.; Exposure: Southeast
Surface Soil	Strong brown, friable, silt loam 10 cm. thick.
Sub-Soil	Strong brown to dark brown, friable, silt clay loam, 90 cm. thick, few rock fragments.
Substratum	Weathered phyllite.
Other Properties	Medium to slightly acid, high in organic matter, medium in nitrogen, very high in potash and low in phosphorous.
Suitability	
Agriculture	Highly suitable for maize, millet, legumes; moderately suitable for wheat; poorly suitable for rice and sugarcane.
Horticulture	Moderately suitable for lime, lemon, peach, and plum; highly suitable for vegetables such as radishes, cabbage cauliflower and broad-leaved mustard.
Pasture	Moderately suitable.
Forestry	Moderately suitable.
Terrace	Moderately suitable.
Limitations	Droughtiness in dry season, moderately steep slopes, risk of soil erosion; requires irrigation for good crops; short growing season; low in phosphorous; wind and hailstorms.
Erosion and Landslide Hazards	This soil unit mostly occupies non-sliding territory. Soil erosion hazards class is estimated to be moderate. Fifty percent of the area has slight erosion. The remaining area is in moderately high to high class.

4b. Chhankhu Soil, Forested (23.47 km^2) Cn_2

Similar to as Chhankhu Soil, cultivated but moderately deep to deep, moderately steep to steep slope, exposure variable.

Suitability	
Agriculture	Poorly suitable for farming.
Horticulture	Moderately suitable.
Pasture	Moderately suitable for forage crops.
Forestry	Highly suitable.
Terrace	Moderately suitable.
Limitations	Droughtiness in dry season; severe risk of soil erosion, moderately steep to steep slope; low in phosphorus; wind and hailstorms.
Erosion and Landslide Hazards	Major area of this soil unit falls in non-sliding territory. Soil erosion hazards class is rated moderate and sheet erosion fall in class I (high).

5. Chhankhu - Tekar Soil (4.50 km^2) Cn - Tk

The Chhankhu - Tekar soil unit occurs in the northeast past of the mapped area on rolling bench terraces ranging from moderately steep to steep slopes. These soils are moderately deep to deep, moderately well drained to well drained and are made up of materials derived from phyllite, quartzite and slate. Texture varies from silt loam to silty clay loam; altitude varies from 1680 to 1830 m.

This unit contains 90 percent Chhankhu and 10 percent Tekar soils.

Chhankhu Soil: This soil has cultivated (Cn_1) and forest phases (Cn_2). Its detail has been presented under mapping units Cn_1 and Cn_2.

Tekar Soil: This soil unit has been described in mapping unit TK.

Suitability	
Agriculture	Moderately suitable for maize, millet, mustard, buckwheat and legumes; poor to moderately suitable for wheat, barley and potato; poorly suitable for rice and sugarcane.
Horticulture	Moderately suitable for lemon, lime, peace, plum and pears; moderate to highly suitable for vegetables such as radish, legume, cole and colocasia.
Pasture	Poor to moderately suitable for forage crops.
Forestry	Moderate to highly suitable for forestry.
Terrace	Moderately suitable.

Limitations	Droughtiness in dry season, requires irrigation for good crops; moderately steep to steep slope, risk of soil erosion; short growing season: low in phosphorus; wind and hailstorms.
Erosion and Landslide Hazards	This soil unit falls under moderately sliding territory. Soil erosion hazards class is rated moderate and sheet erosion mostly moderate to high.

6. Chitlang Soil (4.47 km^2) Cg

This soil occurs in the central part of the mapped area on moderately steep slopes. These soils are moderately deep, moderately well drained and are made up of materials derived from phyllite and quartzite.

This unit is composed of 30 percent forest, 50 percent pasture and the rest barren land.

Altitude	About 1680 m.; Exposure: Southwest.
Surface Soil	Reddish brown, friable, sandy loam, 10-15 cm. thick, few rock fragments.
Sub-Soil	Reddish brown, friable, silty clay, 60-70 cm. thick, few rock fragments.
Substratum	May be hard rock *in situ*.
Other Properties	Slightly acid, very high in organic matter and potash, high in nitrogen and very low in phosphorus.
Suitability	
Agriculture	Moderately suitable for maize, millet, wheat and mustard; poorly suitable for rice and sugarcane.
Horticulture	Moderately suitable for lime, lemon, peace, plum, pear. Suitable vegetables include raddish, legume and colocasia.
Pasture	Highly suitable for raising pasture subject to the addition of phosphatic fertilizer.
Forestry	Highly suitable.
Terrace	Moderately suitable.
Limitations	Droughtiness in dry season, requires irrigation for crops and pasture development; moderately steep slope, risk of soil erosion; relatively short growing season; low moisture holding capacity; severe wind, frost and hailstorms.
Erosion and Landslide Hazards	This soil unit occupies almost 100 percent area of non-sliding class. Soil

erosion hazards class is rated moderate and sheet erosion mostly moderate to high.

7a. Daman Soil, Cultivated (9.84 km^2) Da_1

This soil unit occurs in the central and western parts of the mapped area on rolling bench terraces. These soils are deep, moderately well drained and are made up of materials derived from granite.

This unit contains 20 percent regular and 80 percent irregular relief.

Altitude	About 1830 m.; Expodure: North.
Surface Soil	Yellowish brown, firm, silt loam, 10-15 cm. thick.
Sub-Soil	Yellowish brown to dark brown, firm, silt loam to silty clay loam, 80-90 cm. thick, few rock fragments.
Substratum	Weathered granite.
Other Properties	Strongly acid, very high in organic matter, phosphorous and potash and high in nitrogen.
Suitability	
Agriculture	Poor to moderately suitable for farming.
Horticulture	Moderately suitable.
Pasture	Poor suitability for developing pasture.
Forestry	Highly suitable for forest. About 80 percent of this unit is under forest cover.
Terrace	Poor to moderate suitability.
Limitations	Droughtiness in dry season; susceptibility to erosion under cultivation or human intervention; wind and hailstorms; frost and snow.
Erosion and Landslide Hazards	This soil unit falls under non-sliding territory. Soil erosion hazards class is rated severe and sheet erosion moderately high to high.

7b. Daman Soil, Forested (18.69 km^2) Da_2

This soil unit occurs in the central and western parts of the mapped area on easy rolling to rolling bench terraces. These soils are deep, moderately well drained, and are made up of materials derived mainly from granite.

Altitude	1830-2280 m.; Exposure: Variable.
Surface Soil	Yellowish brown to dark yellowish brown, friable, loam/silt loam, 15-20 cm. thick, few rock fragments.

Sub-Soil	Yellowish brown to brownish yellow, firm, loam to silty clay loam, 60-80 cm. thick, few rock fragments.
Substratum	Weathered granite.
Other Properties	Medium to strong acid, high to very high in organic matter, phosphorous and potash and high in nitrogen.
Suitability	
Agriculture	Moderately suitable for maize, millet, potato and buckwheat; poorly suitable for rice and sugarcane.
Horticulture	Highly suitable for peach, plum, pear; poor to moderately suitable for apples. Suitable vegetables include raddish, cauliflower, cabbage and soybean. Governmental Horticultural Farm is located in this area.
Pasture	Poor to moderately suitable.
Forestry	Moderate to highly suitable for forest.
Terrace	Poor to unsuitable.
Limitations	Droughtiness in dry season, requires irrigation for good crops; short growing season; wind and hailstorms.
Erosion and Landslide Hazards	This soil unit falls under non-sliding territory. Soil erosion hazards class is rated slight to moderately high to high.

8a. Deorali Soil, Cultivated (5.37 km^2) Dr_1

Similar to Deorali soil forested (described later) but cultivated.

Terrace	Unsuitable.
Erosion and Landslide Hazards	About 50 percent of this soil unit consists of non-sliding territory, and the remaining of moderately non-sliding territory. Soil erosion hazards class is rated severe and sheet erosion moderately high to high.

8b. Deorali Soil, Forested (21.58 km^2) Dr_2

This soil unit occurs in the southern and central parts of the mapped area on moderately steep to steep slopes. These soils are shallow, well drained and are made up of materials derived mainly from granite, quartzite and quartzitic phillite.

Altitude	1830-2440 m.; Exposure: Northeast.
Surface Soil	Very dark greyish brown to very dark brown, very friable, sandy loam to silt loam, 10-15 cm. thick.

Sub-Soil	Yellowish brown to dark yellowish brown, very friable, loam 25-40 cm. thick, many rock fragments.
Substratum	Brownish yellow, gravelly sandy loam, many rock fragments.
Other Properties	Medium acid, very high in organic matter, high in nitrogen, low to medium in phosphorus and medium in potash.
Suitability	
Agriculture	Poor to unsuitable for farming.
Horticulture	Moderately suitable.
Pasture	Poor to moderately suitable.
Forestry	Moderate to highly suitable.
Terrace	Unsuitable.
Limitations	Droughtiness in dry season; low moisture holding capacity; many rock fragments on or near the soil surface; severe risk of soil erosion, moderately steep slopes; wind, frost, and hailstorms.
Erosion and Landslide Hazards	This soil unit falls under moderately non-sliding to sliding territories. Soil erosion hazards class is rated moderate and sheet erosion moderately high to high.

9. Khadpu - Bhalukharka Soil (21.31 km^2) Kd - Bk

The Khadpu - Bhalukharka soil unit occurs in the southern part of the mapped area on rolling bench terraces to very steep slopes. The soils are moderately deep to deep, moderately well drained and are made up of materials derived from phyllite and quartzite. Texture varies from silt loam to silty clay loam; altitude varies from 1370-1830 m.

This unit contains 70 percent Khadpu and 30 percent Bhalukharka soils.

Khadpu Soil:

Altitude	About 1830 m.; Exposure: Variable.
Surface Soil	Dark yellowish brown, friable, silt loam, 10-15 cm. thick.
Sub-Soil	Yellowish brown, very friable, silt loam, 40-60 cm. thick. many rock fragments.
Substratum	Weathered phyllite *in situ*.
Other Properties	Medium to slightly acid, high to very high in organic matter and potash, high in nitrogen and medium in phosphorus.

Bhalukharka Soil:

Altitude	1370-1830 m.; Exposure: Variable.
Surface Soil	Dark greyish brown, friable, silt loam, 10-15 cm. thick, few rock fragments.
Sub-Soil	Yellowish brown to dark yellowish brown, firm, silt loam to silty clay loam, 100-140 cm. thick, few rock fragments.
Substratum	May be (a) hard rock in situ (b) poorly sorted alluvial colluvial materials.
Other Properties	Slightly acid, very high in organic matter, phosphorus and potash and high in nitrogen.
Suitability	
Agriculture	Moderately suitable for maize, millet, mustard, wheat and buckwheat; poorly suitable for rice and sugarcane.
Horticulture	Highly suitable for lime and lemon; poorly suitable for apple. Raddish, cauliflower, mustard and colocasia are the suitable vegetables.
Pasture	Poor suitability.
Forestry	Highly suitable.
Terrace	Unsuitable to poor suitability.
Limitations	Droughtiness in dry season, requires irrigation for good crops; steep slopes (Khadpu soil); few to many rock fragments on or near the soil surface; wind and hailstorms.
Erosion and Landslide Hazards	This soil unit occupies approximately 50, 40 and 10 percent area of sliding, moderately non-sliding and non-sliding territories, respectively. Soil erosion hazards are mostly severe in this unit and sheet erosion is rated high.

10. Khadpu Soil (0.53 Km^2) Kd_1

The Khadpu soil unit occurs in the eastern part of the mapped area on steep slopes. These soils are moderately deep, well drained and are made up of materials derived from phyllite.

Altitude	About 1830 m.; Exposure: Variable.
Surface Soil	Dark yellowish brown, friable, silt loam, 10-15 cm. thick, many rock fragments.
Sub-Soil	Yellowish brown, very friable, silt loam, 40-60 cm. thick, many rock fragments.

Substratum	Weathered phyllite *in situ*.
Other Properties	Slightly acid, high in organic matter, nitrogen and potash and medium in phosphorus.

11a. Khuplang Soil Cultivated (12.56 km^2) Ku_1

This soil unit occurs in the western and northwestern parts of the mapped area. These soils are moderately deep to deep, moderately well drained and are made up of materials derived from phyllite, schist and quartzite.

Altitude	2150 m.; Exposure: Northwest.
Surface Soil	Dark yellowish, brown, friable, silt loam, 15-20 cm. thick, few rock fragments.
Sub-Soil	Dark brown to yellowish brown, very friable, silt loam to silty clay loam, 50-80 cm. thick, many rock fragments.
Substratum	Weathered phyllite and schists *in situ*.
Other Properties	Medium to slightly acid, high in organic matter and nitrogen, medium in potash and very low in phosphorus.
Suitability	
Agriculture	Highly suitable for maize, millet, wheat, buckwheat and soybean; poorly suitable for rice and sugarcane.
Horticulture	Moderately suitable for peach, plum, lime and lemon. Poorly suitable for apple.
Pasture	Poor suitability.
Forestry	Moderately suitable.
Terrace	Dominantly poor suitable. (About 50 percent area falls in this class and rest in class I and II).
Limitations	Droughtiness in dry season, requires irrigation for good crops; moderately steep to steep slopes; many rock fragments on or near the surface soil; risk of soil erosion; very low in phosphorus; wind, frost and hailstorms.
Erosion and Landslide Hazards	About half of the area of this unit is occupied by moderately non-sliding territory and the remaining half by non-sliding territory. Soil erosion hazards class is rated moderate and sheet erosion moderately high to high.

11b. Khuplang Soil, Forested (11.13 km^2) Ku_2

This soil unit occurs in the northwestern part of the mapped area on moderately steep to steep slopes. These soils are moderately deep,

moderately well drained and are developed from phyllite, schists and quartzite.

Altitude	About 2100 m.; Exposure: Southeast.
Surface Soil	Reddish brown, very friable, silt loam, 15-20 cm. thick, few rock fragments.
Sub-Soil	Brown to dark brown, very friable, silt loam to silty clay loam, 50 cm. thick, few to many rock fragments.
Substratum	Weathered phyllite and schist *in situ*.
Other Properties	Medium to slightly acid, high to very high in organic matter, medium to high in nitrogen, low in phosphorus and high in potash.
Suitability	
Agriculture	Poor suitability for farming.
Horticulture	Poor suitability.
Pasture	Moderately suitable.
Forestry	Highly suitable existing forest consists mainly of *Rhododendron* spp. *Quercus lanuginosa*, *Quercus semecarpifolia* and *pinus* spp.
Terrace	Unsuitable.
Limitations	Droughtiness in dry season; relatively short growing season; many rock fragments on or near the soil surface; severe risk of soil erosion, moderately steep to steep slope; low in phosphorus; wind, frost and hailstorm.
Erosion and Landslide Hazards	This soil unit falls under moderately non-sliding territory. Soil erosion hazards class is rated moderate and there is high degree of sheet erosion in this unit.

12. Kogte Soil (8.17 km^2) Ko

The Kogte soil unit occurs in the south and southwest part of the mapped area on rolling bench terraces. These soils are deep, somewhat excessively drained and are made up of materials derived from micaceous quartzite and phyllite.

This unit contains 50 percent cultivated and 50 percent forest phase.

Altitude	About 1830 m.; Exposure: Southeast.
Surface Soil	Dark yellowish brown, very friable, sandy loam, 15-20 cm. thick, few rock fragments.
Sub-Soil	Dark yellowish brown to very dark greyish brown, friable, loam, few rock fragments.

Substratum	May be hard rock in situ.
Other Properties	Medium acid, very high in organic matter and potash and high in nitrogen and phosphorus.
Suitability	
Agriculture	Highly suitable for maize, millet, mustard and buckwheat; moderately suitable for rice and sugarcane.
Horticulture	Moderately suitable for lime, lemon, pear, plum, peaches, walnut, vegetables and legumes; poorly suitable for apples.
Pasture	Moderately suitable for pasture.
Forestry	Moderately suitable.
Terrace	Moderately suitable.
Limitations	Droughtiness in dry season, requires irrigation for good crops; short growing season; low moisture holding capacity; wind and hailstorms.
Erosion and Landslide Hazards	This soil falls under non-sliding territory. Soil erosion hazards is rated moderate and sheet erosion moderately high to high.

13. Palung - Tistung Soil (4.92 km^2) Pa - Ti

The Palung - Tistung soil unit occurs in the western and northeast parts of the mapped area on flat to gently undulating terraces. These soils are deep, imperfectly drained and are made up of alluvial colluvial materials derived mainly from phyllite, schists, quartzite and granite. Texture varies from silt loam to silty clay loam, altitude from 1700 to 1830 m.

This unit contains 80 percent Palung and 20 percent Tistung soils.

Palung Soil:

Altitude	About 1750 m.; Exposure: Variable.
Surface Soil	Dark greyish brown to dark yellowish brown, friable, loam/silt loam, 25-35 cm. thick, few rock fragments.
Sub-Soil	Dark greyish brown to dark yellowish brown, friable, sandy loam to silt loam, 50-100 cm. or more thick, few rock fragments.
Substratum	May be (a) dark greyish brown to greyish brown sandy loam to silt loam materials with few rock fragments mainly of granite and schists (b) poorly sorted alluvial colluvial materials from large boulders through to silt.
Other Properties	Medium to slightly acid, very high in organic matter, high in nitrogen, low in phosphorus and medium in potash.

Tistung Soil

The detail of this soil unit has been presented in mapping unit Ti.

Suitability	
Agriculture	Highly suitable for rice; moderately suitable for wheat, potato and mustard; poor to moderately suitable for maize, millet, barley and sugarcane.
Horticulture	Moderately suitable for lemon, lime, pear, plum, peaches and walnut; suitable vegetables include raddish, cauliflower and cabbage.
Pasture	Moderately suitable for pasture.
Forestry	Moderate to highly suitable for forest.
Terrace	Highly suitable.
Limitations	Relatively short growing season; wind and occasional hailstorms.
Erosion and Landslide Hazards	This unit falls under non-sliding class. There is only slight soil erosion hazard in this soil unit and sheet erosion is also slight.

14. Tekar Soil (5.07 km^2) Tk

The Tekar soil unit occurs in the central and southeast parts of the mapped area on rolling bench terraces. These soils are moderately deep to deep, well drained and are made up of materials mainly derived from phyllite, quartzite and slate.

Altitude	1280-1830 m.; Exposure: Variable.
Surface Soil:	Dark brown, friable, loam/silt loam, 15-20 cm. thick, many rock fragments.
Sub-Soil	Dark yellowish brown, very friable, loam/silt loam, 60 cm. thick, many rock fragments.
Substratum	Stones and boulders of phyllite, quartzite and slate.
Other Properties	Slightly acid, high to very high in organic matter and phosphorus, high in nitrogen and very high in potash.
Suitability	
Agriculture	Highly suitable for maize, millet, mustard and buckwheat; moderately suitable for wheat, potato and barley; poor to moderately suitable for rice and sugarcane.

Horticulture	Highly suitable for lime, and lemon; moderately suitable for peach, plum and pears. Suitable vegetables include raddish, cole crops, legume and colocasia.
Pasture	Poor to moderately suitable
Forestry	Moderate to highly suitable for forest.
Terrace	Moderately suitable.
Limitations	Droughtiness in dry season, requires irrigation for good crops; many rock fragments on or near the surface soil; wind and hailstorms.
Erosion and Landslide Hazards	This unit falls under non-sliding class. Soil erosion hazards class is rated moderate. Three-fifths of the area is occupied by slight sheet erosion and remaining by moderately high to high classes.

15. Tistung Soil (4.20 km^2) Ti

The Tistung soil unit occurs in the northern part of the mapped area on flat to gently undulating terraces. These soils are deep, imperfectly drained, and are made up of alluvial colluvial materials derived mainly from phyllite, quartzite and slate.

Altitude	1700 to 1830 m.; Exposure: Variable.
Surface Soil	Light brownish grey to dark greyish brown, friable, silt loam, 15-30 cm. thick, few rock fragments.
Substratum	May be (a) greyish brown to very dark greyish brown silt loam materials with many rock fragments mainly from phyllite, quartzite and slate (b) poorly sorted alluvial colluvial materials from large boulders through to silt.
Other Properties	Neutral to slightly alkaline, very high in organic matter, high in nitrogen and potash and medium in phosphorus.
Suitability	Same as Pa - Ti.
Limitations	Same as Pa - Ti.
Erosion and Landslide Hazards	Similar to Palung - Tistung. This soil unit falls under non-sliding territory. There is light soil erosion hazard in this unit and sheet erosion is also slight.

III. GEOLOGY, EROSION AND TERRACEABILITY

GEOLOGY

1. Physiography

The area consists of land masses of irregular terrains like ridges and valleys. The table top of the ridges mostly depends upon the rock types found in the area. In phyllites the tops of ridges are flat in comparison to those of quartzite, marble and granite. The rivers following the trend of the rock are more active and wide, whereas the streams flowing in any other direction are narrow, steep and form deep gorges.

2. Stratigraphy

A photo-geological map made by J. Stocklin and K. D. Bhattarai (1972) with some modifications by G. Sharma is presented in Sheet No. II, 6a.

The area is composed of different metamorphosed sedimentary rocks and granite bodies. The paleozoic metamorphosed sedimentary rocks belong to the Cambrian, Ordovician and Silurian periods. But the Palung massif of Eocene period, comprised of different types of granites, has been found intruded in these metamorphic rocks. The following stratigraphic groups are identified in the project area:

Bhimphedi Group

Ordovician System

Chisapani Quartzite ($O1_{cp}$): is exposed on the north of Bhainsedobhan marble with east to northeast trend. The quartzite is greenish white in colour and fine grained. It is exposed in Barhaghare and in fault contacts with Palung granite at some places. Its exposed thickness is about 100 meters.

Kulekhani Micaceous Quartzite and Schists (O^2_{1ku}): are stratigraphically identical to the Chisapani quartzite of Bhimphedi-Ipa Khola area. They are grey to dark-grey, impure, strongly micaceous quartzites and quartzitic mica-schists, fine grained and thick-bedded. In the Palung area, dark schists often with abundant segregationary quartz predominate over quartzite in the upper part of the unit. These calcareous bands appear as intercalations in the schists near the top and form a transition to the massive basal limestone of the Markhu calcareous zone. Its total thickness is more than 1000 meters but it is variably truncated by intrusions of Palung Granite.

Markhu Calcareous Zone ($O_2mr+mrs$): a zone of coarsely crystalline marble alternates with calcareous and argillaceous schists. A compact marble

band, 30 to 50 meters thick, forms the mappable base of the unit. Phyllite and micaschist intercalations with biotite increase because of marble in the upper part. Worm tracks and clay cracks have been observed in argillaceous beds in the Kulekhani Valley, and stromatolites in limestones in the lower Agra Khola (Stocklin - 1972). The unit, which is excellently bedded and in places forms marked ridges and dip-slopes is the best marker zone of the whole catchment area, crossing it diagonally from the southeast to the northwest corner. Its total thickness is about 400-500 meters.

Tistung Quartzites and Phyllites (O_3 ti): The calcareous unit of Markhu calcareous zone changes gradually into argillaceous facis of this unit. The transition zone of marble into phyllites, slates and quartzites with quartz mica schist and marble is marked by calcareous, grey, slaty quartzite and phyllites. The transition zone shows a lateral variation from east to west consisting of the replacement of argillaceous metamorphosed rocks by more micaceous ones. It is dominantly represented by slates and quartzites in the east and by phyllites in the west.

The slates are fine-grained, grey to dark grey in colour. The quartzite is grey to dark grey, fine to medium-grained, poorly banded and tough. It is composed mainly of quartz with some gneiss and magnetite. Bands of dark coloured slates are also present. The quartzites and slate bands contain intercalation of calcareous quartzite. In Chakhel and Rakas Kholas slaty quartzite horizons are overlain by the greenish grey phyllite rocks. The phyllite rocks are fine to medium-grained, liniated and foliated.

In Chitlang, Bisenkhel and Tistung Kholas, the Markhu marble has been overlain by phyllitic quartzite. Near the contact, these phyllites are either interbedded with marble or they are represented by micaceous quartzite and quartz-mica schist showing calcareous contact.

The Phyllites are grey to dark grey, pearly, soft, lineated, foliated and microfolded. They consist of mainly micaceous material and occasionally telcose and calcareous. White quartzite and quartz biotite moseorite schists are traced out in it. The calcareous members interbedded with phyllite are represented by micaceous marble and calcareous schists. The marble is fine to medium-grained, white, greyish, brownish, violet and banded.

Phulchauki Group

Silurian System

Chandragiri Limestones (S^1_{lch}) are located in the northern part of the

area. They are light-grey to greenish-grey, yellow-weathered limestone, fine crystalline, partly siliceous or sandy and always well bedded. Argillaceous intercalations are more abundant in the long part where the unit breaks into slate slabs that are extensively quarred at some places. Fine grained pyrite occurs frequently in fine dissemination or as fissure-filling material. A zone of fine grained quartzite, about 150 m. thick, was found within the given unit. The total thickness of the units is 2000-2500 m. Near the top of the limestone section on Chitlang pass and just south of it, fairly well preserved fossils have been found. They comprise small Brachiopoda, Crinoidea and possibly a specimen of a blastoid. These organic remains suggest an age somewhere in Ordovician-Devonian range (J. Stocklin).

Sopyang Slates Thin Limestone (S^2_{1sg}): It is a transition bed between Chitlang series and Chandragiri limestones, thin bedded, soft-weathering, dark-green-grey phyllites with thin intercalations of argillaceous limestone. The latter are a few meters thick and often have a lenticular or rodular aspect. Occasionally more massive limestone bands several meters thick occur also. Contacts of these rocks are gradational. The thickness is about 300-500 m.

Chitlang Slates, Quartzites and Quartzitic Limestones (S_{2cg}): This horizon is marked by the presence of phyllitic quartzite or gritty phyllite with bands of ferruginous material. The members of this unit are well exposed in the Chitlang Khola and its thickness is about 3300 m.

The Quartzite is whitish to brownish, fine to medium-grained, friable, ferruginous and current bedded with a composition of opaque and transparent quartz. Frequently slate and phyllite rocks are also found interbedded. Slates are generally grey to dark-grey, fine grained, moderately consolidated but fractured. Phyllitic rocks that approach a thickness of 50 m. or more and are greenish grey, foliated and fairly degraded. Slaty bands are poorly cleavaged. The long horizon of the unit is more or less calcareous and contains secondary calcite encrustation.

Structurally this horizon shows more or less monotonous strike of NW and a dip of around 50^0 NE.

Granite (Eocene): The Palung is exposed as two separate bodies which be virtually connected at depth. These two are the Daman (Palung) and Ipa granites.

In general Palung massif is aligned WNW-ESE and these granite bodies have smooth and slightly curved contacts with the country rocks. The

northern contact is exposed along Sankhamul and Kulekhani kholas, whereas the southern contact is irregular, though it is exposed in some places.

In the northern Palung granite, muscovite dominates biotite whereas the reverse occurs in the southern half. Palung granite is, in fact, not a single granite body, but is composed of different smaller bodies, which differ mineralogically and chemically. Mineralogically the granites may be divided into biotite granite, muscovite tourmaline granite and quartz-feldspar and tourmaline rocks.

These two members of the Palung massif, namely Daman granite and Ipa granite, have been found intruded into the rocks of the Kulekhani series. At the contact schists and quartzites have been silicified, toughened and baked resulting in dark brown quartzite, quartz-mica schist and garnetiferous schists. The calcareous rocks are also silicified, toughened and ptymatically folded. As in the west of Palung, the intrusion clearly followed a pre-existing fault, which forms its present limit, but further east the intrusion overstepped and these by healded the fault, so that the trace of the later disappears. Although a few younger faults cut through the granite, the intrusion was essentially post-tectonic.

3. Structure

The geological structure of the catchment area is dominated by a large syncline, the Chandragiri syncline. The axis of the mega fold strikes E 30°. The syniclinal apex can be clearly seen at some places on the Tribhuvan Highway at Porichaur, in the upper Chitlang and Chakhel valleys. The syncline has a clear, tough, very gentle axial plunge to ESE, opening in this direction and closing in the opposite direction. Numerous dip measurements indicate that both flanks have an inclination of about 45° with local variations between 30° and 60°. Steeper dips, up to vertical, are found persistently in the northern flank with an approach to the Thankot-Mahesh Khola fault zone, which cuts and limits the synclinal structure in the north.

The gentle overall synclinal structure, is complicated by numerous longitudinal and transverse faults, which have superimposed a complex fault-block pattern on the syncline. The longitudinal (WNW-ESE) fault places are vertical to very steeply inclined (around 80°) to the north; the transverse faults all seem to be practically vertical. There is no evidence of significant thrusting, except perhaps for the Thankot fault zone, where steep (70-80°) up-thrusting to the south (s) might have occurred.

Among the transverse faults, a SSW-ESE direction perpendicular to the regional strike clearly predominates. This is also reflected by the direction of the majority of larger tributaries of the Kulekhani river (Tistung, Chitlang, Rakas Kholas, etc.). Displacements along these faults have both vertical and horizontal components to several hundred meters.

The numerous parallel SSE-NNW faults in the Tistung area, particularly near Tistung Deurali, are of special interest. They are clearly related to the conspicuous Palung-Tistung inflexion, which in turn is evidently related to the large northerly bulge of the Palung granite. In the Bhimphedi area it was observed that the granite cuts indiscriminately through several large folds. The intrusion must therefore be younger than the folding, and most probably, the Chandragiri syncline was already in existence when the granite was emplaced. The inflection of the synclinal flank can therefore be explained as a late distortion, caused by lateral pressure from the relatively "cold" intrusion of the granite bulges and not by adaptation of folding to a preexisting rigid granite mass (J. Stocklin).

The age of granite intrusion is Eocene (evidence from absolute age determination by Khan and Tatar, 1970).

4. Geological History

The geological history of the Kulekhani catchment area can be traced from the Chisapani time of the Ordovician period of the Paleozoic era. At that time, the area was under a water basin where sedimentation of coarse grained material took place. It was a shallow basin, though it covered the entire territory. At the end of the Chisapani time, the territory started folding and an anticline was formed in the Chisapani rocks, but the territory did not emerge over the water surface.

In the Kulekhani time of the same period, the basin was almost unchanged and the sediments were similar. A little more of micaceous material was being brought from the shores and medium to coarse material was sedimented.

In the Markhu time the basin was very warm and the marine organisms were highly developed, as a result of which, calcareous material settled at the bottom of the basin; but as the basin was shallow, the calcareous material settled in layers with silty and sandy materials.

In the Chandragiri time of the Silurian period, the conditions of sedimentation were similar to those of the Kulekhani time and similar

calcareous material was sedimented at the bottom of the basin existing at that time.

In the Sopyang time, the conditions of sedimentation were changing and hence alternate horizons of calcareous and sand-silt materials were sedimented at the bottom. At the end of the above-mentioned period, the territory was highly folding (passing the stage of Kalidonian foldings), as a result of which a syncline was formed at the northern side of the area.

The sediments of the Chitlang time are found only at the synclinal part of the watershed, as if the basin was separated from the existing entire basin.

After the Silurian period, the territory was folded in the Devonian period (at the end of the Kalidonian foldings), and at the end of the Permian period of the Paleozoic era (during Hertianian foldings).

In the Cenozoic era, the territory folded a number of times and at last in the Eocene, the granite body was intruded in the territory. During the Alpine foldings the territory was highly folded, as a result of which mountains and valleys were formed in the catchment.

Kulekhani Khola started its history from the Cenozoic era, as a drainage for the mountains which existed in the past and survive up to the present time.

In the past, the territory was highly eroded (and is still being eroded), as a result of which the watershed formed its present shape.

5. Geomorphology

The geomorphology of Kulekhani catchment area is dominated mostly by lithology, geological structure, the high rate of precipitation during the monsoon and waterset. All these factors have acted, generally together to form the present morphology of the watershed.

The territory is divided into the following four geomorphological units:

(1) Alluvial horizontal or slightly inclined terraces

These are Chitlang, Palung, Tistung and Kulekhani Valleys. These valleys are generally located on the synclinal structure of the bedrock. Chakhel, Tekar, and Lamcahaur are also terraces of the above mentioned unit.

The three biggest alluvial valleys of the watershed are Palung, Chitlang and Tistung with areas 7.8 sq. km., 5.3 sq. km., and 2.7

sq. km. respectively. The total area of the unit in the catchment is approximately 20 sq. km. The valleys have a relative relief varying from 50 to 200 meters.

(2) Eluvial and colluvial, rolling to moderately steep fans

These fans are generally inclined to the alluvial valleys. This unit is located in all Panchayats. The fans are located on the sides of hill slopes.

The area of the unit in the catchment is about 44 sq. km. The relative relief of the unit varies from 50 to 500 meters.

(3) Eluvial horizontal or slightly inclined plateaus

These areas are located on the hilltops of Chitlang, Phakhel and in Daman Panchayats. Their relative relief varies from 200 to 500 meters or more.

The area of the above mentioned unit in the catchment is almost negligible.

(4) Eluvial, moderately steep to very steep slopes

This unit is located between units 2 and 3. It is the most dominant unit in the catchment. It covers 69.8 percent of the total area of the watershed.

Unit 1 is characterized by high depth of soil cover and the occurrence of generally light to medium-textured soil. The unit is either slightly or moderately eroded. Bank erosion along the rivers is very common for this unit.

Soil depth in Unit 2 is moderate to high, but the texture depends upon the parent material on which the fan has formed. The unit is characterized by moderate to high erosion, depending upon the land use of the area.

Sheet erosion in the third group is slight, and generally it is mechanical, due to the rain water, snow, ice, and the high variance in temperature during day and night. These areas are either covered by grasses or are undergrowth.

The fourth unit of the area is characterized by a high rate of erosion and a shallow soil depth. Rock outcrops are frequently present in this unit. These areas are either under growth or the forests of the area are being used as pasture lands. Landslides of small masses are very common in this unit.

Rills and gullies are highly developed in units 2 and 4.

EROSION

Based upon topography, morphology, tectonics, lithology, waterset and biotic interference, the whole project area is classified into different landslide classes and erosion classes.

Landslide Classes:

A rough sketch of different classes of landslides is presented by Sheet No. III, 10a. Table 1 has been developed for the classification.

Table 1

Landslide Hazards Classification

Rock Class Slope	Highly Erodible	Erodible	Non-Erodible
Above 36° 25° - 36°	CLASS - I		
16° - 25°	CLASS - II		
Below 16°	CLASS - III		

Rock classes and slope classes have been used as the main parameters for landslide classification. Rocks have been classified into non-erodible, erodible and highly erodible.

Non-Erodible: Granite is mostly non-erodible under existing conditions, though stone falls are common. Only a variance in hydrostatic balance can alter their future.

Erodible: Quartz, marble, limestone and slate form a group of erodible rocks. Quartzite are strong enough to resist the process of erosion, but as they occur in layers with phyllites and schist, their erodibility is highly increased. In these rocks, small scale landslides are very common. Limestone and marble are soluble in mineral water, so they emphasize karst formation.

Highly Erodible: These are soils of alluvial terraces, phyllites, schist and Sopyang slates. These rocks and soils are mechanically very weak.

On the basis of the above classification, the territory of the watershed is divided as follows:

Class I - Sliding Territory: Examining landslide hazard map (Sheet No. III, 10a), it is clear that about 13 percent of the catchment area falls in this class.

This area has typical old landslides and geomorphology. There is no probability in the dry season, but in the rainy season landslides can occur. The volume of the sliding mass is small and is not dangerous to people. About 60 percent of Deorali (Dr_2), 50 percent of Khadpu-Bhalukharka, 20 percent of Charkhu and 12 percent of Chhankhu soils are included in this category.

Class II - Moderately Non-Sliding Territory: This class comprises about 37 percent of the catchment area. The rocks are stable even in the rainy season but they can slide with a change in the hydrostatic balance of the area. (This class is included here because the hydrostatic balance will change after the completion of the dam in Kulekhani.) The units which fall under this category are Angare, Khuplang (Ku_2) and Chhankhu-Tekar.

Class III - Non-Sliding Territory: Where there are slanting slopes and almost horizontal valleys, there is no possibility of landslides. In these areas soil erosion (bank and bottom erosion) is only possible by rivers, though surface erosion in the rainy season is not uncommon.

About half of the watershed area falls in this category. Practically, the soil units liable to be unaffected by sliding are Daman, Chhankhu, Chitlang, Khadpu (Kd_1), Tekar, Tistung and Palung-Tistung.

Soil Erosion: Depending on its nature, soil erosion can be divided into sheet erosion, rill and gully erosion, and bank and bottom erosion.

Sheet Erosion: Sheet erosion is very high in the area. Sheet erosion is mostly governed by the slopes and more influenced by soil texture, though in some places it is checked by natural vegetation--forests and grass fields. According to erodibility, the soils are divided into the following four groups:

Group 1 - High erodible soils: These are fine sand, loamy sand and silt loam. They are found in cultivated areas.

Group 2 - Erodible soils: These are medium sand, loam, lying in cultivated areas and the soils of the first group in forests and other natural vegetation.

Group 3 - Moderately Erodible Soils: These are clay loam, silty clay loam, coarse sand and sandy clay loam under cultivation and the soils of group 2 under natural vegetation.

Group 4 - Moderately non-erodible soils: These are sandy clay, silty clay, and gravels under cultivation as well as under natural vegetation and the soil of groups 3 under natural vegetation.

A map of potential sheet erosion, made on the basis of soil texture and slope divides the territory into three classes (Sheet No. IVa, 12a). Table 2 gives a general idea of the sheet erosion classification.

Table 2

Sheet Erosion Classification

Slope \ Soil Group	Group 1	Group 2	Group 3	Group 4
Over 25°				
16° - 25°	CLASS - I			
5° - 16°	CLASS - II			
Below 5°	CLASS - III			

Class I - Highly Eroded Territory: These are territories lying on slopes over 25°, and also territories having soil textures of groups 1 and 2 lying on slopes above 16°. These territories are either cultivated or barren. About 68 percent of the catchment area falls into this category. More than 80 percent of Khuplang (K_2), Angare, Chhankhu (Ch_2) and Khadpu-Bhalukharka is included in this class, whereas 60 to 70 percent of the areas of Bisinkel-Chhankhu, Deorali, and Daman fall under this class.

Class II - Moderate to Highly Eroded Territory: These are territories lying on slopes between 16°-25°, having soil textures of groups 3 and 4 and also territories lying on slopes between 5° and 16° and having soil textures of groups 1 and 2.

Approximately 19 percent of the catchment area falls in this class. Over 80 percent area of Chitlang is included in this class. 50 to 70 percent of the areas of Khuplang (Ku_1), Khadpu, Bisingkhel-Chhankhu and Tekar fall under this category.

Class III - Slightly Eroded Territory: These territories lie on slopes below 5° and on slopes below 16° for the soils of groups 3 and 4. About 13 percent of Kulekhani catchment area is included in this class. Palung-Tistung Tistung are the main soil units undergoing a slight degree of erosion. About 50 to 60 percent of the area of Chhankhu (Cn_1) and Tekar fall in this category.

Rill and Gully Erosion:

Rills and gullies are numerous in the project area. The main reason for this type of erosion is the high rate of precipitation during the monsoon and the fact that the watershed is composed of weak, silt-cemented, highly weatherable rocks. The above mentioned process is more conspicuous in those landscapes having high relief and steep slopes. These rills and gullies feed the perennial rivers in the rainy season; hence, they are themselves highly eroded during this process and in consequence increase the erod bility of the perennial rivers.

Bank and Bottom Erosion:

Waterset, which is highly developed in the area, is the main agent of bank and bottom erosion. There are many rivers with perennial flow, though their discharge depends upon the season, with the maximum reached in the monsoon. The biggest of the rivers is Kulekhani Khola which is fed by a number of perennial rivers such as Chitlang Khola, Chakhel Khola, Sankhamul Khola, etc. As mentioned above, the density of steep rills and gullies, serving as seasonal rivers, is high in the watershed.

As the rivers flow on the bedrocks, bottom erosion is negligible but bank erosion in the flood season is common in the alluvial valleys of the catchment.

Soil Erosion Hazard Classes:

Soil erosion hazard classes are mainly defined on the basis of slope, land use, geology and extent of landslides as well as characteristics of soil units recognized in the catchment area. The classes are: slight, slight to moderate, moderate, and severe (Sheet No. IVb, 13a). Table No. 3 gives a general idea of the soil erosion hazard classification.

I. Slight: Soil units of Tistung, Palung-Tistung and Chhankhu-Tekar are completely in the category undergoing slight erosion.

II. Slight to Moderate: Approximately 60 to 70 percent of the area of Daman (Da_2), Khuplang (Ku_2) and Chharkhu (Cr) fall in this class.

III. Moderate: Angare, Deorali (DR_2), Chitlang, Chhankhu (Cn_1), Bisingkhel-Chhankhu and Khadpu are the soil units estimated to be in the class having moderate erosion. Eighty percent of the area of Chhankhu (Cn_2) and Tekar are also included in this class.

IV. Severe: A high or severe degree of erosion can be encountered with soil series such as Daman (Da_1), Khadpu-Bhalukharka and

Table 3 - Soil Erosion Hazards Classification

Slope	Landslide	Soil Units	Soil Erosion Hazard Class		
			Cultivated Land	Pasture Land	Forest
5 - 16°	Non-sliding territory	All other soil units except Lithic soils	I (Valley terrace) II (Other areas)	II	II*
16 - 25°	Non-sliding territory	All other soil units except Lithic soils	II	II,III*	I-II, III*
25 - 36°	Moderately non-sliding territory	All other soil units except Lithic soils	III	III	I-II
		Lithic coils (Angare)	-	-	II
	Non-sliding territory in granitic geology	All other soils units except Lithic soils	III	II	I-II
- 36°	Sliding territory	All other soil units except Lithic soils	III	III	III
	Moderately non-sliding territory in granitic geology	Lithic soils (Deorali)	III	-	II

* Accelerated soil erosion due to human influence.

Deorali (Dr_1). About 80 percent of the area of Khuplang (Ku_1) is included in this class. 20 percent of Chhankhu (Cn_2), 40 percent of Khuplang (Ku_2), and 30 percent of Charkhu also fall under this class.

TERRACIBILITY

Terracibility is an estimate of the suitability of sloping areas for constructing terraces for cultivated crops. A terrace suitability class map of Kulekhani catchment area is shown in Sheet No. V (14a). For classification the criteria used are slope, elevation, relief, presence of landslides and characteristics of soil units. Table 4 gives a general idea of the terrace suitability classification.

Table 4

Terrace Suitability Classification

Elevation	Slope	Relief	Landslides	Soils	Terrace Suitability Class
Below 7000 ft.	5-16°	50-200m	Non-sliding	All other soil units except Lithic soil	I (including valley terrace)
Below 7000 ft.	5-16°	200-500m	Non-sliding territory	All other soil units except Lithic soils	II
Below 7000 ft.	25-36°	200-500m 50-200m 200-500m	Non-sliding territory moderately non-sliding territory	All soil units plus some Lithic soil	III
7000 ft. and above	-36°	200-500m -500m	Non-sliding territory	All other soil units except Lithic soils	
	25-36° -36°	200-500m -500m -500m	Moderately sliding territory	All Other soil units except Lithic soils	Unsuitable
	-36°	-500m	Sliding territory	All other soil units except Lithic soils	
Below 7000 ft.	25-36° -36°	-500m	Moderately non-sliding territory	All other soil units + some Lithic soils	
	-36°	200-500m -500m	Sliding territory	All other soil units except Lithic soils	

Terrace suitability of the areas within Kulekhani catchment have been classified as high, moderate, poor and unsuitable. This is described in the following paragraphs.

Highly suitable: About 5.5 percent of the area of Kulekhani catchment area is highly suitable for terracing. The main soil units in this category are Palung-Tistung and Tistung.

Moderately Suitable: About 30 percent of the catchment area is moderately suitable for terracing. Chhankhu (Cn_1), Chhankhu-Tekar, Chitlang, Khadpu and Kogte are included in this category. Approximately 80 percent area of Chhankhu (Cn_2) and Tekar are also categorized in this class. About 30, 40, and 50 percent of the areas of Khuplang (Ku_1), Daman (Da_1) and Bisingkhel-Chhankhu, respectively, are estimated to be moderately suitable for terracing.

Poor Suitability: About 23 percent of the catchment area is rated to be of poor suitability for terracing. About 50 to 60 percent of the areas of Disingkhel-Chhankhu, Daman, Khuplang (Ku_1), and Khadpu-Bhalukharka are included in this class.

Unsuitable: A major portion of the catchment area has been recognized as unsuitable for terracing. The unsuitable area has been estimated to be 41.5 percent of total catchment area. The soil units identified as unsuitable for terracing are Angare, Charkhu and Deorali. About 80 percent of Khuplang (Ku_2) also falls in this class. Half the areas of Daman (Da_2) and Khadpu-Bhalukharka are also estimated to be unsuitable for terracing.

Conclusions and Recommendations:

a. Conclusions: In view of all the above mentioned factors, we have come to the conclusion that the Kulekhani catchment area is highly active, due to not just a few but many factors acting together to accelerate major and minor types of erosion. The most important factors behind erosion are:

   i. weak bedrock;
   ii. high average annual rainfall and rate of precipitation;
   iii. highly developed riverset;
   iv. steep slopes;
   v. lack of adequate vegetation cover especially near human habitation.

   Landslides in the watershed are not dangerous for the human habitations or for the cultivated areas except in some special cases. Regarding terracing, about 65 percent of the catchment area is poor or unsuitable.

b. Recommendations: On the basis of the above mentioned physical factors, the following points are noted and recommended:

i. Landslides (see Sheet No. III) of the area in some Panchayats (Chitlang, Chakhel, Kogte and Ipa panchayats) though not dangerous now can be dangerous in the future when they will reach the villages and cultivated areas.

ii. In some villages such as Likhu and Majuwa of Chitlang Panchayat, where steep to very steep slopes are being cultivated, landslides can occur with the accumulation of water on the man-made terraces. Such lands should be left under forest or well managed pasture.

iii. Bank erosion, along the rivers of Chitlang, Chakhel, Sankhamul and Kulekhani, is very high, which should be checked with the aid of plantation along the bank or with the aid of any other feasible structures.

iv. Sheet erosion in the cultivated alluvial terraces is very high. Though the process of sheet erosion is not catastrophic, it is noticeable, and hence the soil fertility curve of the area may go down instead of up. Thus, the valley soils will have to be well managed.

v. Sheet erosion is very high in the catchment area. It is a very slow process accelerated on slopes by:

1. multiple use of forests as pasture land,
2. cutting trees for fuel and timber,
3. cutting of bushes and vines for feeding livestock,
4. burning of forests and jungles, etc.

Therefore, the above activities should be strictly controlled and conservation measures established.

vi. During the monsoons, floods occurring in the Kulekhani Khola and its tributaries cause floods in the adjacent cultivated areas, which should be protected by plantation along with some embankments.

vii. Rill and gully erosion connected with the soft silt-cemented rocks and the high rate of percipitation in the monsoon are numerous in the watershed. These areas should be protected.

viii. Criological erosion, though rare, does occur in the catchment, especially on areas above 8000 ft. elevation, which should be taken into account in planning.

ix. About 35 percent of the catchment area is moderate to highly suitable for terrace making.

IV. USES AND MANAGEMENTS OF THE SOILS

Agriculture

The soil units mostly poor to unsuitable for arable farming are Angare, Charkhu, Chhankhu (Cn_2), Deorali (Dr_2) and Khuplang (Ku_2). The main reason that these soils are unsuitable for arable farming may be attributed to moderately steep to steep slopes occupying the upper areas or portions of mountain ridges and many rock fragments on or near the surface soil. These units mostly occupy natural forests.

Suitability for various crops have been worked out (see description under mapping units) and are described in the following:

Rice: Palung-Tistung and Tistung soils are highly suitable for the cultivation of rice. Kogte soils are moderately suitable. Poor to unsuitable soils are Bisingkhel-Chhankhu, Chhankhu-Tekar, Chhankhu (Cn_1), Daman (DA_2), Khadpu-Bhalukharka and Chitlang.

Maize: Highly suitable soil units for maize cultivation are Bisingkhel-Chhankhu, Chhankhu, Khadpu (Kd_1) and Kogte, Khuplang (Ku_1) and Tekar. Chhankhu-Tekar, Chitlang, Daman (Da_2) and Khadpu-Bhalukharka units are moderately suitable for maize growing. Palung-Tistung soil is considered to be poor to moderately suitable.

Millet: Suitable areas for millet are roughly the same as for maize.

Mustard: Soil suitability for mustard is the same as for maize and millet.

Wheat: The Khuplang series (Ku_1) is considered to be highly suitable for wheat cultivation. Moderately suitable areas are Bisingkhel-Chhankhu, Chhankhu (Cn_1), Chitlang, Khadput-Bhalukharka, Palung-Tistung, Tistung and Tekar. The Chhankhu-Tekar unit is poor to moderately suitable for wheat.

Potato: The Bisingkhel-Chhankhu soils unit is highly suitable for growing potatoes. The units identified as moderately suitable are Daman (Da_2), Palung-Tistung, Tistung and Tekar. The Chhankhu-Tekar unit is poor to moderately suitable.

Buckwheat: Khuplang (Ku_1), Kogte and Tekar are highly suitable for buckwheat. The moderately suitable soil units are Chhankhu-Tekar, Daman (Da_2) and Khadpu-Bhalukharka.

Barley: Moderately suitable soil units for barley are Bisingkhel-Chhankhu and Tekar. Chhankhu-Tekar and Palung-Tistung soil units are poor to moderately suitable for barley.

Sugarcane: Sugarcane is only grown to a small extent in the catchment area. The Palung-Tistung soils are moderately suitable for growing sugarcane. Poor to unsuitable soils include Bisingkhel-Chhankhu, Chhankhu-Tekar, Chitlang, Daman (Da_2), Khadpu-Bhalukharka Khuplang and Tekar.

Fertilizer Recommendation

In general, the organic matter status of the soils of the Kulekhani Catchment area ranges from high to very high. Nitrogen is rated high in all the soil units except Angare and Chhankhu (Cn_1) soils which have medium status. Generally the catchment area contains high to very high amounts of potash. The soil units containing a medium amount of potash are Angare, Deorali (Dr_1) Khuplang (Ku_1) and Palung-Tistung. Phosphorus is high in four soils (Da_2, Ko, Kd-Bk, Ti), medium in nine soils (An, Bi-Cn, Cn, Cn-Tk, Da, Dr_1, Pa-Ti, Ti) and low in five soils (Cn, Cg, Kd_1, Ku_1, Ku_2). The fertility status of various soil units is given in Table 5.

The optimum fertilizer recommendation for various crops have been calculated and is presented in table 6.

Horticulture

As mentioned earlier, the altitude of the Kulekhani Catchment area varies from about 1200 to 2400 m. Subtropical fruits such as guava, papaya, and pomegranate are grown in some places, as most of the area falls under the temperate zone. Among citrus fruits, lime and lemon can be grown everywhere. Major important temperate fruits include pear, plum and peach. Other fruits such as apricot, almond, persimmon, walnut, etc., can be grown in limited areas. Although apple is grown in various locations such as Angare, Kogte, Khuplang, Tekar, Daman, etc., the suitability is considered to be poor to moderate because of the unfavourable climatic conditions. In general, the Kulekhani Catchment area can be categorized as moderately suitable for growing the above mentioned fruits.

If the fertility status of the soil with respect to a certain nutrient is high (see Table 1), only 1/4th of the recommended dose is to be applied. If the nutrient rating is medium, half of the recommended dose should be applied. In case of low nutrient status, the full recommended dose should be added.

Among vegetables, cole crops (cauliflower, cabbage, khol khol), radish, colocasia, etc., seem promising. In some places adjoining Kathmandu Valley,

Table 5 - Fertility Status Rating of Various Soil Units of Kulekhani Catchment Area

	Soil Unit	Organic Matter	N	P_2O_5	K_2O
1.	Angare	High	Medium	Medium	Medium
2.	Bisingkhel-Chhankhu	High	High	Medium	High
3.	Charkhu	High	High	Medium	High
4.	Chhankhu	High	Medium	Low	High
5.	Chhankhu-Tekar	High	High	Medium	High
6.	Chitlang	High	High	Low	High
7a.	Daman, Cultivated	High	High	Medium	High
7b.	Daman, Forest	High	High	High	High
8a.	Deorali, Cultivated	High	High	Medium	High
8b.	Deorali, Forest	High	High	Medium	Medium
9.	Khadpu-Bhalukharka	High	High	High	High
10.	Khadpu, Cultivated	High	High	Low	High
11a.	Khupland, Cultivated	High	High	Low	Medium
11b.	Khuplang, Forest	High	Medium	Low	High
12.	Kogte	High	High	High	High
13.	Palung-Tistung	High	High	Medium	Medium
14.	Tekar	High	High	High	High
15.	Tistung	High	High	Medium	High

Table 6 - General Fertilizer Recommendation for Various Crops in Kulekhani Catchment Area (Kg./Ha.)

Crops		Organic Manure 2/	N 1/	P_2O_5 1/	K_2O 1/
Rice	Improved	6000	75	20	20
	Local	6000	30	15	15
Maize	Improved	6000	90	35	25
	Local	6000	45	15	15
Millet		4000	30	20	20
Mustard		6000	30	20	20
Wheat	Improved	6000	75	30	20
	Local	6000	45	20	15
Potato	Improved	10000	60	40	40
	Local	10000	40	20	30
Buckwheat		4000	30	20	20
Barley	Improved	6000	45	20	20
	Local	4000	30	15	15
Sugarcane		10000	90	40	35

1/ Joshy & Deo, 1976.

2/ Karki, 1975.

peas are becoming popular because the farmers can easily sell this produce in the Kathmandu market.

The growing of legumes to only a small extent may be attributed to high acidity. To obtain a satisfactory yield, the soil should be limed to desired pH.

General fertilizer recommendations for vegetables and fruits are given in Table 7.

Pasture

Chitlang soils are highly suitable for pasture subject to the addition of phosphatic fertilizer. Most of the units fall under poor to moderately suitable classes. The units recognized as moderately suitable for pasture are Bisingkhel-Chhankhu, Chhankhu (Cn_1+Cn_2), Kogte and Khuplang (Ku_2). Angare, Chhankhu-Tekar, Daman (Da_2), Deorali (Dr_2) and Tekar units are caregorized in between poor to moderately suitable areas for pasture. Poorly suitable units are Daman (Da_1), Khadpu-Bhalukharka, Khadpu and Khuplang (Ku_1).

Forestry

The highly suitable areas for forestry are Charkhu, Chhankhu (Cn_2), Chitlang, Daman (Da_1), Khadpu-Bhalukharka, Khadpu and Khuplang. Angare, Daman (Da_2) and Deorali (Dr_2) fall in between moderate to highly suitable areas. Moderately suitable units for forestry are Bisingkhel-Chhankhu, Chhankhu (Cn_1), Chhankhu-Tekar and Khuplang (Ku_1).

Various shrubs and trees existing under natural conditions are described in Section I.

Terraceability

The Palung-Tistung soil unit and Tistung soils are recognized as highly suitable for terrace making since these soils occur on flat to gently undulating slopes. Soil units having moderate suitability for terracing are Chhankhu-Tekar, Chitlang, Khadpu and Kogte. About 50 to 60 percent area of Bisingkhel-Chhankhu, Daman, Khuplang and Khadpu-Bhalukharka are categorized in the poorly suitable class. A major portion of the catchment area is identified as unsuitable for terracing mainly because of the steep nature of the slopes, erosion or landslide hazards, and because some areas occupy the upper portions of mountain ridges. Soil units identified as unsuitable for terrace making are Angare, Charkhu, Deorali and Khuplang (Ku_2). About 50 percent area of Daman (Da_2) and Khadpu-Bhalukharka is also unsuitable for terracing.

Table 7

Fertilizer Recommendation for Various Fruits and Vegetables in Kulekhani Catchment Area

	Kind[1/]	FYM or Compost	Chemical Fertilizers (Kg./Ha.)		
			N	P_2O_5	K_2O
1.	Cole Crops	20,000	50	60	40
2.	Bulb Crops	20,000	60	40	60
3.	Radish	20,000	45	30	40
4.	Legume	30,000	25	50	40
5.	Colocasia	25,000	40	30	80
6.	Cucurbits	35,000	20	40	60
7.	Tomato, Chilli, Brinjal, Ochra	25,000	40	30	50
8.	Leafy Vegetables	25,000	40	25	25

1/ Karki, 1975.

Fruits[2/]

	Kind of	Non-Bearing Stage (Amount/Tree)					Bearing Stage (Amount/Tree)				
		FYM or Compost	Oil Cakes	Complexal (20:20:0)	Muriate Potash	FYM only	FYM or Compost	Oil Cakes	Complexal (20:20:0)	Muriate of Potash	FYM only
1.	Papaya	10 kg	-	-	-	-	45 kg	1 kg	1 kg	500 kg	60 kg
2.	Guava	10 kg	-	-	-	-	45 kg	-	-	-	-
3.	Pomegranate	10 kg	500kg	-	100 g	-	45 kg	2.5kg	1.2 kg	-	-
4.	Citrus	10 kg	1kg	200 g	135 g	-	36 kg	4.5kg	-	-	-
5.	Apple	10 kg	-	225 g	85 g	25 kg	45 kg	-	2.25 kg	300 g	-
6.	Peace	-	-	250 g	85 g	25 kg	30 kg	-	1 kg	400 g	-
7.	Plum	10 kg	-	500 g	100 g	25 kg	45 kg	-	2 kg	300 g	60 kg
8.	Pear	10 kg	-	300 g	85 g	25 kg	45 kg	-	2.25 kg	300 g	-
9.	Apricot	-	-	250 g	85 g	25 kg	30 kg	-	1 kg	400 g	-
10.	Walnut	25 kg	-	65 g	-	-	-	-	-	-	-
11.	Persimmom	10 kg	-	-	-	-	45 kg	-	-	-	-

2/ Sinha, 1975.

APPENDIX I - DESCRIPTION OF SOILS AND ANALYTICAL DATA

Technical descriptions and available analytical data for the main soils recognized in each mapping unit are presented in this section. Each soil is classified in terms of Soil Taxonomy: A Basic System of Soil Classification of Making Interpreting Soil Surveys, USDA, Agr. Handbook No. 436. The nomenclature of the USDA Soil Survey Manual (USDA, 1951) and the FAO Guidelines for Soil Description (FAO, 1977) have been followed.

According to the USDA classification, texture is based on hydrometer readings, and the colour notations follow the Munsell Colour Charts (1954). P^H is determined in 1:1 soil water ratio with pH meter and nitrogen by the standard microkjeldahi method. Available P_2O_5 was determined colorimetrically by Bray's or Olsen's method, depending upon soil pH, and potassium by flame photometer (Jackson, M. L. 1962). Physico-chemical analyses of soils collected from the Kulekhani catchmen' area were performed in the Division of Soil Science and Agricultural Chemistry, Khumaltar.

The classification of soils is mainly based on morphological descriptions of soils with a minimum of analytical data available at the time of report writing. Therefore this classification is considered provisional.

1. Angare Series, An

The Angare series are somewhat excessively well drained soils developed on moderately steep to steep slopes, made up of materials derived mainly from marble. These soils are under a forest vegetation dominantly of *Pinus roxburghii*, *Rhododendron Spp.*, *Lyonia ovalifolia* and *Pyrus pashia*.

The Angare series is classified as a course loamy, mixed, mesic family of *Lithic Rendolls*.

Typical Profile

Location:	Site 26, aerial photograph R 20-22, topographic map 72 E/2 near Angare, Makwanpur District 1950 m. a.s.l.; Southwest exposure.
01 3-0 cm	Forest litter, mainly loose undercomposed leaves underlain in places by partly disintegrated leaves and twigs with some fungal hyphae.
A1 0-20 cm	Very dark greyish brown (10 YR 3/2) moist; silt loam; weak to moderate granular crumb + angular blocky, friable moist;

slightly sticky, non plastic wet; few rock fragments, many fine to medium roots; pH6.6; clear boundary.

B2 20-40 cm — Very dark brown (10 YR 2/2) moist; silt loam, moderate to strong fine crumb + angular blocky, very friable moist; sticky, non plastic wet; thin patchy dark greyish cutans along the vertical ped faces and root channels; many rock fragments; pH 6.5; clear boundary.

R 40 + cm — Weathered marble in situ.

Analytical Data

Lab. No.	Horizon	Depth (cm.)	Particle Size Distribution			Texture
			0.05-2.0 sand %	002-05 silt %	.002 clay %	
SS 890	A1	0-20	23	66	11	Silt loam
SS 891	B2	20-40	27	60	13	Silt loam

Horizon	Depth (cm.)	pH	P_2O_5 Kg/ha	K O Kg/ha	% O.C.	% N	C/N	O.M.%
A1	0-20	6.6	24.7	225.7	2.97	0.08	3.7	5.11
B2	20-40	6.5	16.4	150.5	1.42	0.03	4.7	2.45

2. Bhalukharka Series

The Bhalukharka series are well drained soils developed on rolling bench terraces made up of soil material derived from phyllite and quartzite. These soils are mainly in maize, millet, mustard and buckwheat cultivation.

The Bhalukharka series is classified as a fine loamy, mixed, mesic family of Typic Eutrochrepts.

Typical Profile

Location: Site 16, aerial photograph R 17-24, topographic map 72 E/2 near Bhalukharka Todkakhanikhet Panchayat, Makwanpur District 1802 m. a.s.l.; Northeast exposure.

A1 0-14 — Dark yellowish brown (10 YR 4/4) dry; dark greyish brown

(10 YR 4/2) moist; silt loam, moderate to strong fine crumb + angular blocky, friable moist slightly sticky, non-plastic, few rock fragments; pH 6.5; gradual smooth boundary.

B1 14-40 cm — Yellowish brown (10 YR 5/6) moist; diffused yellowish brown mottles; silt loam; moderate to strong, fine to medium crumb + sub-angular blocky, friable moist, slightly sticky, slightly plastic wet; thick patchy cutans along vertical and ped faces; few rock fragments; pH 6.85; gradual boundary.

B21t 40-61 cm — Dark yellowish (10 YR 3/4) moist; silt loam; prismatic + angular blocky; firm moist; sticky, slightly plastic wet; thick dark brown cutans along the vertical ped faces; few rock fragments; pH 6.9: gradual smooth boundary.

B22t 61-98 cm — Dark yellowish brown (10 YR 4/4) moist; silty clay loam; blocky to sub-angular blocky; firm moist; sticky plastic wet; thick patchy brown to dark brown cutans along the vertical ped faces; pH 6.8; abrupt smooth boundary.

B23t 98-150+ cm — Dark brown (7.5 YR 5/4) moist; silty clay loam; massive; firm moist; sticky plastic wet; pH 6.5.

Analytical Data

Lab. No.	Horizon	Depth (cm.)	Particle Size Distribution 0.05-2 sand %	0.002-0.05 silt %	.002 clay %	Texture
SS 810	A1	0-14	26	64	10	Silt loam
SS 811	B1	14-40	20	59	21	Silt loam
SS 812	B21t	40-61	20	54	26	Silt loam
SS 813	B22t	61-98	12	60	28	Silty clay loam
SS 814	B23t	98-150+	12	54	34	Silty clay loam

Horizon	Depth	pH	P_2O_5 KG/Ha	K_2O Kg/Ha	% O.C.	% N	C/N	O.M.%
A1	0-14	6.5	236.0	650.0	3.25	0.33	9.8	5.60
B1	14-40	6.85	63.8	419.3	0.54	0.09	6.0	0.94
B21t	40-61	6.9	67.9	478.4	0.65	0.07	9.2	1.12
B22t	61-98	6.8	96.8	559.1	0.77	0.07	11.0	1.33
B23t	98-150+	6.5	80.3	763.3	0.91	0.09	10.1	1.57

3. Bisingkhel Series

The Bisingkhel series are well drained soils developed on rolling terraces made up of materials derived from slate, limestone and quartzite. It is mainly in maize, millet and mustard cultivation.

The Bisingkhel series is classified as a coarse loamy, mixed, mesic family of Typic Hapludalfs.

Typical Profile

Location: Site 8, serial photograph R 21-31, topographic may 72 E/2, near Bisingkhel, Makawanpur District 1803 m. a.s.l.; South-east exposure.

Ap 0-15 cm Dark yellowish brown (10 YR 4/4) moist; silt loam; moderate fine to medium crumb angular blocky, friable moist, slightly sticky, non-plastic wet; few rock fragments; few fine roots, pH, 6.1; gradual smooth boundary.

B21 15-36 cm Dark yellowish brown (10 YR 3/4) moist; silt loam; moderate fine to medium crumb sub-angular blocky, friable moist, slightly sticky, non-plastic wet; thin patchy brown to dark brown cutans; few rock fragments; pH 6.4; gradual smooth boundary.

B22 36-80 cm Dark yellowish brown (10 YR 4/6) moist; silt loam; weak to moderate fine patches sub-angular blocky, moist friable, slightly sticky non-plastic wet; thin patchy cutans; pH 6.55; gradual smooth boundary.

Alb 80-100+ cm Dark yellowish brown (10 YR 3/4) moist; silt loam; weak to moderate, fine sub-angular blocky, friable moist; slightly sticky, non-plastic wet; few rock fragments; pH 6.6.

Analytical Data

Lab. No.	Horizon	Depth (cm)	Particle Size Distribution			Texture
			0.05-2 sand %	0.002-0.05 silt %	.002 clay %	
SS 784	Ap	0-15	24	61	15	Silt loam
SS 785	B21	15-36	24	59	17	Silt loam
SS 786	B22	36-80	24	65	11	Silt loam
SS 787	Alb	80-110+	24	63	11	Silt loam

Horizon	Depth (cm)	pH	P_2O_5 Kg/Ha	K_2O Kg/Ha	%C	%N	C/N	O.M%
Ap	0-15	6.1	37.6	838.6	2.17	0.16	13.5	3.74
B21	15-36	6.4	20.6	623.6	2.53	0.14	18.0	3.22
B22	36-80	6.5	10.3	467.7	0.69	0.13	5.3	1.19
A1b	80-110+	6.6	10.3	204.2	1.79	0.10	17.9	3.08

4. Charkhu Series, Cr

The Charkhu series are well-drained soils developed on steep slopes made up of materials derived from slate. The soils are under a forest cover dominantly of Quercus incana, Quercus semecarpifolia, Rhododendron spp. Castanopsis spp. Myrica nagi and Pyrus pashia.

The Charkhu series is classified as a fine loamy, mixed mesic family of Umbric Dystrochrepts.

Typical Profile

Location: Site 1, aerial photograph R 21-34, topographic map of E/2 near Charkhu Chautara forest, Chitlang Panchayat Makawanpur District, 2105 m. a.s.l.; southwest exposure.

O1 3-0 cm Forest litter, mainly loose under-composed leaves underlain in places by partly disintegrated leaves and twigs with some fungal hypae.

A1 0-12 Dark brown (7.5 YR 3/2) dry, very dark brown (10 YR 2/2) moist; silt loam; granular + crumb, very friable loose moist, non-sticky, non-plastic wet; few rock fragments, many fine to course roots; pH 5.9 abrupt smooth boundary.

B21 12-36 cm Dark brown (7.5 YR 4/4) moist; silt loam; fine to medium granular crumb + subangular blocky, friable moist; sticky, slightly plastic wet; many rock fragments; few medium to very course roots; ph 5.6 gradual wavy boundary.

B22t 36-52 Dark brown (7.5 YR 4/4) moist, loam, very weak subangular crumb, friable moist; non-sticky, non-plastic wet; Fe roots; pH 6.15.

Analytical Data

Lab No.	Horizon	Depth (cm)	Particle Size Distribution			Texture
			0.05-2 sand %	0.002-0.05 silt %	.002 clay %	
	01	3-0				
SS 845	A1	0-12	23	53	24	Silt loam
SS 844	B21	12-36	23	55	22	Silt loam
SS 845	B22t	36-52	31	49	20	Loam

Horizon	Depth (cm)	pH	P^2O^5 Kg/Ha	K_2O Kg/Ha	%O.C	%N	C/N	O.M.%
01	3-0							
A1	0-12	5.9	26.7	360.1	9.80	0.65	15.0	16.87
B21	12-36	5.6	14.4	96.7	1.75	0.20	8.7	3.01
B22t	36-52	6.15	14.4	119.2	0.28	0.06	4.6	0.49

5. Chhankhu Series

The Chhankhu series are well-drained soils developed on moderately steep to steep slopes made up of materials derived from slate, phyllite and quartzite. These soils are under a forest cover predominantly of Pinus wallichiana, Schima wallichii, Rhododendron spp. Berbaris aristata and Lyonia ovalifolia.

The Chhankhu series is classified as a fine loamy, mixed, mesic family of Ultic Haplustalfs.

Typical Profile

Location: Site 4, aerial photograph R 20-29, topographic map 72 E/2 near Chitlang Panchayat, Makawanpur District; 1802 m. a.s.l.; Southwest exposure.

A1 0-10 cm Yellowish red (5 YR 5/6) dry, yellowish red (5 YR 4/6) moist; loam, weak very fine granular crumb + subangular blocky, non-sticky, non-plastic wet; few rock fragments; few concretion probably of FE and Mn; many fine roots; pH 5.9; gradual smooth boundary.

B21t 10-32 cm — Strong brown (7.5 YR 5/6) moist; silt loam; weak very fine crumb + sub-angular blocky, slightly sticky, non-plastic wet granular friable moist; few rock fragments; few concretion probably of Fe and Mn, pH 6.1; clear smooth boundary.

B22t 32-65+ cm — Strong brown (7.5 YR 5/8) moist; silt clay loam, fine to medium crumb + subangular blocky, friable moist, slightly sticky non-plastic wet; many rock fragments of weathered slate increasing with depth; pH 6.1.

Analytical Data

Lab No.	Horizon	Depth (cm)	Particle Size Distribution			Texture
			0.05-2 sand %	0.002-0.05 silt %	.002 clay %	
SS 826	A1	0-16	42	49	9	Loam
SS 827	B21t	10-32	20	54	26	Silt loam
SS 828	B22t	32-65+	12	58	30	Silt clay loam

Horizon	Depth (cm)	pH	P_2O_5 Kg/Ha	K_2O Kg/Ha	%C	%N	C/N	O.M.%
A1	0-10	5.9	14.4	268.8	3.70	0.28	13.2	6.37
B21t	10-32	6.1	4.1	225.7	0.81	0.31	2.6	1.40
B22t	32-65+	6.1	6.1	209.6	0.04	--	--	0.42

6. Chitlang Series, Cg

The Chitlang series are moderately well-drained soils developed on moderately steep slopes made up of materials derived from phyllite and quartzite. The soils are mainly in natural pasture land.

The Chitlang series is classified as a fine clay, mixed, mesic family of Udic Haplustalfs.

Typical Profile

Location: Site 23, aerial photograph R 19-30; topographic may 72 E/2

Markhu panchayat, Makawanpur District; 1930 m. a.s.l.; Southwest exposure.

A1 0-14 cm — Reddish yellow (5 YR 6/6) dry; reddish brown (5 YR 4/4) moist; sandy loam; strong fine to very fine crumb + sub-angular blocky, friable moist; sticky non-plastic wet; few rock fragments; few fine roots; pH 6.2; gradual boundary.

B21t 14-32 cm — Dark reddish brown (5 YR 3/4) moist; silty clay; strong fine crumb + angular blocky; friable moist; sticky, non-plastic wet; dark reddish brown cutans along the vertical ped faces and root channels; few rock fragments; pH 6.5; gradual boundary.

B22t 32-85 cm — Reddish brown (5 YR 4/4) moist: silt clay; moderate to strong fine to medium crumb + sub-angular blocky; firm moist; slightly sticky, slightly plastic wet, few rock fragments, dark reddish brown cutans along the vertical ped faces and root channels; few concretion probably of Fe and Mn; pH 6.4.

Analytical Data:

Lab No.	Horizon	Depth (cm)	Particle Size Distribution			Texture
			0.05-2 sand %	0.002-0.05 silt %	.002 clay %	
SS 899	A1	0-14	59	38	3	Sandy loam
SS 900	B21t	14-32	6	52	42	Silty clay
SS 901	B22t	32-85	7	52	41	Silty clay

Horizon	Depth (cm)	pH	P_2O_5 Kg/Ha	K_2O Kg/Ha	%C	%N	C/N	O.M.%
A1	0-14	6.2	4.1	795.6	3.58	0.30	11.9	6.16
B21t	14-32	6.5	4.1	817.1	1.01	0.12	8.4	1.75
B22t	32-85	6.4	4.1	752.6	0.32	0.17	4.5	0.75

7. Damian Series

The Daman series are moderately well-drained soils developed on rolling bench terraces made up of materials derived mainly from granite. These soils are mainly in fruit (apple, peach, plum) and vegetable (radish, cabbage and caluiflower) cultivation.

The Daman series is classified as a fine silty, mixed, mesic family of Ultic Hapludalfs.

Typical Profile

Location: Site 33, aerial photograph R 18-20, topographic map 72 E/2 at Daman Horticulture Farm, Makwanpur District, 2300 m. a.s.l.; East southeast exposure.

Ap 0-15 cm Very pale brown (10 YR 7/3) dry; dark yellowish brown (10 YR 4/4) moist; silt loam; moderate to strong fine crumb + angular blocky, very friable moist; slightly sticky non-plastic wet; many fine to medium roots; pH 5.2; gradual boundary.

B21t 15-28 cm Yellowish brown (10 YR 5/6) moist silty clay loam; strong fine crumb + sunabgular blocky, friable moist; sticky slightly plastic wet; very thin yellowish brown cutans along vertical root channels, few medium to fine roots; pH 5.3; smooth boundary.

B22t 28-48 cm Yellowish brown (10 YR 5/6) moist; silty clay loam; moderate to strong granular crumb + angular blocky, friable moist; sticky slightly plastic wet; very thin yellowish brown cutans along vertical ped faces and root channels, few fine roots; pH 5.4 gradual wavy boundary.

C 48-80 cm Yellowish brown (10 YR 5/4) moist; brown to dark brown distinct mottless; loamy sand; blocky firm, slightly sticky plastic wet; thick continuous strong brown cutans, pH 5.0.

Analytical Data

Lab. No.	Horizon	Depth (cm)	Particle Size Distribution			Texture
			0.05-2 sand %	0.002-0.05 silt %	.002 clay %	
SS 906	Ap	0-15	26	55	19	Silt loam
SS 907	B21t	15-28	5	57	38	Silty clay loam
SS 908	B22t	28-48	3	64	33	Silty clay loam
SS 909	C	48-80	77	20	3	Loamy sand

Horizon	Depth (cm)	pH	P_2O_5 Kg/Ha	K_2O Kg/Ha	%C	%N	C/N	O.M.%
Ap	0-15	5.2	410.97	1075.2	4.37	0.41	10.6	7.52
B21t	15-28	5.3	--	268.8	1.11	0.11	10.0	1.92
B22t	28-48	5.4	--	182.7	0.56	0.08	7.0	0.98
C	48-80	5.0	--	139.7	0.42	0.07	6.0	0.73

8. Deorali Series

The Deorali series are well-drained soils developed on moderately steep to steep slopes made up of materials derived mainly from granite, quartzite and quartzitic phyllite. These soils are under a forest vegetation dominantly of Quercus spp. Rhodcdendron spp. and Lyonia ovalifolia.

The Deorali series is classified as a coarse loamy, mixed, mesic family of Lithic Dystrochrepts.

Typical Profile

Location: Site 39, topographic may 72 E/2, near Deorali Bhimphedi Panchayat Makawanpur District 2025 m. a.s.l.; Northeast exposure.

01 3-0 cm Forest litter, mainly loose undercomposed leaves and twigs.

A1 0-14 cm Very dark greyish brown (10 YR 3/2) moist; sandy loam; moderate strong fine crumb angular blocky, friable moist; slightly sticky non-plastic wet; many rock fragments; many medium to fine roots, pH 5.7; clear smooth boundary.

B 14-39 Yellowish brown (10 YR 5/6) moist; loam; massive, friable moist; slightly sticky, non-plastic wet, very many rock fragments; gravel increases with depth; few fine to medium roots.

Analytical Data

Lab No.	Horizon	Depth (cm)	Particle Size Distribution			Texture
			0.05-2 sand %	0.002-0.05 silt %	.002 clay %	
SS 919	A1	0-14	53	41	6	Sandy loam
SS 920	B	14-39	40	49	11	Loam

Horizon	Depth (cm)	pH	P_2O_5 Kg/Ha	K_2O Kg/Ha	%O.C	%N	C/N	O.M.%
A1	0-14	5.7	20.6	204.2	7.32	0.63	11.6	12.60
B	14-39	5.6	6.1	64.5	1.66	0.13	12.7	2.87

9. Khadpu Series

The Khadpu series are well drained soils developed on moderately steep, bench terraces made up of materials derived mainly from phyllite. These soils are mainly in maize, millet and mustard cultivation.

Khadpu series is classified as fine loamy, mixed, mesic family of Lithic Ustrochrepts.

Typical Profile

Location: Site 11, aerial photograph R 19-23, topographic map 72 E/2 near Khadpu village, Makawanpur District; 1803 m. a.s.l.; Northeast exposure.

Ap 0-15 cm Dark yellowish brown (10 YR 4/6) moist; silt loam; moderate to strong fine crumb + sub-angular blocky; friable moist; slightly sticky, non-plastic wet; few rock fragments; pH 6.2; gradual smooth boundary.

B_2 15-32 cm Yellowish brown (10 YR 5/6) moist; silt loam; moderate to strong fine to medium crumb + sub-angular blocky; friable moist; slightly sticky, non-plastic wet; few rock fragments; pH 6.55, abrupt smooth boundary.

C 32-80+ cm Weathered phyllite in situ.

Analytical Data

Lab No.	Horizon	Depth (cm)	Particle Size Distribution			Texture
			0.05-2 sand %	0.002-0.05 silt %	.002 clay %	
SS 796	Ap	0-15	22	53	15	Silt loam
SS 797	B2	15-32	24	57	19	Silt loam

Horizon	Depth (cm)	pH	P^2O^5 Kg/Ha	K_2O Kg/Ha	%C	%N	C/N	O.M.%
Ap	0-15	6.2	28.8	354.8	1.46	0.15	9.7	2.52
B2	15-32	6.5	8.5	107.5	0.30	0.04	7.5	0.52

10. Khuplang Series

The Khuplang series are moderately well-drained soils developed on moderately steep slopes made up of materials derived from phyllite, schists and quartzite. These soils are under a forest cover dominantly of *Pinus roxburgii*, *Rhododendron spp*. *Quercus incana*, *Quercus semecarpifolia* and *Lyonia Ovalifolium*.

The Khuplang series is classified as a fine silty, mixed mesic family of *Ultic Haplutalfs*.

Typical Profile

Location:	Site 28, aerial photograph R 21-29, topographic map 72 E/2 near Tistung Panchayat, Makawanpur District 2068 m. a.s.l.: Southeast exposure.
01 2-0 cm	Forest litter, mainly loose and composed leaves and twigs.
A1 0-15 cm	Dark brown (7.5 YR 4/4) dry, reddish brown (5 YR 4/4) moist; *silt loam*; weak to moderate fine crumb + subangular blocky, friable moist; sticky non-plastic wet; few rock fragments; many fine to medium roots; pH 5.55; gradual boundary.
B21t 15-35 cm	Dark brown (7.5 YR 4/4) moist; *silty clay loam*; strong fine crumb + sub-angular blocky, very friable moist; slightly sticky slightly plastic wet; dark brown patchy cutans; many rock fragments; few fine roots; pH 5.95; gradual boundary.
B22t 35-60 cm	Brown (7.5 YR 5/4) moist; *silty clay loam*; strong; fine to medium crumb + angular blocky, firm moist; slightly sticky, slightly plastic wet; patchy moderately thick dark brown cutans along the vertical ped faces, many rock fragments, many medium to course roots; pH 6.1.
C 60+ cm	Weathered phyllite *in situ*.

Analytical Data

Lab No.	Horizon	Depth (cm)	Particle Size Distribution			Texture
			0.05-2 sand %	0.002-0.05 silt %	.002 clay %	
SS 896	A1	0-15	23	56	21	Silt loam
SS 897	B21t	15-35	15	54	31	Silty clay loam
SS 898	B22t	35-60	12	51	37	Silty clay loam

Horizon	Depth (cm)	pH	$P^2 O^5$ Kg/Ha	K_2O Kg/Ha	%C	%N	C/N	O.M.%
A1	0-15	5.8	6.1	118.2	1.50	0.18	8.3	2.59
B21t	15-35	5.9	10.3	86.0	0.91	0.11	8.2	1.57
B22t	35-60+	6.1	4.1	96.7	0.20	0.06	3.3	0.35

11. Kogte Series, Ko

The Kogte series are somewhat well-drained soils developed on rolling bench terraces made up of soil materials derived from micaceous quartzite and phyllite. These soils are mainly in maize, millet, mustard, potato and buckwheat cultivation.

The Kogte series is classified as a coarse loamy, mixed, mesic family of Dysteric Entrochrepts.

Tpyical Profile

Location: Site 16, topographic map 72 E/2 near Kogte village, Makawanpur District, 1802 m. a.s.l.; Southeast exposure.

API 0-18 cm Dark yellowish brown (10 YR 4/4) moist; sandy loam; moderate fine crumb + angular blocky, very friable moist; non-sticky non-plastic wet; moderately thick dark brown cutans along the vertical ped faces; few rock fragments; pH 6.0; gradual smooth boundary.

B 81-40 cm Dark yellowish brown (10 YR 4/4); loam; strong fine granular blocky; very friable moist; non-sticky, non-plastic wet; few rock fragments; pH 6.0.

A1b 40-60 cm Very dark greyish brown (10 YR 3/2) moist; loam; strong fine granular crumb + angular blocky, friable moist; non-sticky,

non-plastic wet; pH 6.0; diffused boundary.

11B21 60-90 cm — Dark yellowish brown (7.5 YR 4/4) moist; loam; moderate granular crumb + sub-angular blocky, friable moist: yellowish brown cutans; few rock fragments; pH 6.5; gradual boundary.

IIB22 90-125+ cm — Dark yellowish brown (7.5 YR 4/4) moist; loam; moderate granular crumb + sub-angular blocky, friable moist; sticky slightly plastic wet; thin patchy dark yellowish brown cutans; few rock fragments; pH 5.6.

Analytical Data

Lab No.	Horizon	Depth (cm)	Particle Size Distribution			Texture
			0.05-2 sand %	0.002-0.05 silt %	.002 clay %	
SS 821	AP1	0-18	46	48	6	Sandy loam
SS 822	B	18-40	48	42	10	Loam
SS 823	Alb	40-60	36	50	14	Loam
SS 824	II B	60-90	32	46	22	Loam
SS 825	II B22t	90-125+	32	46	22	Loam

Horizon	Depth (cm)	pH	P^2O^5 kg/Ha	K_2O Kg/Ha	%C	%N	C/N	O.M.%
AP1	0-18	6.0	72.1	569.8	2.09	0.17	12.2	3.60
B	18-40	6.0	57.6	274.1	1.76	0.14	12.5	3.04
Alb	40-60	6.0	43.3	279.5	2.72	0.19	14.3	4.69
II Bt	60-90	6.1	72.1	252.6	1.36	0.12	11.3	2.34
II B22t	90-125+	5.6	103.0	403.2	1.34	0.12	11.1	2.31

12. Palung Series

The Palung series are poor to imperfectly drained soils developed on flat to gently undulating terraces made up of alluvium derived from granite. These soils are mainly in paddy, wheat and potato cultivation.

The Palung series is classified as a coarse loamy, mixed, mesic family of Aeric Haplacuepts.

Typical Profile

Location:	Site 24, aerial photograph R 19-23, topographic map 2 E/2, near Palung High School, Makawanpur District; 1725 m. a.s.l.; Northwest exposure.
Apl+AP_2 0-29 cm	Light brownish grey (10 YR 6/2); dark greyish brown (10 YR 4/2) moist; few patchy strong brown mottles; loam; massive; very friable moist, slightly sticky, non-plastic wet; few fragments of slightly weathered granite; pH 5.50; clear smooth boundary.
B21 29-53 cm	Dark greyish brown (10 YR 4/2) moist; prominent many strong brown mottles; sandy loam; moderate to strong fine to medium crumb, sub-angular blocky, fine to crumb; sticky slightly plastic wet; thick horizontal and vertical patchy greyish brown cutans; few fragments of slightly weathered granite; pH 6.1; diffuse boundary.
B22 53-70 cm	Brown (10 YR 5/3) moist; diffuse strong brown mottles; loam; massive; friable moist; sticky slightly plastic wet; thick vertical patchy light brownish grey cutans, few fragments of slightly weathered granite; pH 6.3; diffuse boundary.
Alb 70-85 cm	Dark greyish brown (10 YR 4/2) moist; diffuse prominent very dark brown mottles; loam; weak fine to medium crumb, angular blocky, friable moist; sticky, slightly plastic wet; dark greyish brown cutans along the root channels; few fragments of slightly weathered granite; pH 6.3; diffuse boundary.
IIB21 85-110 cm	Brownish yellow (10 YR 6/6) moist; clay loam, massive, sticky slightly plastic wet; many thick, light yellowish brownish cutans along the vertical ped faces: diffuse brownish yellow cutans; few fragments of slightly weathered granite; pH 6.4; gradual boundary.
IIB22 110-130+ cm	Brownish yellow (10 YR 6/6) moist; clay loam, massive; firm moist, sticky, slightly plastic wet; patchy thin dark yellowish brown cutans on vertical ped faces; few concretions

probably of iron and manganese; few fragments of slightly weathered granite; pH 6.5.

Analytical Data

Lab No.	Horizon	Depth (cm)	Particle Size Distribution			Texture
			0.05-2 sand %	0.000-0.5 silt %	.002 clay %	
SS 880	Ap1+Ap2	0-29	49	40	11	Loam
SS 881	B21	29-53	61	26	13	Sandy oam
SS 882	B22	53-70	43	38	19	Loam
SS 883	A1b	70-85	41	40	19	Loam
SS 844	IIB2	85-110	23	40	37	Clay oam
SS 885	IIB2	110-130+	35	35	30	Clay oam

Horizon	Depth (cm)	pH	$P^2 O^5$ Kg/Ha	K_2O Kg/Ha	%C	%N	C/N	O.M.%
Ap1+AB	0-29	5.5	6.1	311.8	2.48	0.25	9.9	4.27
B21	29-53	6.1	39.1	204.2	1.01	0.35	2.8	1.75
B22	53-70	6.3	22.6	236.5	0.91	0.10	9.1	1.57
A1b	70-85	6.3	45.3	344.0	2.37	0.24	9.8	4.09
IIB21	85-110	6.4	45.3	370.9	0.54	0.09	6.0	0.94
IIB2	110-130	6.5	26.7	295.6	--	0.05	--	--

13. Tekar Series

The Tekar series are well-drained soils developed on rolling bench terraces made up of materials mainly derived from phyllite, quartzite and slate. These soils are mainly in maize, millet and mustard cultivation.

The Tekar series is classified as a coarse loamy, mixed, mesic family of Typic Eutrochrepts.

Typical Profile

Location: Site 18, aerial photograph R 17-24; topographic map E/2 near Tekar, Chanaute Village, Makawanpur District, 1355 m. a.s.l.; Southwest exposure.

Ap 0-15 cm Dark yellowish brown (10 YR 4/4) dry, dark brown (10 YR 3/3) moist; silt loam; strong fine crumb; angular blocky, very friable moist; non-sticky, non-plastic wet; many rock fragments, few fine to medium root hairs; pH 6.4; gradual smooth boundary.

B21 15-40 cm Dark yellowish brown (10 YR 3/4) moist; silt loam; moderate to strong granular crumb subangular blocky, friable moist, slightly sticky, non-plastic wet; moderately thick patchy yellowish brown cutans; many rock fragments; few fine root hairs; pH 6.6; gradual smooth boundary.

B22 40-80 cm Dark yellowish brown (10 YR 4/4) moist; silt loam; moderate to strong granular crumb subangular blocky, very friable moist, non-sticky, non-plastic wet; thin patchy yellowish brown cutans along the vertical ped faces; many rock fragments; pH 6.90; gradual smooth boundary.

C 80+ cm Stones, boulders and gravels.

Analytical Data

Lab. No.	Horizon	Depth (cm)	Particle Size Distribution			Texture
			0.05-2 Sand %	0.000-0.05 Silt %	.002 Clay %	
SS 815	Ap	0-15	30	62	8	Silt loam
SS 816	B21	14-40	26	66	8	Silt loam
SS 817	B22	40-80	50	46	4	Silt loam

Horizon	Depth (cm.)	pH	P_2O_5 Kg/Ha	K_2O Kg/Ha	%C	%N	C/N	O.M.%
AP	0-15	6.4	105.0	550.1	1.30	0.22	5.90	2.25
B21	15-40	6.4	49.4	266.8	0.77	0.11	7.0	1.33
B22	40-80	6.9	63.8	344.6	0.58	0.06	9.6	1.01

14. Tistung Series, Ti

The Tistung series are imperfectly drained soils developed on flat to gently undulating terraces made up of alluvial/colluvial materials derived mainly from phyllite, quartzite and slate. These soils are mainly in paddy, wheat and potato cultivation.

The Tistung series is classified as a fine loamy, mixed, mesic family of Aquic Haplaudalf.

Typical Profile

Location:	Site 31, aerial photograph R 20-24, topographic map E/2 near Tistung Bazaar, Makawanpur District, 1685 m. a.s.l.; Northeast exposure.
Ap1+Ap2 0-28 cm	Light grey (10 YR 7/2) dry, light brownish grey (10 YR 6/2) moist; silt loam; weak to moderate fine crumb angular blocky, friable moist; slightly sticky non-plastic wet; pH, 6.0; gradual boundary.
B21t 28-50 cm	Dark brown (10 YR 4/3) moist; yellowish brown mottles; silt loam; blocky breaking into sub-angular blocky; firm moist; sticky plastic wet, continuous thick greyish brown cutans along the vertical ped faces pH 6.6; gradual boundary.
B22t 50-70 cm	Dark brown (10 YR 4/3) moist; many prominent strong brown mottles; silt loam; coarse prismatic breaking into angular blocky, firm moist; sticky slightly plastic wet; moderately thick patchy greyish brown cutans, pH 6.8; gradual boundary.
A1b 70-100 cm	Very dark greyish brown (10 YR 3/2) moist; few prominent strong brown mottles; silt loam; moderate fine crumbs angular blocky, friable moist; slightly sticky, non-plastic wet; thin greyish brown cutans along the vertical ped faces and root channels; pH 6.7; clear boundary.
IIc 100-120 cm	Dark Brown (10 YR 4/3) moist; silt loam; massive; loose moist; few rock fragments.

Analytical Data

Lab. No.	Horizon	Depth (cm)	Particle Size Distribution			Texture
			0.05-2 Sand %	0.000-0.05 Silt %	.002 Clay %	
SS 902	Ap1+Ap2	0-28	27	59	24	Silt loam
SS 903	B21t	28-50	14	65	21	Silt loam
SS 904	B22t	50-77	17	63	20	Silt loam
SS 905	A1b	77-100	29	56	15	Silt loam

Horizon	Depth (cm.)	pH	P_2O_5 Kg/Ha	K_2O Kg/Ha	%OC	%N	C/N	O.M.%
Ap1+Ap2	0-28	6.0	63.6	258.0	2.03	0.29	7.0	3.50
B21t	28-50	6.6	30.9	215.0	-	0.13	-	-
B22t	50-77	6.8	43.2	145.1	-	0.11	-	-
A1b	77-100	6.7	53.5	112.9	-	0.07	-	-

REFERENCES

Brammer, H. 1965 Soil correlation boxes: a technique to simplify soil correlation, Pak. J. Soil Sci. 1(2): Dacca.

Climatic Records of Nepal 1977 Department of Irrigation, Hydrology and Meterology, HMG/Nepal

FAO/DSWC 1978 A working paper work plan for watershed condition and natural inventory of Nepal. Integrated Watershed Management Project FAO and Department of Soil and Water Conservation HMG/Nepal, Nep/74/020.

FAO 1977 Guidelines for soil description (2nd Ed.) Soil Resource Development and Conservation Service, Land and Water Development Division, FAO, Rome.

Jackson, M. L. 1962 Soil Chemical Analysis, Prentice Hall, Inc., USA.

Joshy, D. and Deo, G. P. 1976 Fertilizer recommendation for major crops of Nepal. Div. Soil Sci. & Agri. Chem. Khumaltar, HMG/Nepal.

IWM/DSWC 1978 A soil survey of Phewa Tal catchment, Phewa Tal Technical Report No. 4 DSWC/IWM.

Karki, A. B. 1975 Organic manure for vegetables "Krishi," Agricultural Information Section, Harihar Bhawan, Lalitpur, Ashad-Sharawan (in Nepali).

Khan, R. H. and Tated, J. M. 1970 Radiometric dates of some Nepalese rocks. Nepal Geological Survey, HMG/Nepal.

Maharjan, P. L. 1976 Criterias for adducing approximate soil boundaries by interpretation of base map (memo).

Moorman, F. R. and Breeman, N. V. 1978 Rice: Soil, Water and Land. International Rice Research Institute, Las Banos, Laguna, Philippines.

Singh, T. N. 1975 Organic manure for fruit crops "Krishi", Agricultural Information Section, Harihar Bhawan, Lalitpur, Ashad-Shrawan (in Nepali).

Stainton, J. D. A. 1972 Forest of Nepal, London, John Murray.

Stocklin, J. and Bhattarai, K. D. 1972 Photo-geological map of Chandragiri-Chisapani area. HMG/UNDP Mineral Exploration Project.

Taylor, N. H. and Pohlen, I. V. 1970 Soil Survey Method: A New Zealand Handbook for the field study of soils. Soil Bureau Bulletin 25, DSIR, Soil Bureau Traiter Experimental Station, Lower Hutt, New Zealand.

UNDP/FAO 1975 General Soil Survey of Bagmati and Narayani Zones. Increasing use of high yielding crop varieties and fertilizers, Central Nepal, AG:DP/NEP/70/512.

USDA 1975 Soil Taxonomy: A Basic System for Making Interpreting Soil Surveys. USDA Handbook No. 436.

USDA 1951 Soil Survey Manual USDA Handbook No. 18, with supplement of 1962.

CHAPTER III

SOILS AND GEOLOGY OF DARAUNDI CATCHMENT AREA
(Gorkha District)

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I. PHYSICAL AND ENVIRONMENTAL FEATURES

Location and Extent

The Daraundi project area is situated between 84°27' and 84°48' east longitude and 27°51'2" and 28°21'43" north latitude. The area is located in the central and southern part of Gorkha District covering 795 sq. km. The total area of Gorkha District is 3456 sq. km. The effective catchment area of the Daraundi River is 597 sq. km. Panchayat boundaries rarely coincide with the watershed boundary. All the panchayats that fall partly or wholly in Daraundi Catchment have been included in the project for administrative reasons.

Climate

Four types of climates are found in the Daraundi catchment area, namely tropical, sub-tropical, temperate and arctic. The lower river valleys have a tropical climate and the lower foothill slopes a sub-tropical climate. The northern hills and mountains have a temperate climate and the high Himalayas an arctic climate.

There are only two weather stations in Gorkha District, located at Gorkha and Setibas. Thus it is difficult to make generalizations for the whole catchment area. The mean annual precipitation, based on the records of these two stations, are 1400 mm and 1600 mm respectively. In general, south-facing slopes receive a very heavy rainfall during the monsoon as the southern side of the upper slopes around 2400 m are generally always covered with drizzling mist and clouds during that time. In general, more than 75 percent of the annual precipitation falls from July to September. Maximum 24 hour rainfall intensities of 100-140 mm have also been recorded in these stations (Department of Hydrology and Meterology, 1977).

The only temperature records available are from the Gorkha weather station. Here the mean January temperature is 12.4° with a mean minimum dropping to 6.3°C. The July mean is 22.3°C with a mean maximum of 27.3°C. It has been calculated that average temperature decline northward and with altitude (about 7°C/100 m) to a summer mean of about 10°C at the treeline, and a mean annual temperature of less than 0°C above the snow line. In the south facing low-lying valleys, pre-monsoonal temperatures reach 35°C, as recorded by the RCUP team in May, 1979. Relative humidities at Gorkha range between 41 percent in March and 93 percent in the monsoon period of June and July. Evapotranspiration rates thus are greatest in the pre-monsoon period, dropping to minimum levels during the monsoon, increasing the post-monsoon,

and declining again during winter.

Physiography

The Daraundi catchment area consists of a series of hills and valleys varying from about 600 to 6700 m. within an aerial distance of approximately 58 km north to south. Thus, within this relatively small area a variety of topographic features are found. The project area can broadly be grouped into three physiographic units, namely Midland, Fore Himalaya and High Himalaya.

Midland: The Midland, consisting of low sunken hills and mountain valleys of the Nepal Himalaya system, lies between the Mahabharat Lekh in the south and the Fore Himalaya in the north. This area is mainly composed of slight to moderate metamorphic rocks like phyllite, schist, phyllitic limestone, dolomites and sometimes quartzites and sandstones. The height of the Midland varies from 600 to 2000 m., covering about 85.7 percent of the project area.

The region as a whole can be characterized as an easy rolling to moderately steep to steep terrain, with fertile soil and an agreeable climate except in some parts of the northern sector. The southern half of the project area contains more than 95 percent of the inhabitants.

In this area human livelihood is based on agriculture. A few people derive their livelihood from livestock farming. Maize and millets are the principal crops but the lower valleys are dominated by rice.

The overall population density in the Midland region is unusually high considering its land carrying capacity. As a result, the farmers are receding fast to the north; and the steeper marginal lands are being cultivated, which is accelerating erosion and degrading the physical environment.

Fore Himalaya: The Fore Himalaya lies between the Midland in the south and the High Himalaya in the north. The elevation ranges from 2000 to 4500 m. a.s.l. stretching over 13.6 percent of the project area. It is very steep, rugged and has a high relief. Winter is severe and summer is short. Because of hostile terrains and the harsh climate, this area has a very sparce population. Animal husbandry and potato cultivation are the main economy of this region. The area has a good stand of alpine forest above which is grassland that extends up to the snow line.

High Himalaya: The High Himalaya region covers the northern periphery, accounting for less than one percent of the project area. It is permanently covered by snow.

Drainage

About 75 percent of the catchment area is drained through the Daraundi

River. The Daraundi River originates near Narad Pokhari in the north. Padlung, Andhara and Ghatta Kholas are the main drainage rivers in the northern parts of the catchment area. Lungdi, Khara Chukti, and Rangdi Kholas drain the catchment area from the southern hills and small valleys. Similarly, Beni, Bhusundi, Jarang and Ludi Kholas drain the southern, central and lower southern central parts of the area. All these rivers are tributaries of the Daraundi River. The Daraundi River covers about 66 km from source to mouth until it merges with the Marsyangdi River at Majuakhairani.

Natural Vegetation

Based on altitude, the natural vegetation of the Daraundi catchment area can be classified as follows:

Tropical forest (up to 1200 m): In this zone, the river sides and lower valleys have tropical deciduous forests. The main species recognized are *Dalbergia sisso*, *Acacia catechu* and *Shorea robusta*.

Subtropical forest (1200-1800 m): In the subtropical forest zone, the vegetation identified are *Pinus roxburghii*, *Lagerstroemia ovalifolia*, *Berberis asiatica*, *Castanopsis indica*, *Quercus incana*, and *Impereta cylindrica*.

Temperate forest (1800-3000 m): Temperate forests occur mostly in the higher altitudes. The main species observed are *Pyris ovalifolia*, *Rhododendron arboreum*, *Pinus cerasoides*, *Ficus nemoralis*, *Quercus semecarpifolia*, *Quercus incana*, *Castanopsis indica*, *Castanopsis taubalaris*, and *Myrica nagi Pyrus pashia*.

Subalpine forest (3000-4000 m): Subalpine forests mainly includes *Abies spectabilis*, *Betula utilis*, *Rhododendron campunulatum*, *Picea smietuana*, and *Tsuga dumosa*.

Alpine meadows (4000-5000 m): In alpine meadows the vegetation consists mainly of *graminaceae* and *cyperaceal* families.

Land Use

The existing land use of the project area is briefly described as follows:

Forest: About 328.6 km^2 of the project area is under forest, which is nearly 41 percent of the total area. Mainly tropical, subtropical, temperate forest and alpine meadows occur in the project area. The northern part of the project area has temperate, dense, coniferous forest. In the lower hills and valleys,

the original species are disappearing. On the other side, reforestation projects, which are very important from a soil conservation point of view, are in progress. Otherwise the mountains and hills will be deprived of soils.

Cultivated Land: About 307.8 km^2 are under agriculture, covering nearly 39 percent of the total area. Irrigated rice is mainly cultivated in the river belts and lower valleys where irrigation facilities are available. Rice is also grown in the higher hills to a limited extent. In comparison to maize and millet, rice covers far less of the catchment area. In other words, the maximum cultivatable land has been occupied by maize and millet.

All mountain and hill areas are suitable for growing maize, millet, potato and buckwheat. Other important grains and legume crops occupying the cultivatable land are wheat, barley, groundnut, bajara, black gram, soybean, cowpeas, and beans. The fruit and vegetable crops are generally grown on waste. The lower altitude areas have a warm climate supporting fruit plants such as papaya, banana, pineapple, litchi, mango, jack fruits and guavas. Lime, lemon, orange, peach, plum and pear are grown in both tropical and subtropical areas. The area under vegetables also appears to be increasing.

Pasture Land: No improved pasture lands were observed in the catchment area. The total figure of the natural pasture land has been estimated to be 133 km^2, comprising 17 percent of total area. The higher altitudes are represented by relatively large areas of natural pasture which are covered with snow for about five months out of the year. These lands are very fertile due to high amounts of organic matter. Other natural pasture lands are found in the middle and lower hill valleys.

Snow-Covered Land: About 8.25 km^2 is perpetually covered by snow. There are also areas where snow falls only during winter season.

II. GENERAL NATURE OF THE SOILS

A. Methodology

Mapping and Classification of the Soils: The Daraundi watershed has a surface of around 597 km^2. The soil survey was done on a reconnaissance scale with the primary objective of identifying the RCUP Project needs for research and planning. Soil pits were dug along vertical cross-sections of the project area. A topographical and a slope category map (both with a scale of 1:63,360) were used as field maps.

Thirty-three pits were dug and described in detail according to the Soil Survey Manual (USDA, 1951) and classified according to Soil Taxonomy

(USDA, 1975) in levels of subgroups. The purpose of the pit descriptions is to give detailed soil profile information for the different soil series. Typical profile descriptions and the range of characteristics in each series are given.

The depth, texture type and phase classes are the same as those described in the "Soil Survey Manual" (reissued in October 1962). Soil color was determined according to the "Munsell Color Chart" and the taxonomic classification was made according to the "Soil Taxonomy" book during fieldwork. Use was also made of the "FAO Guidelines for Soil Descriptions."

Special correlation boxes developed by Charter and Brammer (Brammer, 1965) were used for soil correlation as well as for retention of representative soil profiles in the Nepalese soil museum.

During fieldwork, samples were collected for laboratory analysis. These samples were taken from throughout the profile with the purpose of analyzing the texture, pH, organic matter, N, P, K and exchange capacity of bivalent cations. This was needed for soil classification. The data are presented in APPENDIX I.

A detailed description of the mapping units are presented in the following sections (Sheet No. I, 11b).

B. Description of Mapping Units

1. Ambote Soil (31.6 km^2), Ab[1/]

Pockets of the ambote soil units are scattered in the central and southern part of the mapped area on easy rolling river terraces. These soils are moderately deep, poorly drained and are made up of alluvium/colluvium materials derived mainly from quartzite.

Altitude	About 460 to 500 m.; Exposure: Variable.
Surface Soil	Grayish brown to dark grayish brown, strong brown mottles, firm, loam to silt loam, few rock fragments, 10 cm. thick.
Sub-Soil	Gray to grayish brown, strong brown to yellowish brown mottles, sandy loam to silt loam, usually 50 cm. thick.

1/ Harmi soil (See Appendix I for description) is correlated with Ambote soil.

Substratum	May be poorly sorted alluvial/colluvial materials from large boulders through to silt.
Other Properties	Slightly acid, strongly to medium in organic medium, nitrogen and phosphorus high in potash.
Suitability	
Agriculture	Highly suitable for rice; moderately suitable for wheat, mustard and sugarcane; moderate to poorly suited for maize and potato.
Horticulture	Poor to moderately suitable for mango, litchi, papaya, pineapple and banana.
Pasture	Poor to moderately suitable.
Forest	Poor to suitable. Presently existing species includes Shorea robusta, Schima wallichii and Castanopsis indica.
Terrace	Moderately suitable.
Limitations	Imperfect drainage and susceptibility to flooding; high acidity; occasional hailstorms.
Erosion and Landslide Hazards	Erosion hazard class in this soil unit is rated as moderately high to high and sheet erosion as moderately high. This unit falls under slightly sliding to moderately sliding territory.

2. Ampchaur Soil (7.0 km^2), Am

Pockets of the Ampchaur soil unit are located in the far western and far southern part of the mapped area on flat to slightly undulating river terraces. These soils are moderately deep, poorly drained and are made up of alluvium/colluvium materials derived mainly from quartzite.

Altitude	420 m.; Exposure: Southwest.
Surface Soil	Yellowish red, firm, silt loam, many rock fragments, 15 cm. thick.
Sub-Soil	Yellowish red to dark brown, friable, silt loam to gravelly sandy loam, many rock fragments, 70 cm. thick.
Substratum	May be boulders of quartzite.
Other Properties	Strongly acid to neutral, medium in organic matter and nitrogen, high in phosphorous and low in potash.
Suitability	
Agriculture	Highly suitable for rice; moderately suitable for wheat, mustard and sugarcane; poorly suitable for maize and potato.

Horticulture	Poorly suitable.
Pasture	Poor to moderately suitable.
Forestry	Poor to moderately suitable. A few existing species include Acacia catechu and Lagerstroemia parviflora.
Terracibility	Highly suitable.
Limitations	Imperfect drainage, susceptibility to flooding and deficiency of potash are the major limitations besides occasional hailstorm problems.
Erosion and Landslide Hazards	Erosion hazard class in this soil unit is rated as slight to moderate to moderate and sheet erosion as slight to moderate. This unit falls under non-sliding territory.

3. Batase-Bhulbhule Soil (43.9 km^2) Ba-Bh

The Batase-Bhulbhule soil unit occurs in the southern part of the mapped area on moderately steep to steep mountain slopes. The soils are moderately deep to deep, excessively drained and are made up of materials derived from phyllite and schist. Texture varies from silt loam to silty clay, altitude varies from 500 to 1080 m.

Batase Soil - Altitude	720-1080 m.; Exposure: Variable.
Surface Soil	Yellowish red to strong brown, firm, clay loam to silty clay, few to many rock fragments, 20 cm. thick.
Sub-Soil	Yellowish red to strong brown, firm, gravelly silty clay to silty clay, few to many rock fragments, 50 cm. thick.
Substratum	May be hard rock of phyllite and schist in situ.
Other Properties	Moderate to slightly acid, medium in organic matter and nitrogen, high in phosphorus and very high in potash.
Suitability	
Agriculture	Moderate to highly suitable for maize, millet, legume and upland paddy; poorly suitable for lowland paddy, wheat, barley and sugarcane.
Horticulture	Highly suitable for orchard development, suitable fruits and vegetables include lemon, orange, papaya, banana, pineapple, mango and soybean, bean and colocasis respectively.
Pasture	Poor to moderately suitable for forage crops and grazing.
Forest	Moderately suitable for forest development.

Bhulbhule Soil - Altitude	500-630 m.; Exposure: Variable.
Surface Soil	Dark brown to red, firm to friable, silt loam to silty clay, few rock fragments, 10 cm. thick.
Sub-Soil	Red to dark red, firm to friable, silty clay to clay, many rock fragments, 80 cm. thick.
Substratum	May be hard rock in situ.
Other Properties	Strongly acid, medium in organic matter and phosphorus, high in nitrogen and potash.
Suitability	
Agriculture	Poorly suitable for farming.
Horticulture	Poor to moderately suitable for orchard development.
Pasture	Poor to moderately suitable for forage crops and grazing.
Forestry	Highly suitable. About 80 percent area is covered with the mixed forest mainly of Shorea robusta and Castanopsis indica.
Terracibility	Poor to unsuitable.
Limitations	Steep topography, susceptibility to erosion, many rock fragments on or near the soil surface droughtiness in winter and strong acidity are major limitations.
Erosion and Landslide Hazards	Erosion hazard class in this soil unit is classified as moderately high to hich and sheet erosion as moderately high. This unit falls under slightly sliding to moderately sliding territory.

4. Batase-Bhulbhule-Manakamana Soil (93.7 km^2), Ba-Bh-Mn

The Batase-Bhulbhule-Manakamana soil unit occurs in the southern part of the mapped area on moderately steep to steep to steep mountain slopes. These soils are shallow to moderately deep to deep, moderately well drained to excessively drained and are made up of soil materials derived from phyllite and schist. Texture varies from silt loam to silty clay; altitude varies from 500 to 1250 m.

Batase Soil:

This soil has also been described under mapping unit Batase-Bhulbhule (Ba-Bh).

Bhulbhule Soil:

This soil has also been described under mapping unit Batase-Bhulbhule (Ba-Bh).

Manakamana Soil - Altitude	1250 m.; Exposure: South.
Surface Soil	Dark reddish brown, friable, silt loam, few rock fragments, 10-15 cm. thick.
Sub-Soil	Reddish brown to dark reddish brown, firm silty clay loam, few rock fragments, 30 cm. thick.
Substratum	Weathered phyllite.
Other Properties	Medium to slightly acid, high in organic matter, nitrogen and phosphorus and very high in potash.
Stability	
Agriculture	Highly suitable for maize, millet, buckwheat and mustard; moderately suitable for paddy and wheat.
Horticulture	Moderately suitable for citrus fruits and pear, plum and banana.
Pasture	Moderately suitable.
Forestry	Moderately suitable.
Terracibility	Unsuitable to poorly suitable.
Limitations	Droughtiness in dry season; moderately steep to steep topography, risk of soil erosion; occasional hailstorms.
Erosion and Landslide Hazards	Erosion hazard class of this unit is rated as moderately high to high and sheet erosion as moderate to high. This unit is included in slightly sliding to moderately sliding territory.

5. Chhepetar Soil (Level) (39.3 km^2) Ch[1/]

This soil unit occurs along the Daraundi River in the southern part of the mapped area on lower terraces and tars. These soils are moderately deep, imperfectly drained and are made up of materials derived from phyllite, schist and quartzite.

Altitude	460 to 760 m.; Exposure: Variable.
Surface Soil	Dark reddish brown to dark red, silty clay loam, few rock fragments, 50 cm. thick.
Substratum	May be hard rock *in situ*.
Other Properties	Strongly to medium acid, high in organic matter and phosphorus and potash and medium in nitrogen.

1/ Source: Division of Soil Science and Agricultural Chemistry, Khumaltar.

Suitability	
Agriculture	Highly suitable for maize, sugarcane, upland paddy, millet, black gram and mustard.
Horticulture	Moderate to highly suitable for fruit crops like mango, litchi, jackfruit, papaya and lemon, suitable vegetables include radish and yams.
Pasture	Poor to moderately suitable.
Forestry	Poor to moderately suitable for forest development.
Terracibility	Moderately suitable.
Limitations	Droughtiness in winter; imperfect drainage; occasional hailstorms.
Erosion and Landslide Hazards	Erosion hazard class of this unit is rated as moderately high to high and sheet erosion as moderate. This unit falls under non-sliding to sliding territory.

6. Chhepetar Soil (Rolling) (20.1 km^2) Ch.r

This soil unit occurs in the southern part of the mapped area in the right bank of Daraundi River on rolling terraces. The soils are moderately deep, imperfectly drained and are made up of soil material derived from phyllite, schist and quartzite.

Altitude	390 t0 781 m.; Exposure: Variable.
Surface Soil	Yellowish red to dark brown, friable to firm, gravelly silt loam to silty clay loam, few rock fragments, 10-20 cm. thick.
Sub-Soil	Reddish brown to yellowish red, silty clay to clay, few rock fragments, 60 cm. thick.
Substratum	May be (a) rock *in situ* (b) poorly sorted colluvial materials.
Other Properties	Slightly to strongly acid, low in organic matter, medium in nitrogen and high in phosphorus and potash.
Suitability	
Agriculture	Moderate to highly suitable for maize, millet, mustard and soybean; poorly suitable for rice, wheat and sugarcane.
Horticulture	Highly suitable for fruit plants like mango, litchi, papaya, pineapple, lime and lemon; moderately suitable for vegetables such as legumes, colocasia, radish and leafy vegetables.

Pasture	Moderate to highly suitable for range managements.
Forestry	Moderate to highly suitable. A few existing species are Shorea robusta, Castanopsis indica and Schima wallichii.
Terracibility	Unsuitable to poorly suitable.
Limitations	Droughtiness in dry season, low in organic matter, imperfect drainage, and occasional hailstorms are some of the limitations.
Erosion and Landslide Hazards	Erosion hazard of this unit can be classified as moderate to high and sheet erosion also falls in the same class. This unit is included in slightly sliding to moderately sliding territory.

7. Chhepetar-Bhulbhule Soil (52 km^2), Ch-Bh

The Chhepetar-Bhulbhule soil unit occurs in the southern part of the mapped area.

Chhepetar Soils

These soils have been described under mapping unit, Cheepetar level phase (Ch-L-Ph).

Bhulbhule Soils

These soils have been described under mapping unit Batase-Bhulbhule (Ba-Bh).

Terracibility	Poor to moderately suitable.
Erosion and Landslide Hazards	Erosion hazard class of this soil unit is rated as moderately high to high and sheet erosion also falls in the same class. This unit falls under sliding to non-sliding territory.

8. Daraundi Soil (10.0 km^2), Da

The Daraundi soil unit occurs in the southern part of the mapped area adjacent to Daraundi River on level flood plain. These soils are shallow, poorly drained and are made up of soil materials derived from phyllite.

Altitude	426 m.; Exposure: Variable.
Surface Soil	Olive grey, friable, fine sand, many rock fragments, 10 cm. thick.
Sub-Soil	Olive grey, yellowish red mottles, friable, loam, many rock fragments, 20 cm. thick.
Substratum	May be (a) light grey medium to coarse sand materials with many rock fragments (b) poorly sorted alluvial materials from large boulders through to silt.

Other Properties	Slight to medium alkaline, low in organic matter, medium in nitrogen, high in phosphorus and potash.
Suitability	
Agriculture	Highly suitable for rice, wheat and sugarcane; poor to unsuitable for maize, millet and soybean.
Horticulture	Poorly suitable except for seasonal vegetables like onion, garlic, fenugrik, sometimes potato.
Pasture	Poor to moderately suitable. Grazing is common in winter season.
Forest	Poorly suitable.
Terracibility	Highly suitable.
Limitations	Imperfect drainage, susceptibility to seasonal flooding, many rock fragments on or near the soil surface and low-moisture holding capacity are the main restriction.
Erosion and Landslide Hapzards	Erosion hazard class of this soil unit is rated as moderate to high and sheet erosion as slight. This unit falls under non-sliding to slightly sliding territory.

9. Digra-Manakamana Soil (76.6 km^2), Di-Mn[1/]

The Digra-Manakamana soil unit occurs in the central part of the mapped area on moderately steep to steep mountain slopes. These soils are shallow to moderately deep, moderately well drained to well drained and are made up of materials derived mainly from schist and phyllite. Texture varies from silt loam to silty clay loam, altitude varies from 1250 to 1650 m.

Diagra Soils - Altitude	1650 m.; Exposure: Southwest
Surface Soil	Olive brown, very friable, silt loam, few rock fragments, 15-20 cm. thick.
Sub-Soil	Dark brown, friable, loam, few rock fragments, 15-20 cm. thick.
Substratum	May be hard rock *in situ*.

Manakamara Soils

These soils have been described under mapping unit Batase-Bhulbhule-Manakamana (Ba-Bh-Mn).

1/ Source: Division of Soil Science and Agricultural Chemistry, Khumaltar.

Other Properties	Very strongly acid, very high in organic matter and potash, high in nitrogen and low in phosphorus.
Suitability	
Agriculture	Highly suitable for maize and millet; moderately suitable for barley, wheat and potato; poorly suitable for paddy.
Horticulture	Moderately suitable. Plum, pear and citrus fruits are commonly grown in the area.
Pasture	Moderately suitable.
Forestry	Moderate to highly suitable.
Terracibility	Poorly suitable.
Limitations	Moderately steep to steep slope, risk of soil erosion; droughtiness in winter, requires irrigation for good crops; relatively short growing season very strong acidity; low in phosphorus; occasional hailstorms.
Erosion and Landslide Hazards	Erosion hazard of this unit ranges from high to very high classes and sheet erosion is rated high. This unit falls under moderately sliding territory.

10. Manakamana-Bhogteni Soil (189.0 km^2), Mn-Bo[1/]

The Manakamana-Bhogteni soil unit occurs in the central part of the mapped area on moderately steep to steep slopes. These soils are shallow to moderately deep well drained and are made up of materials derived mainly from schist and phyllite. Soil texture varies from silt loam to silty clay loam, altitude varies from 1150 to 1250 m.

Manakamana Soils:

These soils have been described under mapping unit Batase-Bhulbhule-Manakamana (Ba-Bh-Mn).

Bhogteni Soils - Altitude	1150 m.; Exposure: West.
Surface Soil	Greyish brown, friable, silt loam, few rock fragments, 20 cm. thick.
Sub-Soil	Greyish brown, firm, silt loam, few rock fragments, 25 cm. thick.
Substratum	May be hard rock of phyllite and schist in situ.
Other Properties	Very strongly to medium acid, high in

1/ Source: Division of Soil Science and Agricultural Chemistry, Khumaltar.

	organic matter and nitrogen, medium in phosphorus and very high in potash.
Suitability	
Agriculture	Moderate to highly suitable for maize, millet, mustard and potato; moderately suitable for paddy and wheat.
Horticulture	Moderately suitable for citrus fruits (lime, lemon and orange) and pear and plum.
Pasture	Moderately suitable.
Forestry	Moderately suitable.
Terracibility	Poor to moderately suitable.
Limitations	Droughtiness in dry season; moderately steep to steep slopes, risk of soil erosion; occasional hailstorms.
Erosion and Landslide Hazards	Erosion hazard class of this unit ranges from moderately high to high and sheet erosion is rated as moderate to high. This unit falls under slightly sliding to moderately sliding territories.

11. Rautepani-Amppipal Soil (66.2 km^2), Ra-Ap

The Rautepani-Amppipal soil unit occurs in the southwest part of the mapped area on moderately steep to steep slopes. These soils are moderately deep to deep, somewhat excessively drained and are made up of soil materials derived mainly from phyllite and schist. Soil texture varies from silt loam to clay loam, altitude varies from 650 to 1050 m.

Rautepani Soils - Altitude	630-1030 m.; Exposure: Variable.
Surface Soil	Dark brown, firm, loam/silt loam, few rock fragments, 10-15 cm. thick.
Sub-Soil	Yellowish red to dark greyish brown, firm, silt loam to clay loam, few to many rock fragments 50 cm. thick or more.
Substratum	May be hard rock of phyllite and schist *in situ*.
Other Properties	Medium acid, medium in organic matter and nitrogen, high in phosphorus and very high in potash.
Suitability	
Agriculture	Highly suitable for maize, millet, upland paddy and black gram; poorly suitable for lowland rice and sugarcane.
Horticulture	Moderate to highly suitable for fruit crops such as orange, lime, lemon, papaya, banana and pomegranate. Suitable vegetables include radish.

Pasture	Moderate to highly suitable for forage and fodder trees.
Forestry	Moderately suitable.
Amppipal Soils - Altitude	About 1000 m.; Exposure: Northwest.
Surface Soil	Very dark greyish brown, firm, loam, many rock fragments, 6 cm. thick.
Sub-Soil	Dark brown to strong brown, very friable, clay loam, many rock fragments, 45 cm. thick.
Substratum	Weathered schist *in situ*.
Other Properties	Very strongly to strongly acid, very high in organic matter and potash, high in nitrogen and medium in phosphorus.
Suitability	
Agriculture	Unsuitable for farming.
Horticulture	Poorly suitable.
Pasture	Moderately suitable for pasture.
Forestry	Highly suitable for forestry (about 90 percent of this unit is covered by forest.
Terracibility	Poorly suitable.
Limitations	Moderately steep to steep topography, susceptible to erosion, many rock fragments on or near the soil surface, droughtiness in dry season, occasional hailstorms and strong acidity are the main factors restricting its use.
Erosion and Landslide Hazards	Erosion hazard as well as sheet erosion class ranges from moderate to high. This unit falls under moderately sliding territory.

12. Rangrung-Aupa Soil (18.4 km^2), Rn-Au

The Rangrung-Aupa soil unit occurs in the northern part of the mapped area on rolling to moderately steep to steep slopes. These soils are moderately deep, well drained to somewhat excessively drained and are made up of materials derived from phyllite. Soil texture varies from loam to clay loam, altitude varies from 900 to 1980 m.

Rangrung Soils - Altitude	900 to 1860 m.; Exposure: Variable.
Surface Soil	Dark brown to dark reddish brown, friable, loam/silt loam, many rock fragments, 20 cm. thick.
Sub-Soil	Strong brown, friable to firm, loam to clay loam, many rock fragments, 75 cm. thick.

Substratum	May be hard rock of phyllite in situ.
Other Properties	Slightly alkaline, high in organic matter and phosphorus, medium in nitrogen and low in potash.
Suitability	
Agriculture	Unsuitable for farming.
Horticulture	Poorly suitable for orchard development.
Pasture	Poor to moderately suitable.
Forestry	Highly suitable for forest development. (This soil unit is mainly under forest.)
Aupa Soils	
Terracibility	Poor to unsuitable.
Limitations	Droughtiness in dry season, requires irrigation for good crops; rolling to moderately steep to steep slope, some risk of soil erosion; many rock fragments on or near soil surface; occasional hailstorms.
Altitude	1390 m.; Exposure: Northwest to North.
Surface Soil	Very dark greyish brown to dark yellowish brown, friable, gravelly silty loam, many rock fragments, 20 cm. thick.
Sub-Soil	Very dark greyish brown to dark brown, friable, loam/silt loam, many rock fragments, 35 cm. thick.
Substratum	May be brownish yellow, friable, loamy sand materials with many rock fragments.
Other Properties	Medium acid to slightly alkaline, medium in organic matter and potash and high in nitrogen and phosphorus.
Suitability	
Agriculture	Moderate to highly suitable for maize, upland paddy, millet, barley, mustard, soybean and sugarcane, major part of this unit is under unirrigated cereals.
Horticulture	Moderately suitable for fruits such as peach, plum, pear and walnut.
Pasture	Moderate to highly suitable for pasture and fodder trees plantation, but poorly suitable for grazing.
Forestry	Highly suitable for forestry. Major area of this unit is under forest trees mainly of Rhododendron arboreum.
Erosion and Landslide Hazards	Erosion hazard class of this unit is rated as high to very high and sheet erosion as high. This unit falls under moderately sliding to actively sliding territories.

13. Tasa-Aupa Soil (32.2 km^2), Ta-Au

The Tasa-Aupa soil unit occurs in the northern part of the mapped area on moderately steep to steep slopes. These soils are moderately deep to deep, moderately well drained to well drained and are made up of materials derived from phyllite. Soil texture is loam or silt loam with altitudinal variation from 1390-1980 m.

Tasa Soils - Altitude	1830-1920 m.; Exposure: Variable.
Surface Soil	Dark brown to dark greyish brown, friable loam, many rock fragments, 15 cm. thick.
Sub-Soil	Very dark greyish brown, friable, loam/silt loam, many rock fragments, 50 cm. thick.
Substratum	May be hard rock *in situ*.

Aupa Soils:

The description of Aupa soils are given under mapping unit Rangrung-Aupa (Ra-Au).

Suitability

Agriculture	Highly suitable for maize, millet, barley, wheat and potato; unsuitable for rice and sugarcane.
Horticulture	Moderate to highly suitable for fruits like peach, plum, pear, walnut, apricot, suitable vegetables include cole crops, radish, broad-leaved mustard.
Pasture	Moderately suitable for forage crop and fodder-trees; poorly suitable for grazing.
Forestry	Moderately suitable.
Terracibility	Unsuitable.
Limitations	Moderately steep to steep topography, risk of soil erosion; droughtiness in dry season, requires irrigation for good crops; many rock fragments on or near the soil surface; occasional hailstorms.
Erosion and Landslide Hazards	Erosion hazard as well as sheet erosion class is rated high. This unit falls under moderately sliding territory.

14. Tasa-Kabo Soil (90.0 km^2), Ta-Ka

The Tasa-Kabo soil unit occurs in northern part of the mapped area on moderately steep to steep slopes. These soils are shallow to moderately deep, well drained and are made up of materials derived mainly from

phyllite. Soil texture is loam or silt loam with altitudinal variation from 1830 to 1920 m.

Tasa Soils:

These soils have been described under mapping unit Tasa-Aupa (Ta-Au).

Kabo Soils - Altitude	1860 m.; Exposure: West.
Surface Soils	Dusk red, friable, silt loam, many rock fragments, 20 cm. thick.
Sub-Soil	Very dusk red, friable, silt loam, many rock fragments, 20 cm. thick.
Substratum	(a) May be poorly sorted alluvial colluvial materials (b) hard rock *in situ*.
Other Properties	Medium acid, very high in organic matter and potash and high in nitrogen and phosphorus.
Suitability	
Agriculture	Moderate to highly suitable for maize, millet, barley, wheat and potato; poorly suitable for rice and sugarcane.
Horticulture	Moderately suitable (important fruit crops include peach, plum, pear, marmelos, etc.)
Pasture	Moderately suitable.
Forestry	Highly suitable. Major area of this unit is under forest consisting mainly of *Rhododendron arboreum*, *Schima wallichii* and *Alnus nepalenis*.
Terracibility	Unsuitable to poorly suitable.
Limitations	Moderately steep to steep slope, susceptible to erosion; droughtiness in dry season; many rock fragments on or near the soil surface; occasional hailstorms.
Erosion and Landslide Hazards	Erosion hazard class of this unit is rated as high to very high and sheet erosion as high. This unit falls under moderately sliding to actively sliding territory.

15. Gyachok-Digra Soil (19.1 km^2), Gy-Di[1/]

The Gyachok-Digra soil unit occurs in the northern part of the mapped area on moderately steep to steep slopes. These soils are moderately deep, moderately well drained to well drained and are made up of soil

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1/ Division of Soil Science and Agricultural Chemistry, Khumaltar.

materials derived mainly from phyllite and schist. Soil texture varies from loam to silty clay loam and altitude varies from 1650 to 2250 m.

Gyachok Soils - Altitude	2250 m.; Exposure: East.
Surface Soil	Dark brown, massive, silt loam, few rock fragments, 20 cm. thick.
Sub-Soil	Dark yellowish brown, massive, silt clay loam, few rock fragments, 30 to 40 cm. thick.
Substratum	May be hard rock in situ.
Other Properties	Extremely to very strongly acid, very high in organic matter and potash, high in nitrogen and medium in phosphorus.

Digra Soils:

These soils have been described under mapping unit Digra-Manakama (Di-Mn).

Suitability

Agriculture	Moderate to highly suitable for barley and potato; moderately suitable for maize, millet, and wheat; poorly suitable for paddy.
Horticulture	Moderately suitable.
Pasture	Moderate to highly suitable for pasture and livestock farming.
Forestry	Moderately suitable.
Terracibility	Poor to unsuitable.
Limitations	Droughtiness in dry season; moderately steep to steep topography, risk of soil erosion; relatively short growing season; very strong to extreme acidity; occasional hailstorms.

16. Minor Soils

1. Kanelthok Soils (Km)

A moderately deep, moderately well drained soil developed on easy rolling to rolling fan, made up of materials derived from phyllite.

Altitude	570-690 m.; Exposure: Variable.
Surface Soil	Dark reddish brown to yellowish red, friable to firm, silty clay, many rock fragments, 10 cm. thick.
Sub-Soil	Weak red to dark red, friable to firm, gravelly clay to clay, few rock fragments 70 cm. thick.
Substratum	May be hard rock in situ.

Other Properties	Strongly to slight acid, medium in organic matter and phosphorus, and high in potash.
Suitability	
Agriculture	Moderate to highly suitable for maize, millet, barley, wheat and potato; unsuitable for rice and sugarcane.
Horticulture	Moderately suitable for walnut, peach, plum, pear and citrus species; highly suitable for vegetables like cole crops, radish, beans and colocasia.
Pasture	Moderately suitable for pasture development.
Forestry	Highly suitable for forest management.
Limitations	Strong acidity, droughtiness in dry season, many rock fragments on or near the soil surface.

2. Tinmana Soil (Ti)

A moderately deep, excessively drained soil developed on very steep slopes made up of soil materials derived mainly from quartzite.

Altitude	1080 m.; Exposure: Northwest.
Surface Soil	Dark brown, very friable, silt loam, few to many rock fragments, 10 cm. thick.
Sub-Soil	Strong brown to dark reddish brown, very friable, loam to silt loam, few rock fragments, 80 cm. thick.
Substratum	May be poorly sorted alluvial/colluvial materials from quartzite.
Other Properties	Strongly to medium acid, high in organic matter, nitrogen and phosphorus and very low in potash.
Suitability	
Agriculture	Poor to moderately suitable for farming.
Horticulture	Moderately suitable.
Pasture	Moderate to highly suitable for fodder trees and forage crops but poorly suitable for grazing due to very steep slopes. At present few species of fodder trees such as Bauhinia longifolia, Artocarpus lakoocha and Litsea citrata are existing.
Forestry	Moderate to highly suitable for reforestation.
Limitation	Very steep topography, susceptible to erosion; droughtiness in dry season,

many rock fragments on or near the soil surface, medium to strong acidity and low fertility especially of potash are the main limiting factors.

3. Gorakhakali Soil (Go)

A deep, well drained soil developed on moderately steep slopes made up of soil materials derived from phyllite and schist.

Altitude	1500 m.; Exposure: Northwest.
Surface Soil	Dark brown, friable, loam, many rock fragments, 15 cm. thick.
Sub-Soil	Dark brown, friable, loam, many rock fragments, 80 cm. thick.
Substratum	May be hard rock of phyllite *in situ*.
Other Properties	Medium to neutral acid, medium in organic matter and nitrogen, high to very high in phosphorus and low in potash.
Suitability	
Agriculture	Highly suitable for maize, millet and mustard; moderately suitable for wheat, barley and buckwheat, poorly suitable for rice and sugarcane.
Horticulture	Moderately suitable for fruit plants such as peach, plum, pear, lime and lemon. Suitable vegetables like cabbage, cauliflower, radish and broad-leaved mustard are grown in these soils.
Pasture	Moderately suitable for range managements.
Forestry	Moderate to highly suitable for forest. Some existing forest species are *Quercus incana*, *Castanopsis indica*, *Rhododendron spp*, *Lyonia ovalifolia*.
Limitations	Moderately steep topography, susceptible to erosion, many rock fragments on or near the soil surface, deficiency of phosphorus are the main factors affecting use in farming.

4. Belawara Soil (Be)

A moderately deep, well drained soil developed on moderately steep slopes made up of soil materials derived from micaceous and non-micaceous schist.

Altitude	630 m.; Exposure: South.
Surface Soil	Dark brown, friable, loam, few to many rock fragments, 10 cm. thick.

Sub-Soil	Dark brown to strong brown, friable loam to silty clay loam, few to many rock fragments, 60 cm. thick.
Substratum	May be rock in situ.
Other Properties	Strongly acid, high in organic matter and potash and medium in nitrogen and phosphorus.
Suitability	
Agriculture	Poorly suitable for agriculture development.
Horticulture	Poor to moderately suitable.
Pasture	Poor to moderately suitable for forage crops. Grazing in the forest is very common
Forestry	Highly suitable. Nearly 80 percent of this unit is under forest.
Limitations	Strong acidity, steep topography, susceptible to erosion, many rock fragments on or near the soil surface.

5. Kipat Soil (Ki)[1/]

A deep, moderately well drained soil developed on moderately steep slopes made up of soil materials derived mainly from phyllite and schist.

Altitude	1350 m.; Exposure: South.
Surface Soil	Dark reddish brown, friable, silt loam, few rock fragments, 10-15 cm. thick.
Sub-Soil	Reddish brown to dark reddish brown, firm, silty clay loam, few rock fragments, 25 to 35 cm. thick.
Substratum	Red to dark red weathered and semi-weathered phyllite.
Other Properties	Very strongly acid, high in organic matter, medium in nitrogen and very high in phosphorus and potash.
Suitability	
Agriculture	Highly suitable for maize, millet, buckwheat and mustard; moderately suitable for paddy and wheat.
Horticulture	Moderately suitable for citrus fruits, pear, plum and banana.

1/ Source: Division of Soil Science and Agricultural Chemistry, Khumaltar.

Pasture	Moderately suitable.
Forestry	Moderately suitable.
Limitations	Droughtiness in dry season, moderately steep slope, risk of soil erosion; occasional hailstorm; high acidity.

III. GEOLOGY, EROSION AND TERRACEABILITY

GEOLOGY

1. Stratigraphy

The project area is composed of different metamorphosed sedimentary rocks of the Daram, Khahare, and Hilang suites of the Proterozoic group and the Himal and Okharbot suites of the Palaeozoic group. All the suites have an East-West trend (Sheet No. II, 6b).

The area covered by different geological units, the percentage of the total area of the watershed covered by the units, and their occurrence in different panchayats is presented in Table No. 12.

Proterozoic Group

The proterozoic group is represented by the Daram, Khahare and Hilang suites of middle Proterozoic sub-group.

Middle Proterozoic Sub-group

Daram Suite (PR_2dr): The Daram suite is exposed in the central part of the catchment in Pandrung, Taku, Jaubari and Shrinkathkot Panchayats. It has a fault contact with the rocks of Paleozoic group in the south and a normal contact with the rocks of the Khahare suite.

The suite is represented by quartzites, calcareous quartizites, phyllites and biotite quartz schists. They are generally brown to greyish brown, rarely white to yellowish white in color. These strong to moderately consolidated, moderately fractured and slightly weathered rocks have a minimum thickness of 1200 meters.

Khahare Suite (PR_2kh): The Khahare suite lies on the rocks of the Daram suite, covering it from the north. The suite has normal contact with the rocks of the Hilang suite, which lie on top of it.

These are white to greyish white quartzites, brown to dark brown, rarely pinkish schists and sandstones. They are moderately consolidated and fine to moderately fractured.

The suite is around 6000 meters thick and is located in a number of panchayats lying between Jaubari and Taku in the south and Barpak and Simjung in the north.

Table No. 1a. Areas and percentages of different geological units of Daraundi Watershed

Geological Units	Area sq. km.	Percentages	Panchayats
1. Daram suite (PR_2Dr)	19.5	2.46	
2. Khahare suite (PR_2Kh)	170.8	21.48	
3. Hilang suite (PR_2Hl)	48.6	6.11	
4. Okharbot suite (C_2Ok)	474.8	59.72	
5. Himal suite (C+O Hm)	81.3	10.23	
TOTAL	795.0	1100.00	

Hilang Suite (PR_2Hl): This suite lies on the rocks of the Kahare suite and is located on the northern side of Barpak and Simjung Panchayats.

The suite is composed of light to dark brown phyllites, schists, phyllitic limestones and dolomites. The Dolomite is white to yellowish white.

All the rocks of the suite are weak to moderately consolidated and highly weathered. Surface and underground forms of karst are highly developed in limestones and dolomites. The thickness of the suite is unknown.

Paleozoic Group

The Paleozoic group in the area is represented by Cambrian and combined Cambro-Ordovician systems.

Cambrian System

The Okharbot suite represents the Cambrian system in the catchment area.

Okharbot Suite (C_2Ok): These are brown to reddish brown, pinkish phyllites, schists and quartzites, moderately consolidated, fine to moderately fractured. This suite is located in the entire central and the southern part of the territory. (It is named as a kunchha formation by J. Stocklin and K. D. Bhattarai, 1977.)

This suite has a fault contact in the north with the rocks of the Daram suite, Proterozoic group. Its thickness has not been measured or estimated.

Indifferential Cambro-Ordovician System

Himal Suite (C+O hm): Grey granitized schists and quartzites with bands of limestones represent this suite. These rocks are high to moderately consolidated and slightly fractured.

This suite is located in the far north of the project area. No estimation of its thickness has been made.

2. Structure

The geological structure of the area is dominated by a large anticline, the Gorkha anticline. The axis of the anticline strikes E 45°. Numerous dip measurements indicate that both of the flanks of the anticline have an inclination of about 25° with local variations between 20° and 35°. The southern flank is very gentle whereas the northern one is generally steeper with some variation in inclination. The influence of this anticline is cut off by a mega fault (uplift) - The Taku fault, lying 4 km. north of the mega fold. The gentle overall anticlinal and synclinal structures of the area are complicated by numerous sublongitudinal faults. Displacement along these faults have generally only a vertical component. These macro faults are almost parellel to the mega fault.

The Taku megafault has both vertical and horizontal components. Its horizontal component is small in comparison to the vertical component, which is likely to have an uplift of some thousand meters. The characteristics of this megafault have not yet been studied.

The folding of the territory and the formation of the faults occurred almost at the same time, following the Okharbot time. However, the Taku mega fault already existed at the end of the Daram time.

3. Geological History

The geological history of the project area can be traced from the Middle Proterozoic period.

In the Daram time of the middle Proterozoic period, the entire area was under water. The Proterozoic basin was not deep in the present catchment area, and hence, fine to medium sized quartz with silt material was deposited. All these medium to coarse materials were brought from the south and the north, from the Chinese and the Indian plateaus. The Proterozoic basin was a quiet basin with no volcanoes.

At the end of the Daram time, the Taku mega fault was formed and its northern flank was uplifted with a gentle inclination to the north. The entire basin was separated into two basins--one of them covered the southern part (the southern and the central part of the present catchment). The other basin was shifted to the north.

In the Khahare time of the same period, the Proterozoic basin was covering a little less of the project area than in the Daram time. But the basin was as shallow as before and the sediments were similar. As

the uplifting of the northern flank of the Taku mega fault was proceeding, the basin was shifted to the lower side. During the Khahare time the beach was shifted about 13 km. to the north.

The basin was receding further in the Hiland time. It was warmer than before, and hence organic and chemical carbonate as well as silt material was settled at the bottom of the basin.

In the Cambrian and the Ordovician periods, the condition of sedimentation was similar to that of the Hilang time, though the basin was receding in dimension.

At last, in the Ordovician period, the water pool disappeared from the territory.

The history of the central and the southern part of the area is unknown from the end of the Daram time to the beginning of the Okharbot time of the Cambrian period.

In the Okharbot time of the Cambrian period, the southern flank of the mega fault was under water. It was a moderately shallow basin, where sedimentation of silt material took place. At the same time the southern flank of the mega fault started folding and a large anticline was formed in Khanchok-Shrinathkot area. At the end of the Okharbot time, the basin left the territory and shifted to the south of the southern boundary of the project area.

In the Cambrian period the area was folded many times (the exact time of folding can not be estimated) and is being denuded up to the present time.

The Daraundi River came after the formation of the snow-covered mountains, the high Hymalayas, in the Cenozoic era. In the primary stage it was fed by the ice cap, which covered the tops of the Himalayas and melted under the high radiation of the sun.

The territory was highly influenced by the foldings of the Himalayas, which occurred in the Tertiary period.

In the beginning, the Daraundi River was very insignificant because all its tributaries were fed by the melting of snow, and as the mountains were not then so high, they had a seasonal snow cover and limited snow. At that time the river followed a narrow, zig-zag path. As the mountains rose further, the accumulation of snow increased on the one hand and on the other the mountains started blocking the monsoon clouds, drifting to the north from the Bay of Bengal.

Later, the monsoon rains started in the territory, as a result of which many seasonal rivers started to flow as tributaries to the Daraundi River. Thus, its discharge increased. With the increment of its discharge, this river together with its tributaries started eroding the banks (with high erodibility) and its present shape was formed.

4. Geomorphology

The geomorphology of the watershed is mostly governed by the high rate of precipitation in the monsoon and the soft silt cemented rocks composing the territory.

The catchment is composed of the following geomorphological units:

I. Alluvial horizontal or slightly inclined terraces:

These terraces are located in Tarangar, Palungtar and Chhoprak Panchayats, although small alluvial terraces are also found in Ghairung, Gaikhur, Deurali and in other panchayats adjacent to the Daraundi River. This unit is characterized by a high rate of bank erosion, although the surface erosion in the area is more or less checked by the slopes. Rill and gulley erosion is common for this unit. The terraces are generally covered by medium textured soil.

The total area of this unit in the Daraundi catchment is about 35.0 sq. km. which is approximately 4.40 percent of the watershed.

II. Eluvial and colluvial rolling to moderately steep fans at the foot slopes:

These fans are inclined to the alluvial terraces and the Daraundi River. This unit is characterized by high to moderate sheet erosion. Rills and gulleys are highly developed in the unit, depending upon the relative relief. These fans, generally cultivated, are located in all the panchayats of the catchment.

This unit is composed of colluvial, proluvial and eluvial soils. These soils are generally medium textured, although heavy and light-textured soils are not uncommon. The unit has a thick to moderately thick soil cover.

III. Eluvial, colluvial and proluvial horizontal or slightly inclined intermediate terraces:

This unit is located in Barpak, Simjung, Gorkhakali, Palungtar, Harmi, and other panchayats.

These terraces are moderate to highly eroded and small to medium

landslides are common. This is because the soils lie over steep to very steep slopes. Rill and gulley erosion is very common in this unit. Aolian process is one of the factors of sheet erosion in the dry season.

These terraces are either cultivated or are under growth.

The unit is characterized by deep to moderately deep soil cover.

IV. Eluvial steep to very steep slopes:

About 50 percent of the total area of the catchment is covered by this unit, and this unit is located in all panchayats.

The unit lies between units 2 and 3 and units 3 and 5. In some places, active landslides are occurring. Erosion in these slopes is very high, although most of the slopes are under dense, natural forest. These forests are the main source of firewood for the area. However, further cutting of trees and bushes will greatly undermine the suitability of the slopes. Soil depth is very shallow in these slopes. Rocky out-crops, as well as stone falls, are common in this unit.

V. Eluvial high plateaus:

These plateaus are very rare in the area. They are located in Barpak and Simjung panchayats. Accumulation of snow in winter is common on the plateaus. The main agents of erosion of this unit are water, wind and temperature.

VI. Snow covered mountains:

These mountains are located in the far north of the watershed. Eluvial, glacial, glacio-fluvial and aolian processes are the main agents of erosion.

Sliding of slopes can occur, only because of the weight of the accumulated snow, which sometimes becomes unbearable for the rocks that compose the mountains.

EROSION

Erosion is one of the major problems of the Daraundi catchment. The "curse" of the area is the Daraundi River and its tributaries. Erosion is further triggered by lithology and heavy precipitation which causes floods and increases the erodibility of the rivers during the monsoons.

Lithology: The lithology of the area is represented by rocks of different formations and suites, which are mainly composed of phyllites, schisty phyllites, phyllitic limestones, gritstones, and sandstones. These rocks have different physical characteristic. and their erodibility depends upon many factors, e.g., con-olidation and fracture, water balance and topography.

Phyllite is the main lithological component of the project area. Small scale landslides are very common in these rocks. Being soft, these rocks are highly erodible. Rill and gully erosion of the soil developed from this rock are very common. When the soil dampens, its erodibility increases very fast and in many cases it falls down under the action of gravity and is washed away by streams.

A number of large landslides have occurred in phyllites, especially in Harmi, Chhoprak, Shrinathkot and Barpak Panchayats. The process of karst formation is highly developed in phyllitic limestones and limestones.

Erodibility of all the rocks found in the area is highly increased by the phyllites, which occurs in layers with all the other rocks. Lithologically, the main agent of erosion is weathered phyllitic material, which itself is highly erodible and weakens the other rocks in the territory.

Soil Erosion: Soil erosion is classified as rill and gully erosion, bank and bottom erosion and sheet erosion. All these types of erosion are highly developed in the project area.

Rill and Gully Erosion: Rills and gullies are common in all panchayats of the project area. They are generally connected with the high rate of precipitation occurring in the watershed during the monsoon and the soft silt-cemented rocks which compose the territory. Rills and gullies connected with the melting of snow are found only at the northern end of the catchment area.

Bank and Bottom Erosion: These types of erosion are connected with the river system of the watershed. The Daraundi Khola, the biggest river of the area, has a number of tributaries. Some of the tributaries have perennial flow, although many of them are seasonal. The main rivers feeding the Daraundi khola are: Bhusundi, Ludi, Sirdi, Chhutki, and Ramrung. Although these rivers have perennial flow, the discharge is negligible in dry periods. Among the seasonal rivers the Pahiro khola and Khahare khola are notable. In the vicinity of these seasonal rivers, a number of active landslides occur. Since the Daraundi River flows across the general trend of the rocks, its bed is quite wide, which shows that bank erosion was very high in the past.

Sheet Erosion: A map of sheet erosion has been made (on the same basis as the erosion map of the Kulekhani catchment), which divided the territory in three classes. This map is presented by Sheet No. IIIa, 12b. Table No. 1 shows the erosion condition of the different soil units of the watershed.

Table 1 - Erosion Condition Soils

Units	Area sq. km.	Percentage of the Total Area
1. Highly erodible	551.6	69.39
2. Moderately erodible	196.3	24,69
3. Slightly erodible	41.2	5.18
4. Snow Covered	5.9	0.74

5.9 (0.74%) sq. km., which is covered by perpetual snow, is not taken into account.

Erosion hazard classes: Using sheet erosion, bank erosion, and landslide erosion classes as parameters, the erosion hazard of the project area is classified as very high, high, moderate and slight. Table No. 2 shows classification.

Table 2 - Erosion Hazard Classification

Landslides	Sheet Erosion	Bank Erosion	Erosion Hazard Classes
1. Active			Very high
2. Moderate	I	I	High
3. Slight	II	II	Moderate
4. Non-sliding	III	III	Slight

On the basis of Table No. 2, a map of erosion hazard classes was prepared, which divides the whole watershed area into the following seven groups (see Sheet No. IIIb, 13b).

I. Very high erosion hazard: These areas are located in active sliding territories. About 75 sq. km. (9.4%) area of the catchment is included in this class.

II. Very high to high erosion hazard: Landslides are very common in these areas, sheet erosion as well as rill and gully erosion is high, and bank erosion is high enough to cause landslides in the near future. About 19 sq. km. (2.40%) of the catchment is included in this class.

III. High erosion hazard: These areas are characterized by high bank and sheet erosion as well as high rill and gully erosion. Active landslides are rare and are of small masses. Approximately 493.5 sq. km. (62.09%) of the catchment is included in this class.

IV. Moderate to high erosion hazard: This is an intermediate class, where some types of erosion are high and others are moderate. Around 114.0 sq. km. (14.30%) of the watershed is included in this class.

V. Moderate erosion hazard: These areas are characterized by moderate sheet erosion and moderate rill and gully erosion. They are located in slightly sliding territories. About 65 sq. km. (8.21%) of the catchment is included in this class.

VI. Slight to moderate erosion: This is an intermediate class, between slightly eroded and moderately eroded areas. About 17.5 sq. km. (2.19%) of the catchment area is covered by this class.

VII. Slight erosion hazard: These areas are located in non-sliding territories and are characterized by slight sheet erosion, slight rill and gully erosion as well as slight bank erosion. About 11.0 sq. km. (1.39%) of the watershed is covered by this class.

Table No. 3 shows the erosion hazard classes encountered in the Daraundi watershed.

Table 3 - Erosion Hazard Classes in Daraundi Watershed

Soil Units	Erosion hazard classes %						
	Very high	High to very high	High	Moderate to high	Moderate	Slight to moderate	Slight
Ab	10	-	30	30	10	20	-
Am	-	-	-	-	50	30	20
Ba-Bh	-	10	60	15	15	-	-
Ba-Bh-Mn	-	-	75	15	-	10	0
Ch	-	-	75	15	10	-	-
Ch	-	-	60	-	5	10	25
Ch-Bh	-	-	65	10	25	-	-
Da	-	-	10	90	0	-	-
Di-Mn	40	10	45	5	-	-	-
Mn-Bo	-	5	60	15	20	-	-
Ra-Ap	15	-	20	50	15	-	-
Rn-Au	30	10	60	-	-	-	-
Ta-Au	-	5	95	-	-	-	-
Ta-Ka	20	5	75	-	-	-	-
Gy-Di	30	5	65	-	-	-	-

N.B. Percentages of the units are given approximately.

Table 4 - Landslides and sheet erosion 1/

Soil Unit	Landslide classes					Sheet erosion classes			
	AS	MS	SS	NS	Mean Value	H	M	S	Mean Value
Ab	10	25	45	20	SS-MS	50	40	10	M-H
Am	-	-	-	100	NS	-	70	30	S-M
Ba-Bh	-	75	25	-	SS-MS	75	25	-	M-H
Ba-Bh-Mn	-	65	30	5	SS-MS	70	30	-	M-H
Ch.l	-	20	25	55	NS-SS	35	15	50	M
Ch.r	-	60	25	15	SS-MS	60	25	15	M-H
Ch-Bh	-	55	30	15	SS-MS	60	40	-	M-H
Da	-	-	25	75	NS-SS	-	-	100	S
Di-Mn	35	40	25	-	MS	80	20	-	H
Mn-Bo	5	70	25	-	SS-MS	65	35	-	M-H
Ra-Ap	20	25	45	10	MS	55	40	5	M-H
Rn-Au	35	65	-	-	MS-AS	100	-	-	H
Ta-Au	-	100	-	-	MS	100	-	-	H
Ta-Ka	25	75	-	-	MS-AS	100	-	-	H
Gy-Di	25	75	-	-	MS-AS	100	-	-	H

NS - Non-sliding
SS - Slightly sliding
MS - Moderately sliding
AS - Active sliding

H - Highly eroded
M - Moderately eroded
S - Slightly eroded

1/ The figures indicate the approximate percentages of the units.

Landslides: Small scale landslides are fairly common in the area and are found almost everywhere within the catchment. A map of landslides is prepared on the basis of slope analysis and mass movements, holding tectonical and geological factors constant for the catchment.

On the basis of the above, the watershed area is divided into the following four classes (see Sheet No. IV, 10b).

I. Active sliding territory: In this territory active landslides with volume of about 1,0000 cu. m. or more are found. These are very steep slopes with inclinations varying from 56 to 80 percent and above. These areas need immediate attention and protection.

II. Moderately sliding territory: Small scale landslides are very common in the project area. These areas lie on steep slopes with inclinations above 56 percent but below 80 percent.

III. Slightly sliding territory: Small scale landslides, though not so common, are found on moderately steep slopes with inclinations varying between 36 and 56 percent. The landslides of the area are generally harmless. Very often they are not natural but accelerated due to some external activity.

IV. Non-sliding territory: No mass movement is found in these areas. They are on slanting slopes with inclinations below 36 percent.

Table No. 4 shows the landslides and sheet erosion conditions of the watershed.

TERRACIBILITY

To prepare a terrace suitability map (Sheet No. V, 14b), the main criteria used were slope, altitude, land use, landslide and characteristics of soil units, especially soil depth. Terracibility is classified as high, moderate, poor and unsuitable. Table 5 shows the classification of terrace suitability.

Table 5 - Terrace Suitability Classification

Landslide	Slope	Terrace Suitability	
		Cultivated Land	Forest and Pasture
Active Sliding		Unsuitable	
Moderately Sliding	Above 39°	Poorly Suitable	Unsuitable
Slightly Sliding	16°-36°	Moderately Suitable	Poorly Suitable
Non-Sliding	Below 16°	Highly Suitable	Moderately Suitable

This classification was checked by soil depth as shown below:

Deep	100 cm	High suitable
Moderately Deep	50-100 cm	Moderately suitable
Shallow	50 cm	Poorly suitable

I. Highly Suitable: Approximately 38.84 sq. kms. (4.88%) of the Daraundi catchment is included in this class, Am and Di soil units are considered highly suitable for terrace making.

II. Moderately Suitable: This class includes about 181.57 kms. of Daraundi catchment. Chhepetar level phase is moderately suitable for terracing. The soil units which fall between poorly and moderately suitable classes for terrace making are Ab, Ch-Bh, Di-Mn and Mn-Bo.

III. Poorly Suited: In this class covers about 293.14 sq. kms. (36.87%) of the Daraundi watershed. The Ra-Ap soil unit is poorly suitable for terracing. The units which fall between unsuitable to poorly suited are Ba-Bh, Ba-Bh-Mn, Ch.r., Rn-Au, Ta-Ka and Gy-Di.

IV. Unsuitable: About 275.69 kms (34.68%) of the Daraundi watershed falls in this class. Ta-Au is considered to be unsuitable for terrace making.

Conclusions and Recommendations

Conclusion: The areas studied are highly active due to many factors acting together to accelerate landslides and other major and minor types of erosion. The most important of these factors is that the land lies in silt-cemented mountains and dales, with rain and numerous small streams that accelerate erosion.

Recommendations: Suitable land for terrace making is very low in the catchment area. On the basis of the physical factors discussed above, the following points are noted and recommended:

a. There are some villages in Chhoprak Panchayat such as Chilaune village, which are highly susceptible to active landslides occuring along the river Khahare (here the people of the area are in danger). Some precautions should be taken either to protect the village from sliding or to shift the inhabitants of the area to another safe place.

b. Some active landslides which are effecting cultivated lands are found in the Darimchaur area of Harmi Panchayat. In the near future these slides can reach the villages lying just above the present sliding territory.

c. Some trails in Harmi, Chhoprak, Amppipal and Palungtar Panchayat have suffered from landslides. They need some protection from the slides in the rainy season (these territories are actively sliding only in the rainy season).

d. The cultivated areas adjacent to the Ramrung and Daraundi Rivers in Barpak Panchayat are suffering from landslides. To some extent this can be controlled by increasing tree plantation in that area.

e. Rill and gully erosion in this area is related to the soils developed from soft cemented rocks, like schists and phyllites, and to the high rate of precipitation in the monsoon. This type of erosion is quite widespread in the area. It can be controlled with the aid of gabion rock structures, revegetation and other related practices.

f. Sheet erosion is very high in the catchment area. It is a very slow process emphasized on slopes by:

   i. Overgrazing of forests and pasture lands.
   ii. Cutting of bushes and vines for stall feeding of livestock.
   iii. Cutting of trees for fuel and timber.
   iv. Burning of forests and jungles.

   These processes should be controlled and conservation reserves be set up in the catchment as examples of proper land management.

g. Daraundi khola and its tributaries commonly flood during the monsoon and cause damage to adjacent cultivated areas. These areas could be protected by river embankments.

h. The areas identified as highly suitable for terrace making should be properly managed. Moderately suitable areas require better management practice from a conservation point of view.

IV. USES AND MANAGEMENT OF THE SOILS

Soil suitabilities for various uses have been determined, based on data presented in Section II and additional information collected during the soil survey:

Agriculture

Amppipal and Rangrung soils are unsuitable for farming. Belswara is poorly suitable and Tinmana falls into a poor to moderately suitable class so far as arable farming is concerned. Suitabilities for various crops have been determined and are described as follows:

Rice: Chheptar level phase and Rautepani soils are highly suitable for upland paddy cultivation. Batase and Aupa soils fall into a moderate to highly suitable class. Ambote, Amchaur and Daraundi soils are highly suitable for lowland paddy. Harmi soils are moderately suitable. The soil units identified as poorly suited for rice are Bhulbhule, Belswara and

and Gorkhakali. Panara, Kabo, Tasa and Kanelthok soils are considered to be unsuitable for rice production.

Maize and Millet: Highly suitable soil units for maize and millet cultivation are Mankamana, Chhepetar (level phase), Digra and Rautepani. Rautepani, Tasa, Batase, Chhepetar (rolling phase), Bhogteni, Aupa, Kabo, Gorkhakali and Kanelthok, soil units are included in a moderate to highly suitable class. Gyachok and Panara soils are moderately suitable for maize and millet growing. Belswara, Bhulbhule and Daraundi soils are poorly suited for these crops.

Wheat: Soil units identified as highly suitable for wheat cultivation are Tasa, Daraundi and Panara. Kabo, Harmi and Kanelthok fall in a moderate to highly suitable class for wheat. Ambote, Ampchaur, Gorkhakali, Manakamana, Digra, Bhogteni and Gyachok soils are moderately suitable, while Batase, Bhulbhule and Belswara are rated as poorly suited for wheat cultivation.

Barley: Tasa and Panara soil units are highly suitable for barley. Kabo, Gyachok and Kanelthok are moderate to highly suitable, and Digra and Gorkhakali soils fall under a moderately suitable category. Soils identified as poorly suited for barley are Batase, Belswara, Bhulbhule and Digra.

Potato: Tasa and Panara soils are highly suitable for potato cultivation. Moderate to highly suitable soils for growing potato are Kabo, Gyachok, Manakamana and Bhogteni. Digra soils are moderately suitable. Ambote and Aupa soils are rated as poor to moderately suitable, while Belswara, Bhogteni and Harmi falls into a poorly suited class.

Mustard: Highly suitable soil units for this oilseed are Manakamana and Chhepetar (level phase). Chhepetar (rolling phase) Gorkhakali, Bhogteni, Aupa and Harmi soils are moderate to highly suitable for mustard growing. Ambote, Amppipal and Panara soils are categorized as moderately suitable and Belswara and Bhogteni are poorly suited.

Sugarcane: Highly suitable soils for growing sugarcane are Daraundi and Chhepetar (level phase). Aupa soils are moderate to highly suitable. Moderately suitable soil units are Ambote and Amppipal. The soils identified as poorly suited for sugarcane

growing are Batase, Bhulbhule, Belswara, Gorkhakali and Harmi. Tasa, Kabo and Panara and considered unsuitable for this crop.

Buckwheat — Buckwheat is grown to a limited extent in the Daraundi catchment area. Manakamana soils are highly suitable for this crop. Gorkhakali and Belswara fall under moderate and poorly suited classes, respectively.

Soil Fertility status and Fertilizer recommendation

Soil Reaction (pH)

In general the soils of the Daraundi catchment area are acidic in reaction. The soils of Gy are extremely acid (pH below 4.3). Very strongly acid soils are Ap, Bo and Di. The soils which are strongly acid in reaction are Am, Bh, Be, Che, Chr, Ka and Ti. The medium acid soils are Au, Ba, Go, Ha, Mn, Pa, Ph, Ra and Ti. The soils which are slightly acid in reaction are Ab, Ba, Chr, Ha, Ka, Mn, Pa, Ra and Ta. The neutral soils are Am, Go and Ph.

A slightly alkaline soil unit is Au. A slight to medium alkaline soil is Da.

Organic Matter: In general, the soils of the Daraundi Catchment area are medium to high in organic matter. Ch. 1, Da and Ph soil units are included in a low organic matter category. The soils units containing medium amounts of organic matter are Ab, Am, Au, Ba, Bh, Go, Kn, Ra and Ta. Be, Bo, Ch. 1, Mn, Ra, Ran and Ti contain high amounts of organic matter. Only four soil units (Ap, Di, Gy and Ko) are very high in organic matter.

Nitrogen: The Daraundi catchment area is medium to high in nitrogen content. The soil units considered to be medium in nitrogen are Ab, Am, Ba, Be, Ch. 1, Ch. r, Da, Go, Ha, Pa, Ph and Ra. The high nitrogen content soils are Au, Bh, Bo, Di, Gy, Mn, Kn, Ta and Ti.

Phosphorus: The soils of the Daraundi catchment area are medium to high in phosphorus content. The soil units having medium phosphorus content are Ab, Ap, Bh, Bo, Gy, Kn and Ph. Other such as Am, Ba, Ch.1, Ch.r, Da, Ko, Mn, Pa, Ra, Rn, and Ta are high in this nutrient.

Potash: Most of the soils of the Daraundi catchment area are high to very in potassium content. These soils are Ab, Be, Bh, Ch.1, Ch.r, Da, Kn, Ap, Ba, Bo, Di, Gy and Ko. Au, Ha, Pa and Ti soil units are medium in potash. The soils which are low to very low in potassium content are Ph, Ti, Am, Go and Rn.

The fertility status of various soil units is given in Table 1. The fertilizer recommendation for various crops have been calculated (Joshy and Deo, 1976) and is presented in Table 7.

Table 6 - Fertility status rating of various soil units of Daraundi Catchment Area

	Soil Unit	Organic Matter	Nitrogen	Phosphorus	Potash
1.	Ambote (Ab)	Medium	Medium	Medium	High
2.	Amchaur (Am)	Medium	Medium	High	Low
3.	Ampipal (Ap)	Very high	High	Medium	Very high
4.	Aupa (Au)	Medium	High	High	Medium
5.	Batase (Ba)	Medium	Medium	High	Very high
6.	Belswara (Be)	Medium	Medium	Medium	High
7.	Bhulbhule (Bh)	Medium	High	Medium	High
8.	Bhogteni (Bo)	High	High	Medium	Very high
9.	Chhepetar level (Ch.l)	High	Medium	High	High
10.	Chhepetar rolling (Ch.r)	Low	Medium	High	High
11.	Daraundi (Da)	Low	Medium	High	High
12.	Digra (Di)	Very high	High	Low	Low
13.	Gorkhakali (Go)	Medium	Medium	Medium	Low
14.	Gyachok (Gy)	Very high	High	Medium	Very high
15.	Harmi (Ha)	Medium	Medium	High	Medium
16.	Kabo (Ka)	Very high	High	High	Very high
17.	Kanelthok (Kn)	Medium	High	Medium	High
18.	Manakamana (Mn)	High	High	High	Very high
19.	Panara (Pa)	High	Medium	High	Medium
20.	Phalade (Ph)	Low	Medium	Medium	Very low
21.	Rangrung (Rn)	High	High	High	Low
22.	Rautepani (Ra)	Medium	Medium	High	Very high
23.	Tasa (Ta)	Medium	High	High	Medium
24.	Tinmana (Ti)	High	High	High	Very low

Table 7 - Fertilizer recommendation for various crops in Daraundi Catchment Area (Kg/Ha)

	Crops		Organic Manure 2/	N 1/	P_2O_5 1/	K_2O 1/
1.	Rice	Improved	6,000	75	30	20
		Local	6,000	30	20	15
2.	Maize	Improved	6,000	55	30	20
		Local	6,000	30	20	10
3.	Millet		4,000	30	20	20
4.	Mustard		6,000	30	20	20
5.	Wheat	Improved	6,000	75	40	20
		Local	6,000	45	35	15
6.	Potato	Improved	10,000	60	40	40
		Local	10,000	40	20	30
7.	Buckwheat		4,000	30	20	20
8.	Barley	Improved	6,000	64	40	20
		Local	4,000	30	15	15
9.	Naked Barley		4,000	30	15	15
10.	Sugarcane		10,000	90	40	35

1/ Joshy and Deo (1976).

2/ Karki (1975).

If the fertility status of the soil with respect to a certain nutrient is high, only 1/4 of the recommended dose is to be applied. If the nutrient rating is medium, half of the recommended dose should be applied. In case of low nutrient status, the full recommended dose should be added.

Horticulture

The altitude of the Daraundi catchment varies from 500 to 5000 m. or above, resulting in subtropical to arctic climates. Therefore, these regions should be able to grow almost all the fruits found in Nepal. The main fruits grown in the area are lemon, lime, orange, mango, litchi, jackfruits, papaya, banana, pineapple, pomogranate, pear and plum. Apple growing has been recently introduced in the northern part of the catchment area. Radish, cole crops, legumes (mainly soybean, black gram), yam, colocasia and some other common summer and winter vegetables are generally grown. Suitabilities for horticultural crops have been worked out and are presented in the following categories.

Highly suitable: The Batase and Chhepetar soil units are highly suitable for growing horticultural crops and vegetables. The suitable fruit crops include lime, lemon, orange, mango, banana, pineapple and jackfruits. Among vegetables, radish, yams, colocasia and leafy vegetables are grown in these units.

Moderate to highly suitable: Rautepani, Digra and Bhogteni are identified as moderate to highly suitable units for orchard development. In Digra and Bhogteni, the suitable fruits grown are lime, lemon, orange, pear and plum. In Rautepani, which is situated at a lower elevation, pomogranate, guava, papaya and banana are grown as well as citrus fruits.

Moderately suitable: The Manakamana series is moderately suitable for growing fruits such as citrus, pear, plum and banana.

Poor to moderately suitable: In this category are included the Ambote and Bhulbhule soil units. Suitable fruits grown in these soil units are mango, litchi, papaya and pomogranate.

Poorly suited: The soil units identified as poorly suited for horticulture development are Ampchaur, Amppipal and Rangrung.

Pasture

Moderate to highly suitable units for pasture development are Chhepetar (rolling phase) and Rautepani. Forage and fodder crops could be grown in these areas. Amppipal, Manakamana, Digra and Bhogteni are rated as moderately suitable for pasture. Poor to moderately suitable soil units include

Ampchaur, Batase, Bhulbhule, Chhepetar (level phase) and Rangrung. Ambote is considered as poorly suited for pasture development.

Forestry

Amppipal and Bhulbhule soil units, having 80 to 90 percent forest cover, are highly suitable for forestry. Rangrung also falls in this category. Chhepetar (rolling phase) and Digra are identified as moderate to highly suitable for forestry. Batase, Manakamana, Bhogteni and Rautepani have moderate suitability, whereas Ambote, Ampchaur and Chhepetar (level phase) have poor forest suitability.

Various forest species identified in the area have been given in Section I.

Terracibility

Am and Di soil units are highly suitable for terrace making. Ch.l is moderately suitable, while Ab, Ch-Bh, Di-Mn and Mn-Bo are poor to moderately suitable for terracing. The Ra-Ap soil unit has poor to moderately suitability, whereas Ba-Bh, Ba-Bh-Mn, Ch.r., Rn-Au and Gy-Di are poorly suited to unsuitable class. Ta-Au is identified as unsuitable for terrace purpose.

APPENDIX I - DESCRIPTION OF SOILS AND ANALYTICAL DATA

Technical descriptions and available analytical data for the main soils recognized in each mapping unit are presented in this section. Each soil is classified in the terms of Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys, USDA, Agriculture Handbook No. 436. The nomenclature of the USDA Soil Survey Manual (USDA, 1951) and the FAO Guidelines for Soil Description (FAO, 1977) have been followed.

Textural classes were worked out in terms of feel (USDA, 1951) and color notation follows the Munsell Color Charts (1954). pH is determined in 1:1 soil water ratio with pH meter and nitrogen by standard micro-kheldahl method. Available P_2O_5 was determined colorimetrically by Bray's or Olsen's method depending upon soil pH and potassium content was determined by flame photometer (Jackson, M. L. 1962).

The classification of soils are mainly based on morphological description of soils with a few analytical data available at the time writing. Therefore, the classification is considered provisional.

1. Ambote Series

The Ambote series are poorly drained soils developed in recent alluvium. It is on very gently undulating river terraces, mainly in rice and rabi crop cultivation.

This soil is classified as coarse loamy, mixed, thermic family of Aquic Dysteric Eutrochrept.

Typical Profile

Location:	Site 2, topographic may 71D/8 near Thatipokhari Village, Palungtar Panchayat, Gorkha District.
Ap 0-11 cm	Grey (7.5 YR 6/1) dry; greyish brown (10 YR 5/2) moist; few fine prominent strong brown mottles; loam; subangular blocky, friable moist; non-sticky; non-plastic wet, very many fine roots, thin and broken cutans, few rock fragments, pH 5.5; abrupt smooth boundary.
B21 11-26 cm	Greyish brown (10 YR 5/1) moist; many fine prominent strong brown mottles: non-sticky; non-plastic wet; thin and broken cutans, few rock fragments, pH 6.0: gradual pH and weavy boundary.
B22 26-48 cm	Grey (10 YR 5/1) moist; many fine prominent strong brown mottles; loam, subangular blocky friable moist;

non-sticky non-plastic wet; think patchy cutans; few fine roots; few rock fragments; pH 6.2; abrupt smooth boundary.

II B21 48-74 cm — Dark yellowish brown (10 YR 4/4 meter) moist; silty loam; subangular blocky; friable moist; non-sticky, non-plastic wet; thick broken cutans; many rock fragments, pH 6.2; clear smooth boundary.

II B22 74-87 cm — Very dark greyish brown (10 YR 3/2) moist; few fine strong brown mottles; silt loam, massive; friable moist; non-sticky, non-plastic wet; thin patchy cutans; many rock fragments, pH 6.2.

Analytical Data:

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
G 6	Ap	0-11cm	5.5	11.0	682.5	1.14	0.098	11.63	1.96
G 7	B 21	11.26cm	6.0	64.0	162.5	0.95	0.063	15.01	1.63
G 8	B 22	26.48cm	6.2	32.0	292.5	0.91	0.126	7.22	1.56
G 9	II B21	48.74cm	6.2	96.0	1102.5	0.43	0.098	4.38	0.73
G 10	II B22	74.87cm	6.2	80.0	1495.0	0.85	0.028	30.35	1.46
G									

2. Ampchur Series

A moderately deep, poorly drained soil developed on alluvium/colluvium materials derived mainly from quartzite.

This area is flat to slightly undulating river terraces mainly in rice and crop cultivation.

This soil is classified as sandy skeletal, mixed, thermic family of Aquic Eutrochrept.

Typical Profile

Location: Site 7, topographic may 71 D/8 near Palungar Panchayat Gorkha district 420 m. a.s.l.; southwest exposure.

Ap 0-16 cm — Grey (5 YR 5/1) dry; yellowish red (5 YR 1/8) moist;

silt loam; subangular blocky firm moist; non-sticky non-plastic wet; many fine roots; few rock fragments; pH 5.4.

B_2 16-29 cm — Yellowish red (5 YR 5/8) moist; dark greyish, few fine mottles; silty loam; subangular blocky, friable moist; non-stick, non-plastic wet; moderately thick and continuous cutans; few very fine roots; many rock fragments; pH 6.7.

B_3 29-88 cm — Brown to dark brown, (10 YR 4/3) moist; loam; weak subangular blocky breaking into fine grain, very friable moist; non-stick non-plastic wet; very few very fine rock fragments; pH 7.1.

Analytical Data:

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
G 26	Ap	0-16	5.4	24.4	97.5	0.93	0.182	5.10	1.59
G 27	B_2	16-29	6.7	66.0	97.5	0.64	0.105	5.80	1.04
G 28	B_3	29-88	7.1	66.0	227.5	0.07	0.042	1.66	0.12

3. Amppipal Series

A moderately deep, somewhat excessively drained soil developed on moderately steep to steep hill slopes made up of materials derived mainly from phyllite and schist.

It is under a subtropical forest mainly of Schima wallichii, Castanop sis indica, lyonia ovalifolia.

This soil is classified as a fine loamy mixed, thermic, family of Ultic Haplaudalf.

Typical Profile

Location: Site 4, topographic map 71 D/12 Amppipal Village, Gorkha district 100 m. a.s.l.; Northwest exposure.

O_1 2-0 cm — Forest litter, mainly loose undecomposed leaves and twigs.

A_1 0-6 cm — Very dark greyish brown (10 YR 3/2) moist; loam; subangular blocky, friable moist non-sticky, non-plastic wet, many coarse to medium roots, many rock fragments; pH 4.6; abrupt smooth boundary.

B_1 6-48 cm — Dark brown (7.5 YR 4/4 moist); clay loam; weak subangular, blocky, very friable moist; slightly sticky slightly plastic wet; many medium roots; many rock fragments, pH 5.2; clear weavy boundary.

B2t 48-67 cm — Strong brown (7.5 YR 5/6) moist; clay loam; weak subangular blocky, very friable moist, slightly sticky slightly plastic wet; few fine roots, many rock fragments with Fe and Mn concetion through the profile; pH 5.4.

Analytical Data:

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
G 15	A1	0-6	4.6	33.0	2275.0	2.03	0.112	18.12	3.49
G 16	B1	6-48	5.2	33.0	195.0	1.22	0.196	6.22	2.0
G 17	B2t	48-67	5.4	3.2	487.5	1.99	0.133	14.96	3.42

4. Aupa Series

A moderately deep well drained soil developed on alluvium/colluvium soil materials derived from phyllite. It occurs on moderately steep to steep slopes under forest mainly in Rhododendrun spp.

This soil is classified as loamy skeletal mixed mesic family of Hapludollic Arent.

Typical Profile

Location: Site 28, topographic may 71-D/16 near Aupa Kharkh, Barpak Panchayat 1390 m. a.s.l. Northwest to north exposure.

01 3-0 cm — Forest litter, mainly loose undercomposed leaves and twigs.

A 0-29 cm — Dark yellowish brown (10 YR 4/4) moist; silty loam; medium to coarse subangular blocky breaking into fine crumb; friable moist; non-sticky non-plastic wet; many fine to medium roots; many rock fragments, pH 6.0; clear wavy boundary.

A3 29-74 — Very dark greyish brown (10 YR 3/2) moist; silty loam; massive; friable moist; non-sticky non-plastic wet; many fine to coarse roots, many rock fragments; pH 5.6; abrupt wavy boundary.

C 74-93 cm — Brownish yellow (10 YR 6/8) moist, loamy sand; massive; friable moist; non-sticky non-plastic wet; very many rock fragments.

Analytical Data:

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
G 92	A	0-29	6.0	80.0	188.5	0.95	0.182	5.21	1.63
G 93	A_3	21-74	5.6	80.0	163.0	2.16	0.315	6.85	3.72

5. Batase Series

A moderately deep excessively drained soil developed on steep slope. It is made up of alluvium/colluvium probably derived from phyllite. It is in steep mountain slopes under forest mainly in Schima wallichii, Castanopsis indica, Lyonia ovalifolia, Fugenia jambolana and Zyziphus mauritiona.

This soils is classified as fine loamy mixed mesic family Dysteric.

Typical Profile

Location: Site 21, topographic map 72 A/9; near Batase Village, Gorkha district, 1050 m. a.s.l.; Northeast exposure.

Ap 0-8 cm — Yellowish red (10 Yr 5/6) dry; dark brown (7.5 YR 4/4) moist; silty clay loam; medium angular blocky breaking into fine crumb; firm moist, slightly sticky slightly plastic wet; many fine to medium roots; few rock fragments; pH 5.8; clear wavy boundary.

B21 8-18 cm — Brown (7.5 YR 5/4) moist; silty clay; medium subangular blocky breaking into fine crumb; firm moist; plastic and sticky wet; many fine roots; few rock fragments; pH 6.6; diffuse boundary.

B22 18-85 cm — Yellowish red (5 YR 4/6) moist; silty clay; weak subangular, blocky; firm moist; slightly sticky slightly plastic wet; few fine roots; few to many rock fragments; pH 6.5.

Analytical Data:

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	%N	C/N	O.M.%
G 79	Ap	0-8	5.8	1160.0	1487.5	1.097	10147	6.59	1.66
G 80	B21	18-18	6.6	113.20	1520.0	1.101	10154	6.55	1.73
G 81	B22	18-85	6.5	121.0	585.0	0.85	0.09	9.44	1.46

6. Bhogteni Series[1/]

A moderately deep, moderately well drained soil developed on moderately steep to steep slopes made of soil materials mainly derived from phyllite and schist.

This soil is classified as fine loamy, mixed mesic family of Aquic (lithic) Haplaudalf. These soils are related to Rautapani series (lithic Haplaudalfs).

Typical Profile

Location	Site GP 19, topographic map 71/D.12 near Nareshwar Bhogteni Village, Gorkha District, 1150 m. a.s.l.; West exposure.
Ap 0-28 cm	Greyish brown (2.5 YR 5/2) moist; common bire and distinct dark brown mottles; silt loam, stmoture non-defined; friable moist; slightly sticky plastic wet; fine roots common; pH 5.8; smooth boundary.
B2t 20-43 cm	Greyish brown (2.5 YR 5/2) moist; many medium distinct yellowish red mottles; silt loam; structure not defined firm moist; structure not defined; firm moist; sticky plastic wet; few fine roots; few rock fragments; pH 6.6 diffuse boundary.
A_1b 43-65 cm	Very dark greyish brown (10 YR 3/2) moist; silt loam; weak subangular blocky; friable moist; a very sticky plastic wet; fine patchy cutans on vertical ped faces; very few fine roots; few rock fragments; pH 6.1.

1/ Source: Division of soil science and Agricultural Chemistry Khumaltar

Analytical Data:

Lab. No.	Horizon	Depth cm	pH	Org. Matter%	N %	kg/ha	kg/ha	Texture		
								sand	silt	Clay
Z 88	Ap	0-20	5.55	1.65	0.082	117	344	54	33	13
Z 89	B2t	20-43	5.7	1.38	0.069	46	306	48	34	18
Z 90	A_1b	43-65+	6.1	1.77	0.088	60	226	52	29	19

7. Bhulbhule Series

A deep; somewhat excessively drained soil developed on moderately steep to steep slopes. It is made up of soil materials derived from phyllite and schist.

It is in hill slope under forest mainly in shorea robusts and castanopsis indica. This soil is classified as fine clayey mixed thermic family of Typic Rhodustult.

Typical Profile

Location: Site 15, topographic map 71-D/12 near Khoplang, Gorkha district 580 m. a.s.l. South to Southeast.

O_1 2-0 cm Forest litter, undercomposed twigs, and leaves.

A_1 0-12 cm Red (2.5 YR 4/8) dry, red (10 R 4/6) moist, silty clay; massive; friable moist; slightly sticky slightly plastic wet, light gray continuous cutans along the vertical ped faces; many medium to course roots, few rock fragments; pH 5.4; gradual boundary.

B_2t 12-122+ cm Red (2.5 YR 4/6) moist; silty clay; massive; friable moist; slightly sticky, slightly plastic wet; many coarse roots; many rock fragments; pH 5.5

Analytical Data:

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
G 52	A_15	0-12	5.4	33	260	1.10	0.252	4.36	1.89
G 53	B_2t	12-122+	5.5	11	195	0.45	0.147	3.06	0.77

8. Belswara Series

A moderately deep, well drained soil developed on moderately steep slope made up of soil materials derived from micaceous and nonmicaceous schist.

It is in moderately steep fan under forest mainly in Shorea robusta and Schima wallichii.

This soil is classified as fine clayey, mixed, thermic family of Typic Hapludult.

Typical Profile

Location:	Site 1, topographic map 71 D.8 near Palungar, Gorkha district, 6.30 m. a.s.l. South exposure.
O_1 2-0 cm	Forest litter, under composed twigs and leaves.
A_1 0-5 cm	Dark brown (7.5 YR 4/4) moist; loam; weak subangular blocky, friable moist; non-sticky non-plastic wet; many coarse roots; few rock fragments; pH 5.5; clear boundary.
A_3 5-16 cm	Dark brown (7.5 YR 4/4) moist; loam; weak subangular blocky; friable moist; non-sticky non-plastic wet; many coarse roots; many rock fragments; pH 5.1; abrupt smooth boundary.
B_1 16-35 cm	Yellowish red (3 YR 5/6) moist; loam; weak subangular blocky; friable moist; non-sticky non-plastic wet; moderately thick patchy cutans; many coarse roots; many rock fragments; pH 5.4; clear smooth boundary.
B_2t 34-79 cm	Strong brown (7.5 YR 5/6) moist; silty clay loam; weak subangular blocky firm moist; slightly sticky slightly plastic wet; patchy thick cutans, many coarse roots; few rock fragments; pH 5.1; abrupt smooth boundary.
$B_{22}t$ 79-85+ cm	Reddish brown (YR 4/4) moist; clay loam; weak subangular blocky; friable moist; slightly sticky non-plastic wet; reddish brown patchy thick cutans; common coarse roots; few root fragments; pH 5.2.

Analytical Data:

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
G 1	A_1	0-5	5.5	33.0	162.5	5.76	0.098	58.77	9.90
G 2	A_3	5-16	5.1	44.0	715.0	1.66	0.147	11.29	2.85
G 3	B_1	16-34	5.4	11.0	227.5	0.95	0.063	15.07	1.63
G 4	B_2t	34-79	5.1	11.0	1592.5	0.06	0.259	4.09	1.82
G 5	$B_{22}t$	79-85	5.2	11.0	617.5	1.22	0.182	6.70	2.09

9. Chhepetar Series:

A moderately deep, imperfectly drained soil developed on level to rolling terraces made up of alluvium/colluvium probably derived from phyllite, schist and quartzite.

It is in an upland area, mostly used for mango, litchi, lemon banana and mixed vegetables and other such as black gram, maize, mustard and millet.

This soil is classified as fine clayey, mixed, thermic family of Ultic Haplustalf.

Typical Profile

Location:	Site 16, topographic may 72 A/9 near Tara Nagar Village, Gorkha district, 390 to 781 m. a.s.l.; southwest exposure.
A_p1 0-10 cm	Strong brown (7.5 YR 5.6) dry; dark brown (7.5 YR 4/4) moist; silty clay; weak to medium angular blocky; firm moist; slightly sticky slightly plastic wet; fine common roots; few rock fragments; pH 6.2; abrupt smooth boundary.
$B_{21}t$ 10-33 cm	Reddish brown (5 YR 4/4) moist; clay; medium to strong subangular blocky; firm moist: very sticky very plastic wet; few fine roots; light gray thin and continuous cutans; few rock fragments; pH 6.1; gradual smooth boundary.
$B_{22}t$ 33-76+ cm	Reddish brown (5 YR 4/4) moist; clay; massive; firm moist; very sticky very plastic wet; light grey thin and continuous cutans; pH 5.4.

10. Daraundi Series

A shallow, poorly drained soil developed on level flood plain made up of alluvium/colluvium soil materials probably derived from phyllite.

It is in a level flood plain area mostly used for rice, wheat and sugarcane.

This soil is classified as sandy skeletal mixed, thermic family of Typic Fluvent.

Typical Profile

Location:	Site 14, topographic map 72 A/9 - 71 D/12 near Taranagar Village, Gorkha district, 426 m. a.s.l.; Variable exposure.
A_p 0-8 cm	Olive grey (5 YR 5/2) moist; fine sand; non-plastic wet; few fine roots; few rock fragments; pH 7.8; abrupt smooth boundary.
C_1 8-23 cm	Olive gray (5 YR 4/2) moist; loam massive; friable moist non-sticky non-plastic wet; abundant fine roots; few rock fragments; pH 8.0; clear smooth boundary.

IIC_2 23-36 cm — Coarse sand; many rock fragments and boulders; clear smooth boundary.

IIC_2 36-46 cm — Light grey (7.5 YR 7/0) moist; red prominent mottless; sand, massive.

Analytical Data:

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
G 50	Ap	0-8	7.8	64.04	552.5	0.20	0.077	2.59	0.34
G 51	C_1	8-23	8.0	80.0	332.5	0.37	0.105	3.52	0.63

11. Digra Series[1/]

A moderately deep, well drained soil developed on moderately steep to steep slopes made up of soil materials derived from phyllite.

This soil is classified as fine loamy, mixed, mesic family of Aquic Dystrocherpt. These soils are related to Gorkhakali series (Umbric Dystrochrepts).

Typical Profile

Location: Site GP 5, topographic map 71 D/12 near Shertan Village panchayat, Gorkha district, 1650 m. a.s.l.; Southeast exposure.

Ap 0-16 cm — Olive brown (2.5 YR 4/4) moist; common medium faint yellowish red mottles; structure not defined; very friable moist; slightly sticky plastic wet; fine to medium roots common; pH 4.8; clear and smooth boundary.

B_2 16-67+ — Dark brown (10 YR 4/3) moist; many medium distinct reddish browh mottles; friable moist; few fine roots; few rock fragments; pH 5.0.

Analytical Data:

Lab. No.	Horizon	Depth cm	pH	O.M.%	N %	P_2O_5 kg/ha	K_2O kg/ha	Texture 2/		
								sand%	Silt%	Clay%
Z 46	Ap	0-16	4.8	2.88	0.144	125	784	49	27	24
Z 47	B2	16-67+	5.0	2.03	0.101	50	451	56	24	20

1/ Source: Division of Soil Science and Agriculture Chemistry, Khumaltar.
2/ Texture was interpreted in terms of International System.

12. Gorkhakali Series

A deep, well drained soil developed on moderately steep slopes made of soil material derived from phyllite and schist. It is in a hill slope area cultivated in maize and millet.

This soil is classified as coarse loamy, mixed, mesic family of Umbric Dystrochrept.

Typical Profile

Location: Site 12, topographic map mainly 71 D/12 near Gorkhakali Village, Gorkha district, 1501 m. a.s.l.; Northwest exposure.

Ap 0-15 cm Dark brown (10 YR 4/3) dry; dark brown (10 YR 3/3) moist; loam, massive, friable moist; non-sticky non-plastic wet, many fine roots; many rock fragments; pH 5.5; abrupt smooth boundary.

B_{21} 15-36 cm Dark brown (10 YR 4/3) moist; loam; weak angular blocky; friable moist; non-sticky non-plastic wet; few fine roots; few rock fragments; pH 5.6; clear smooth boundary.

B_{22} 36-50 cm Dark brown (10 YR 4/3) moist; loam; weak angular blocky, firm moist; non-sticky non-plastic wet; light grey thin patchy broken cutans; very few fine roots; many rock fragments with Fe and Mn concretion; pH 5.6; gradual smooth boundary.

B_{23} 50-110 cm + Dark brown (10 YR 4/3) moist; loam; massive; friable moist; non-sticky non-plastic wet; light brown patchy broken moderately thick cutans; many rock fragments with Fe and Mn concretion; pH 5.6.

Analytical Data

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
G 41	Ap	10-15	5.5	220.0	32.5	0.87	0.161	5.40	1.49
G 42	B_{21}	115-36	5.6	256.0	32.5	0.65	0.077	8.44	1.11
G 43	B_{22}	36-50	5.6	272.0	32.5	0.48	0.077	6.23	0.82
G 44	B_{23}	50-100+	5.6	336.0	32.5	0.24	0.98	2.44	0.4

13. Ghyachok Series[1/]

A moderately deep, moderately well drained soil developed on moderately steep slopes made up of soil materials derived mainly from phyllite and schist.

This soil is classified as fine, loamy, mixed, mesic family of Himic Hapludalfs. These soils are related to Belswara series (Typic Haplaudalf).

Typical Profile

Location:

Ap 0-17 cm	Dark brown (7.5 YR 3/2) moist; silt loam, massive, slightly non-plastic wet; fine roots common; pH 5.15; clear and smooth boundary.
B_2t 17-50+ cm	Dark yellowish brown (10 YR 3/4); silty clay loam; moderate + subangular blocky; thin cutans, few fine roots; pH 5.1.

Analytical Data

Lab. No.	Horizon	Depth cm	pH	O.M.%	N %	P_2O_5 kg/ha	K_2O kg/ha	Texture[2/] sand%	silt%	clay%
Z 52	Ap	0-17	5.15	4.54	0.227	6	2043	36	40	24
Z 53	B_2t	17-50+	5.10	2.65	0.132	1	Very High	34	36	30

14. Harmi Series

A moderately deep, moderately well drained soil developed on rolling to moderately steep slopes made up of alluvium/colluvium soil material probably derived from phyllite and schist.

It is in a steep hill slope mainly used for rice, wheat and mustard.

This soil is classified as coarse loamy, mixed, thermic family of Aquic Dysteric Eutrochrept.

Typical Profile

Location:	Site 11, topographic map 71 D/12 Southwest near Harmi Village, Gorkha district, 1000 m. a.s.l.;
Ap 0-15 cm	Greyish brown (2.5 YR 5/2) dry; olive grey (5 YR 4/2) moist; many fine prominent clear yellowish brown mottles; silty loam; massive; friable moist; non-sticky non-plastic wet; many fine roots; few rock fragments; pH 5.7; abrupt

1/ Source: Division of Soil Science Agricultural Chemistry, Khumaltar
2/ Texture was interpreted in terms of international system.

smooth boundary.

B_2 15-31 cm — Olive grey (5 YR 5/2) moist; many diffuse brownish yellow mottles; silty loam; weak subangular blocky, firm moist; non-sticky non-plastic wet; common fine roots; many rock fragments; pH 5.8; gradual weavy boundary.

C 31-80+ cm — Pale olive (5 YR 6/3) moist; silt; massive; friable moist; non-sticky non-plastic wet; many rock fragments with weathered schist and quartzite; pH 6.5.

Analytical Data:

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
G 38	Ap	10-15	5.7	160.0	130.0	0.88	2.28	3.14	1.51
G 39	B2	15-31	5.8	144.0	130.0	0.55	0.126	4.36	0.94
G 40	C	31-80+	16.5	160.0	60.0	0.16	0.063	2.53	0.27

15. Kabo Series

A shallow, well drained soil developed on moderately steep slopes made up of alluvium/colluvium soil material probably derived from phyllite. It is in a hill slope, unirrigated up-land (Bari) used for maize, millet, barley, potato and wheat.

This soil is classified as coarse loamy, mixed, mesic family of Lithic Haplumbrept.

Typical Profile

Location: Site 27, topographic map 71 D/16 near Kabo Gaun, Barak Panchayat, Gorkha district, 1860 m. a.s.l.; West exposure.

Ap 0-11 cm — Dusk red (2.5 YR 3/2) moist; silty loam; massive; friable moist; non-sticky non-plastic wet; common fine to medium roots, many rock fragments; pH 7.4, diffuse boundary.

B_2 11-34 cm — Very dusk red (2.5 YR 2/5/2) moist; silty loam; medium to weak subangular blocky breaking into medium crum; friable moist; non-sticky non-plastic wet; common fine to medium roots; few rock fragments; pH 5.9.

R 34+ cm — Phyllite rocks.

Analytical Data:

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
G 90	Ap	0-11	7.4	208.0	975.0	2.53	0.420	6.02	4.36
G 91	B2	11-34	5.9	32.0	390.0	3.66	0.357	10.25	6.30

16. Kanelthok Series

A moderately deep, moderately well drained soil developed on easy rolling to rolling terraces made up of alluvium/colluvium soil material derived from phyllite. It is a fan up-land mainly in buckwheat, maize, black gram, sesame and peanuts. Other existing fruit crops are banana, guava, mango and jackfruits.

This soil is classified as mixed, fine clayey mixed, termic family of Udic Rhodustalf.

Typical Profile

Location: Site 3, topographic map, 71 D/8 near Palung Panchayat Gorkha district, 590 m. a.s.l.; Southwest exposure.

Ap 0-7 cm Yellowish red (5 YR 4/6) dry; yellowish red (5 YR 4/6) moist; silty clay loam; subangular blocky; very firm moist; sticky plastic wet; many fine to medium roots; few rock fragments pH 5.5; abrupt smooth boundary.

$B_{21}t$ 7-14 cm Dark reddish brown (2.5 YR 3/4) moist; silty clay; subangular blocky; very firm moist; sticky plastic wet; very many fine roots; few rock fragments; pH 6.2; clear smooth boundary.

$B_{22}t$ 14-26 cm Dark red (2.5 YR 3/6) moist; clay; subangular blocky firm moist; sticky plastic wet; patchy thin cutans; common fine roots; few rock fragments; with prominent Fe and Mn concretion.

B_{23} 26-27 cm Dark red (2.5 YR 3/6) moist; clay; subangular blocky; firm moist; sticky plastic wet; thin broken cutans; few fine roots; few rock fragments with prominent Fe and Mn concretion.

Analytical Data:

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
G 11	Ap	0-7	7.5	33.0	455.0	1.02	0.217	4.70	1.75
G 12	$B_{21}t$	7-14	6.2	48.0	227.5	1.16	0.175	6.62	1.99
G 13	$B_{22}t$	14-26	6.0	32.0	2925.0	1.08	0.175	6.17	1.85
G 14	$B_{23}t$	26-74	6.0	32.0	3575.0	1.72	0.14	12.28	2.95

17. Kipat Series

Kipat series are moderately well drained soils developed on moderately steep slopes made up of materials derived from phyllite and schist. It is mainly in maize, millet, barley and up-land paddy cultivation.

Kipat series is classified as fine loamy, mixed, thermic family of Humic Haplaudalfs. These soils are related to Belswara series.

Typical Profile

Location: Site GP 2, topographic map 71 D/12 Harmi Village Panchayat, Kipat Village, Gorkha district, 675 m. a.s.l.: Northwest exposure.

Ap 0-12 cm: Dark brown (10 YR 4/3) moist; silt loam; not defined structure, friable slightly sticky slightly plastic wet; few rock fragments; fine roots common; pH 5.06; clear smooth boundary.

B_2t 12-63 cm: Dark brown (10 YR 3/3) moist; silty loam; firm moderate subangular blocky, slightly sticky plastic wet; thick cutans on vertical ped faces; few rock fragments; few fine to medium roots pH 4.6; clear smooth boundary.

A_1b 63-109 cm: Very dark greyish browh (10 YR 3/2) moist; silty loam; not defined structure; friable; sticky plastic wet; thick patchy cutans; few rock fragments; few fine roots, pH 4.65.

18. Manakamana Series[1/]

A shallow moderately deep, moderately well drained soil developed on moderately steep bench terraces made up of soil materials derived from schist and phyllite.

1/ Source: Division of Soil Science and Agricultural Chemistry, Khumaltar.

The soil is classified as fine loamy, mixed, mesic family of Udic Haplustalfs. These soils are related to Chhepeta series (Ultic Hapludalfs).

Typical Profile

Location:	Site GP 37, topographic map 7s A/9 near Manakamana Village, Gorkha district, 1250 m. a.s.l.; south exposure.
AP 0-12 cm	Dark reddish brown (5 YR 3/4) moist; silt loam; structure not defined; friable moist; sticky plastic wet; fine roots common; few rock fragments; pH 6.45 clear smooth boundary.
$B_{21}t$ 12-26 cm	Dark reddish brown (5 YR 3/4) moist; silty clay loam; fine + subangular blocky; firm moist; very sticky plastic wet; fine roots common; few rock fragments; pH 6.45; clear smooth boundary.
C 39-59 cm	Red to dark red (2.5 YR 4/6-3/4) weathered and semi-weathered phyllite.

Analytical Data:

Lab No.	Horizon	Depth (cm)	pH	O.M.%	N%	P_2O_5 Kg/Ha	K_2O Kg/Ha	Texture 2/		
								sand%	silt%	clay%
Z 131	Ap	0-12	6.45	2.64	0.132	216	978	46	30	24
Z 132	B21t	12-26	6.60	1.51	0.075	44	925	33	27	40
Z 133	B22t	26-39	6.45	0.90	0.045	34	688	39	29	32

19. Panara Series

A moderately deep, well drained soil developed on rolling manmade terraces made up of alluvium/colluvium soil material probably derived from phyllite and schist. It is a fan, manmade, terrace mainly used in maize; millets, wheat, barley and potato.

This soil is classified as fine loamy mixed, mesic family of mollic Haplustalf.

2/ Texture was interpreted in terms of International System.

Typical Profile

Location: Site 31, topographic map 71-D/12 near Panara, Maucha Barpak Panchayat 2030 m. a.s.l.; north exposure

Ap 0-17 cm Dark brown (7.5 YR 3/2) dry; loam; weak to medium subangular blocky breaking into fine cruumb; friable moist; slightly sticky, slightly plastic wet; few fine roots, few rock fragments; pH 5.7; clear wavy boundary.

B_2t 17-54 cm Strong brown (7.5 YR 5/6) dry; clay loam; medium to strong subangular blocky breaking into fine to medium crumb; firm moist; slightly sticky, slightly plastic wet; thin cutans with vertical ped-falses; few fine roots; few rock fragments; pH 6.1.

Analytical Data

Lab No.	Horizon	Depth (cm)	pH	P_2O_5 Kg/Ha	K_2O Kg/Ha	C%	N%	C/N	O.M.%
G 100	Ap	0-17	5.7	240.0	429.0	2.37	0.336	7.05	4.00
G 101	B_2t	17-54	6.1	48.0	84.5	0.89	0.099	9.00	1.53

20. Phalade Series

A moderately deep, imperfectly drained soil developed on rolling man-made terrace made up of alluvium/colluvium soil material probably derived from phyllite and schist. It is a level man-made terrace mainly used in rice, maize and rabi crops.

Thus soil is classified as loamy, other sandy skeletal mixed, thermic family of Aquic Dysteric Eutrocherept.

Typical Profile

Location:	Site 13, topographic map mainly A/9 71 D/12 near Raniswara Village, Gorkha district; 825 m. a.s.l.; Southeast exposure.
Ap 0-12 cm	Light olive grey (5 YR 6/2) dry; olive (5 YR 5/3) moist; yellowish red few fine mottles; loam; massive; friable moist non-sticky non-plastic wet; many fine roots; pH 5.6; abrupt smooth boundary.
B_{21} 12-26 cm	Olive (5 YR 5/3) moist; common distinct fine mottles; loam; subangular blocky firm moist; non-sticky slightly plastic wet; few fine roots; pH 5.6; abrupt smooth boundary.
B_{22} 26-52 cm	Pale olive (5 YR 6/3) moist; brownish red; common distinct mottles; loam; subangular blocky, friable moist; non-sticky plastic wet; very few fine roots; pH. .70 clear wavy boundary.
C 52-89+ cm	Light brownish grey (2.5 YR 6/2) moist; sand; weathered schist; pH 6.7.

Analytical Data:

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
G 47	Ap	0-12	5.6	144.0	32.5	0.36	0.098	3.67	0.61
G 48	B_{21}	12-20	7.0	48.0	32.5	0.23	0.063	3.65	0.39
G 49	B_{22}	26-52							
	c	52-89+	6.7	48.0	32.5	0.14	0.077	1.81	0.24

21. Rautepani Series

A deep, well drained to somewhat excessively drained soil developed on moderately steep to steep slopes made up of soil materials derived from phyllite and schist. It is an upland area mainly used for maize, millet, buckwheat; black gram and fodder grasses.

This soil is classified as fine clayey mixed, thermic family of Ultic Hapludalf.

Typical Profile

Location:	Site 5, topographic map 71 D/12 near Amppipal Village; Gorkha district. 1034 m. a.s.l.: Southwest exposure.
Ap 0-10 cm	Dark brown (10 YR 3/3) dry, brown to dark brown (10 YR 4/3) moist; loam; subangular blocky, firm moist; non-sticky non-plastic wet; thick broken cutans; common medium to fine root; few rock fragments; pH 5.5; abrupt smooth boundary.
$B_{21}t$ 10-25 cm	Dark greyish brown (10 YR 4/2) moist: clay loam to loam; subangular blocky, very firm moist; slightly sticky slightly plastic wet; thick and continuous cutans; common fine roots; few rock fragments; pH 5.7; clear smooth boundary.
$B_{22}t$ 25-29 cm	Dark brown (7.5 YR 4/4) moist; loam to clay loam: subangular blocky, very firm moist; slightly sticky slightly plastic wet; thick continuous prominent cutans: few fine roots; few to many rock fragments; pH. 6.6; clear smooth boundary.
$B_{23}t$ 59-105 cm	Strong brown (7.5 YR 5/6) moist; clay loam to clay subangular blocky; firm moist; sticky plastic wet; thick broken cutans; very few fine roots; many rock fragments with Fe and Mn concretion; pH 5.7; diffuse irregular boundary.
IIB_2t 105-111	Strong brown (7.5 YR 5/6) moist; clay; massive; firm moist; sticky plastic wet; thick patchy cutans; few fine roots, many rock fragments; pH. 5.8.

Analytical Data

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
G 18	Ap	0-10	5.5	110.0	1950.0	1.23	0.14	8.75	2.11
G 19	B21t	10-25	5.7	112.0	2080.0	1.19	0.091	13.07	2.04
G 20	$B_{22}t$	25-59	5.6	64.0	715.0	1.17	0.112	10.14	2.0
G 21	$B_{23}t$	59-105	5.7	80.0	1462.5	0.71	0.105	6.76	1.22
G 22	II B_2t	105-111	5.8	80.0	130.0	0.51	0.51	5.60	0.87

22. Rangrung Series

A moderately deep, somewhat excessively drained well developed on rolling to moderately steep to steep slopes made up of alluvium/colluvium soil material probably derived from phyllite. It is in a steep hill base under forest mainly in Schima wallichii shorea robusta.

This soil is classified as fine loamy, mixed thermic family of mollic Hapludalf.

Typical Profile

Location:	Site 33, topographic may 71 D/12 near Ramrung Barpak Panchayat, Gorkha district 901 m. a.s.l.; Northeast exposure.
01 3-0 cm	Forest litter, undercomposed twigs, leaves, barks and moss.
A_1 0-20 cm	Dark reddish brown (5 YR 3/4) silt loam, weak to medium subangular blocky breaking into fine to medium crumb, friable moist; non-sticky non-plastic wet; many fine to medium roots; few rock fragments; pH 7.7 diffuse boundary.
B_2 20-81 cm	Red (2.5 YR 4/6) moist clay loam to loam; medium to medium to strong subangular blocky breaking into fine to medium crumb; firm moist; slightly sticky slightly plastic wet; many fine to medium roots; few rock fragments; pH 7.5 clear boundary.
B_3 81-99 cm	Strong brown (.5 YR 5/6) moist; loam; to medium to medium

strong subangular blocky breaking into fine to medium crumb; friable moist; non-sticky non-plastic wet; common fine to coarse roots; few rock fragments, pH 7.6.

Analytical Data:

Lab. No.	Horizon	Depth cm.	pH	P_2O_5 Kg/Ha	K_2O Kg/Ha	%C	%N	C/N	O.M.%
G 104	A1	0-20	7.7	80	9o.0	1.41	0.140	20.07	2.43
G 105	B2	20-81	7.5	48	32.5	0.57	0.091	6.26	0.98
G 106	B2	81-99	7.6	80	45.5	1.62	0.70	23.1	2.79

23. Tasa Series

A deep moderately well drained soil developed on moderately steep slopes made up of soil material derived from phyllite. It is in a fan mainly used for maize, millet, potato, barley and wheat.

This soil is classified as coarse loamy, mixed, mesic family of Dysteric Fluventic Eutrochrept.

Typical Profile

Location: Site 30, topographic map 71 D/12 - D/16 near Tasa Village, Barpak Panchayat. Gorkha district, 1832 m. a.s.l.; Southwest exposure.

Ap 0-11 cm Dark greyish brown (10 YR 4.2) moist; loam; weak to medium subangular blocky breaking into medium crumb; friable moist, slightly sticky slightly plastic wet; many fine roots, few rock fragments; pH 6.1 diffuse boundary.

B 11-34 cm Dark greyish brown (10 YR 4/2) moist; yellowish brown thin mottles; silt loam; weak to medium angular blocky breaking into fine to medium crumb; friable moist; non-sticky non-plastic wet; few fine roots; few rock fragments; pH 6.1 diffuse boundary.

A_1b 34-45 cm Very dark greyish brown (10 YR 3/2) moist; yellowish brown thin mottles; silt loam; weak to medium angular blocky breaking into fine to medium crumb; friable moist, non-sticky non-plastic wet; many rock fragments; pH 6.3 abrupt smooth.

IIB 45-61+ cm — Yellowish brown (10 YR 5/4) moist; yellowish brown thick mottles; loam; medium to strong angular blocky breaking into medium to coarse crumb; friable moist; slightly sticky slightly plastic wet; thick patchy cutans with vertical ped faces; very few fine roots; many rock fragments; pH 6.3.

Analytical Data:

Lab. No.	Horizon	Depth cm.	pH	P_2O_5 Kg/Ha	K_2O Kg/Ha	%C	%N	C/N	O.M.%
G 96	Ap	0-11	6.1	160.0	214.5	1.48	0.196	7.55	2.54
G 97	B	11-34	6.1	96.0	52.0	0.93	0.161	5.77	1.60
G 98	A1	34-45	6.3	96.0	91.0	0.83	0.168	4.94	1.43
G 99	IIB	45-61	6.3	96.0	195.0	0.63	0.105	6.00	1.08

24. Tinmana Series

A moderately deep, excessively drained soil developed on very steep slopes made up of colluvium/alluvium soil material probably derived from quartzite.

It is a very steep man-made terrace under forest mainly in schima wallichii and Castanopsis indica.

This soil is classified as mixed coarse loamy, mixed, mesic family of Fluventic Dystrochrept.

Typical Profile

Location: Site 181 topographic map 72 A/9, near Taklungpani Village, Gorkha district. 1081 m. a.s.l.; Northwest exposure.

Ap 0-10 cm — Dark brown (7.5 YR 4/4) dry; dark brown (7.5 YR 4.4) moist; silt loam; massive; friable moist; slightly sticky slightly plastic wet; common fine to medium roots; few rock fragments; pH 5.7; abrupt smooth boundary.

B_1 10-23 cm — Dark reddish brown (5 YR 3/4) moist; loam; massive; very friable moist; non-sticky non-plastic wet; common fine to medium roots; few rock fragments; pH 5.3; abrupt smooth boundary.

B_2 22-40 cm — Strong brown (u.5 YR 5/6) moist; silt loam; medium angular blocky, friable moist; slightly sticky slightly plastic wet; common fine to medium roots; few rock fragments; pH 5.4; clear smooth boundary.

A_1b 40-73 cm — Dark reddish browh (5 YR 3/4) moist; loam: massive; very friable moist; non-sticky, non-plastic wet; common roots; few rock fragments; pH 5.2; abrupt weavy boundary.

B_2 73-90+ cm — Strong brown (7.5 YR 5/6) moist; silt; medium angular blocky; friable moist; slightly sticky slightly plastic weak; common fine to medium roots; few rock fragments; pH 5.5

Analytical Data:

Lab. No.	Horizon	Depth cm.	pH	P_2O_5 Kg/Ha	K_2O Kg/Ha	%C	%N	C/N	O.M.%
G 68	Ap	0-10	5.7	64.0	97.5	1.54	0.119	12.94	2.64
G 69	B_1	10-23	5.3	99.0	32.5	1.92	0.168	12.42	3.30
G 70	B_2	23-40	5.4	121.0	19.5	1.10	0.091	12.08	1.89
G 71	A_1b	40-73	5.2	242.0	19.5	1.92	0.252	7.6	3.30
G 72	B_2	73-90+	5.4	33.0	32.5	0.36	10.084	4.28	0.61

REFERENCES

Brammer, H. 1965 Soil correlation boxes: a technique to simplify soil correlation, Pak. J. Soil Sci. 1(2): Dacca.

Climatic Records of Nepal 1977 Department of Irrigation, Hydrology and Meterology, HMG/Nepal.

FAO/DSWC 1978 A working paper work plan for watershed condition and natural inventory of Nepal. Integrated Watershed Management Project FAO and Department of Soil and Watershed Conservation, HMG/Nepal, NEP/74/020.

FAO 1977 Guidelines for soil description (2nd Ed.). Soil Resource Development and Conservation Service, Land and Water Development Division, FAO, Rome.

Jackson, M. L. 1962 Soil Chemical Analysis, Prentice Hall, Inc., U.S.A.

Joshy D. and Deo, G. P. 1976 Fertilizer recommendation for major crops of Nepal. Div. Soil Sci. and Agri. Chem. Khumaltar, HMG/ Nepal.

IWM/DSWC 1978 A soil survey of Phewa Tal catchment. Phewa Tal Technical Report No. 4, DSWC/IWM.

Karki, A. B. 1975 Organic manure for vegetables "Krishi," Agricultural Information Section, Harihar Bhawan, Lalitpur, Ashad-Shrawan (in Nepali).

Maharjan, P. L. 1976 Criterias for adducing approximate soil boundaries by interpretation of base map (memo).

Moorman, F. R. and Breeman, N. V. 1978 Rice: Soil, Water and Land. International Rice Research Institute, Law Banos, Laguna, Philippines.

Singha, T. N. 1975 Organic manure for fruit crops. "Krishi" Agricultural Information Section, Harihar Bhawan, Lalitpur, Ashad-Shrawan (in Nepali).

Stainton, J. D. A. 1972 Forest of Nepal, London, John Murray.

Tatalov, V. A. 1972 Geology and Ores of Nepal, Final Report, Plate No. 1.

Stocklin, J. and Bhattarai, K. D. 1972 Photogeological map of West Dhading-North Chitwan Area, 72 A/5. 72 A/9, HMG/ UNDP Mineral Exploration Project.

Taylor, H. H. and Pohlen, I. V. 1970 Soil Survey Method: A New Zealand Handbook for the

field study of soils. Soil Bureau Bulletin 25, DSIR, Soil Bureau Traiter Experimental Station, Lower Hutt, New Zealand.

UNDP/FAO 1975 General Soil Survey of Bagmati and Narayani zones. Increasing use of high-yielding crop varities and fertilizers, central Nepal. AG:DP/NEP/70/512.

USDA 1975 Soil Taxonomy: A Basic System for Making Interpreting Soil Surveys. USDA Handbook No. 436.

USDA 1951 Soil Survey Manual, USDA Handbook No. 18, with supplement of 1962.

CHAPTER IV

SOILS AND GEOLOGY OF MIDDLE UPPER KALIGANDAKI CATCHMENT

(MYAGDI)

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I. PHYSICAL AND ENVIRONMENTAL FEATURES

Location and Extent

The Myagdi region lies due south of Mustang within the drainage of the lower Kaligandaki River Valley, between Tatopani and Beni along the river's main right bank tributary, the Rahughat Kohla. The lower Kaligandaki catchment area lies between 83°26' and 83°51' 37" east longitude and 28°20' 21" and 28°40' 30" latitude. The surveyed area covers 944 sq. km. The population for 1979 is projected as 39,342.

Climate

Annual precipitation values of between 700 and 1400 mm of rain have been recorded for the Myagdi region, generally increasing southward and with altitude especially on south-facing slopes. The percentage of annual precipitation in the monsoon period increases southward, from 58% at late, to 66% at Dunai, and 85% at Beni Bazaar in the far south. Inversely, winter proportions of total precipitation increase northward from only 5% at Beni Bazaar to over 20% in the north. Maxium 24 years rainfall intensities vary between 40 mm in the north and 150 mm in the south (Departments of Irrigation, Hydrology and Meterology, 1977).

In Myagdi, the main climatic zones are subtropical, temperate and alpine.

Physiography and Drainage

Most of Myagdi district is drained by the Kaligandaki River and the Rahughat Khola. The terrain is a highly dissected portion of the Inner Himalaya, with altitudes extending from 835 m at Beni to over 6,000 m along the peripheral divides. Everywhere relief is great and most slopes are in excess of 35 degrees.

Land Use

As noted above the total area of the lower Kaligandaki catchment area is 944 sq. km. The area under forest, cultivated land, pasture lands, snow-covered, rock outcrops and others are estimated to be 29, 17, 36, 8, 9 and 1 percent respectively (APROSC, 1979).

Twenty-nine percent of the project area is covered by forest. The main forest types include subtropical riverain forest, subtropical wet forest and temperate forest vegetation, but increased population densities have also brought extensive clearing and degradation of the native vegetation.

Pasture: Pasture land comprises 17 percent of the project area. Alpine meadows, suitable natural land for grazing animals, are found towards the south of Dhaulagiri Himal at elevations between 3,500 and 5,000 m. Denuded forest lands used for grazing are widespread, and almost uniformly contribute to high rates of denudation. Barren soils, gullies and ravines, landslide scars, and eroding stock trials all are found in abundance of heavily grazed lands.

Agriculture: Cultivable lands cover about 36 percent of the total project area. Irrigated terraces are found in the few places where the water supplies are adequate. These are relatively well maintained and water supplies are generally limited, but irrigated terraces are found where water supplies are adequate, present no major denudation problem. Maize, wheat, barley/naked barley and potato are the important crops. Paddy is grown at lower altitudes.

Miscellaneous: This includes 1 percent of snow covered land, 9 percent of rock outcrops and 1 percent of "other."

Natural Vegetation

Natural vegetation has been described according to ecological map of Annapurna-Dhaulagiri prepared by J. F. Dobremez and C. Jest (1970).

1. Subtropical Riverain Forest
   This type of forest is found in a narrow belt starting from the middle of Ghasa and Dana and extending along the Kaligandaki River up to Beni. The main vegetation consists of *Alnus nepalensis*, *Cedrella toona* and *Albizzia mollis*.
2. Subtropical Wet Forest
   This type of forest is encountered at altitudes between 1,000 m. and 2,000 m. with precipitation of more than 2,500 mm. per year. It is found towards the southern part of Rahughat Khola. The main vegetation consists of *Castanopsis indica*, *Schima wallichii* and *Engelhardia spicata*.
3. Temperate Forest
   Temperate forests are situated between 200 m and 3000 or 3500 m. with precipitation of less than 1000 mm. per year. The main vegetation includes *Rhododendron sp*, *Quercus semecarpifolia*, *Quercus languinosa*, *Quercus lamellosa*, *Abies spectabilis* and *Betula utilis*.
4. Steppe
   Alpine meadows exist towards the south of Dhaulagiri Himal at

elevations between 3500 and 5000 m. The vegetation is composed mainly of Graminaceae and Cyperraceae.

II. GENERAL NATURE OF THE SOILS

A. Methodology

Mapping and Classification of the Soils: For carrying out a general soil survey of the middle upper Kaligandaki catchment area (Myagdi district), a topographic map with a scale of 1: 63,360 and an ecological map of Annapurna-Dhaulagiri area (1:250,000) prepared by J. F. Dobremez and C. Jest (1970) were used as base maps. Soils were examined in soil pits and notes on topography, vegetation, geology and other physical features were recorded on field sheets. Use was made of a soil survey manual (USDA 1975) and FAO Guidelines for Soil Description (1977) during the field survey.

Morphological characteristics are recognized by soil layers or horizons that differ in color, texture, structure, consistency, reaction, thickness or chemical analysis of soils. All soil profiles are compared with each other and classified according to the USDA system (1975).

Descriptions of the mapping units are given in the following section (see Sheet No. I, 11 C).

B. Description of Mapping Units

1. Dandakot-Kauligaunda-Toripani Soil (Da-Ka-To)

The Dandakot-Kauligaunda-Toripani soils occur in the southwestern part of the mapped area on rolling to moderately steep to steep slopes. These soils are shallow to moderately deep, poorly to moderately well drained and are made up of materials derived mainly from schist, phyllite and slate.

Dandakot Soil - Altitude	1200-1800 m.; Exposure: Northeast.
Surface Soil	Very dark grey to very dark greyish brown, friable, loam/silt loam, 10-15 cm. thick, many rock fragments.
Sub-Soil	Very dark greyish brown, friable, silt loam, 20-35 cm. thick, many rock fragments.
Substratum	May be greyish brown, silt loam with many fragments of weathered schist and phyllite.
Other Properties	Slightly acid, very high in organic matter, medium in nitrogen, high in phosphorus and potash.
Suitability	
Agriculture	Unsuitable for farming.

Horticulture	Moderate to highly suitable for horticulture development. Formerly many soils of this unit were used for unirrigated cereal crops, and were on landslide areas. At present these soils are fallow and are under being planned for horticulture development. The suitable vegetables include radish, cauliflower, cabbage, broad leaf mustard and pumpkin.
Pasture	Moderately suitable for forage crops and fodder trees; poorly suited for grazing.
Forest	Moderate to highly suitable for forest development. The main forest species are pinus roocburgie; Rhodedendron spp; Schiwa wallichii, Castanopsis indica; Barberis amalica; Lynolia ovalifolium; Myrica ragi and Saroja nepalensis.
Limitations	Low water-holding capacity, moderately steep to steep topography, susceptible to erosion, droughtiness in winter season, rock fragments on or near the soil surface, slightly acid and occasional hailstorms are the main restrictions of these soils. Many soils of this unit are in a slidy position, which doesn't permit agriculture.
Kaulegaunda Soil - Altitude	1050-1400 m., Exposure: Variable.
Surface Soil	Dark greyish brown to very dark greyish brown, silt loam/loam, 10-15 cm. thick, many rock fragments.
Sub-Soil	Very dark greyish brown, loam, 15 cm. thick, many rock fragments.
Substratum	May be dark brown, gravelly, loamy sand with many weathered schist fragments.
Other Properties	Slightly acid, medium in organic matter, and nitrogen, high in phosphorus and potash.
Suitability	
Agriculture	Poor to moderately suitable for maize and millet.
Horticulture	Poor to moderately suitable for orange, banana, and other citrus fruits.

Pasture	Moderately suitable for fodder-trees, poorly suited for gazing.
Forest	Highly suitable for forest development. At present many soils of this unit are under pine forest which are protected by the Department of Forest. The re-forestation program will be of benefit in this location.
Limitations	The main limiting factor is that most of the soils of this unit are under dense forest; and others are susceptible to erosion, have a rolling topography, rock fragments on or near the soil surface, droughtiness in the winter season and some hailstorms.
Toripani Soil - Altitude	1650-1800 m. Exposure: South.
Surface Soil	Greyish brown to dark greyish brown, friable silt loam, 10-15 cm. thick, few rock fragments.
Sub-Soil	Dark greyish brown to olive grey, firm, silt loam, many rock fragments.
Substratum	May be hard rock in situ.
Other Properties	Medium acid, high in organic matter, nitrogen, phosphorus and medium in potash.
Suitability	
Agriculture	Highly suitable for wheat, maize and potato, moderately suitable for rice and poorly suitable for sugarcane. Some improved varieties of wheat also are introduced in these soils.
Horticulture	Moderately suitable fruits include peach, plum, pears, citrus and suitable vegetables are cole crops, radish, tomato and colocasia.
Pasture	Moderately suitable for forage crops and grazing.
Forest	Poorly suitable for forest development, because the soils are under agriculture farming and dense population.
Limitations	Limitations are moderately steep topography, droughtiness in winter season, susceptible to landslide and erosion; rock fragments on or near the soil surface, medium acid and low productivity.

2. Dhaskhore-Poon Hill Soils (Dh-Po)

The Dashkhore-Poon Hill Soils occur in the east-west and northern part of the mapped area on moderately steep to steep slopes. These soils are

moderately deep to deep, moderately well drained and are made up of materials derived mainly from schist and phyllite.

Dhaskhore Soils - Altitude	2750-3200 m. Exposure: Southwest.
Surface Soil	Dark brown to very dark greyish brown friable, loam/silt loam 10-15 cm. thick, few rock fragments.
Sub-Soil	Dark brown to yellowish brown, friable, silt loam 20 cm. thick, many rock fragments.
Substratum	May be yellowish brown, very gravelly, very fine sandy loam to loam soil materials with many fragments of weathered schist.
Other Properties	Strongly acid, very high in organic matter, medium in nitrogen and potash, high in phosphorus.
Suitability	
Agriculture	Unsuitable for farming.
Horticulture	Poor to moderately suitable.
Pasture	Poorly suited to pasture development.
Forest	Highly suitable for forest development. Many soils of this unit are under forest. At present, these soils are in thick dense forest, mainly Rhododendron arboreum and Quercus semecarpifolia.
Limitations	Low water holding capacity, steep topography, susceptible to erosion, droughtiness in winter season, short growing season, rock fragments on or near the soil surface, strongly acid, low in potash and sometimes covered with snow.
Poon Hill Soil - Altitude	About 3050 m.; Exposure: Southeast.
Surface Soil	Very dark grey, friable, loam 10-15 cm. thick, few rock fragments.
Sub-Soil	Dark grey, friable, loam 25 cm. thick, many rock fragments.
Substratum	May be reddish yellow, gravelly, loam, soil materials with many rock fragments.
Other Properties	Strongly acid, very high in organic matter, medium in nitrogen, high in phosphorus and low in potash.
Suitability	
Agriculture	Unsuitable for farming.
Horticulture	Poorly suited.

Pasture	Highly suitable for forage crops, grazing. At present wild grass lands are available in this unit. These soils are also suitable for range management.
Forest	Highly suitable for forest plants; at present about 50 percent of the soils of this unit are under dense forest, mainly Pinus excelsa, Rhododendron and Arundinaria spp.
Limitations	The principal limiting factors for agriculture are the climate, the topography, rock-fragments on or near the soil surface; snow-fall during the winter season, strong acidity and low fertility, and existing dense forest.

3. Gharsoona-Sikha-Nagi-Pangdr Soils (Gr-Si-Na-Pa)

The Gharsoona-Sikha-Nagi-Pangdr soils occur in the central part of the mapped area on bench terraces and moderately steep slopes. These soils are shallow to moderately deep, poorly to well drained and are made up of materials derived mainly from schist and phyllite.

Gharsoona Soil - Altitude	1800-2400 m. Exposure: Variable.
Surface Soil	Dark brown to very dark greyish brown, friable, silt loam, 20-35 cm. thick, many rock fragments.
Sub-Soil	Dark greyish brown to yellowish brown, friable, sandy loam to silt loam, 30 cm. thick, many rock fragments.
Substratum	May be strong brown loamy sand with many fragments of mica and schists.
Other Properties	Slightly acid, high in organic matter, medium in nitrogen, phosphorus and potash.
Suitability	
Agriculture	Moderate to highly suitable for maize, millet, barley, naked barley and potato. Poorly suited for rice and sugarcane.
Horticulture	Moderate to highly suitable for peach, plum, pear, walnut and apple. Recently fruit plants are being distributed from LAC, and farmers seem interested in fruit growing. Suitable vegetables include cauliflower, cabbage, knolkhol, asparagus, radish, and broad-leaf mustard.
Pasture	Poorly suited to pasture development.

Forest	Poor to moderately suitable for forest development.
Limitations	Many soils of this unit are under crop farming and are located in dense residential areas. Low water-holding capacity, moderately steep topography, susceptibility to erosion, rock fragments on or near the soil surface, droughtiness in the winter season, low soil fertility, and hailstorms are the main limitations of these soils.
Sikha Soil - Altitude	1829-2134 m. Exposure: Northeast.
Surface Soil	Very dark grey to dark brown; firm; gravelly silt loam; 15-35 cm. thick; many rock fragments.
Sub-Soil	Dark greyish brown to dark reddish brown; friable silt loam; 15-65 cm. thick; few rock fragments.
Substratum	May be poorly sorted alluvial/colluvial materials ranging from large boulders to silt.
Other Properties	Medium to slightly acid, high in organic matter, nitrogen and phosphorus and medium in potash.
Suitability	
Agriculture	Highly suitable for maize, millet, naked barley and potato; unsuitable for rice and sugarcane.
Horticulture	Moderate to highly suitable for peach, plum, pear, walnut and moderately suitable for apples. The suitable vegetables include cole crops, radish, asparagus and broad leaf mustard.
Pasture	Poor to moderately suitable.
Forest	Moderate to highly suitable for forest development; reforestation is very important in this area because many soils of this unit are under active slide.
Limitations	Moderately steep topography, low water holding capacity, susceptible to erosion, risk of landslide, droughtiness in winter season, frost, rock fragments on or near the soil surface, medium acid in reaction.
Nagi Soil[1/] - Altitude	About 2300 m.; Exposure:

1/ Source: Division of Soil Science and Agriculture Chemistry, Khumaltar.

Surface Soil	Very dark greyish brown, friable, silt loam, 10-15 cm. thick, few rock fragments.
Sub-Soil	Yellowish brown, firm, silty clay loam, 40 cm. thick, many rock fragments.
Substratum	Hard bed rock of schist in situ.
Other Properties	Medium acid, very high in phosphorus and high in potash. (Organic matter and nitrogen are not estimated.)
Suitability	
Agriculture	Highly suitable crops are maize, millet, barley and wheat.
Horticulture	Moderately suitable for peach, plum and citrus fruits. The suitable vegetables include cole crops, radish and broad leaf mustard.
Pasture	Poor to moderately suitable.
Forest	Moderately suitable.
Limitations	Low waterholding capacity, acceptible to erosion, many rock fragments on or near the soil surface, medium in acid.
Pangdar Soil[1/] - Altitude	About 2300 m. Exposure:
Surface Soil	Olive grey, massive, loamy sand, 10-15 cm. thick, many rock fragments.
Sub-Soil	Olive grey, friable, silt loam, 25 cm. thick, many rock fragments.
Substratum	May be hard rock in situ.
Other Properties	Slightly acid, high in phosphorus and potash. (Organic materials and nitrogen are not estimated.)
Suitability	
Agriculture	Poor to moderately suitable.
Horticulture	Moderately suitable.
Pasture	Highly suitable.
Limitations	Cool to cold climate is one of the main restrictions; also susceptible to erosion, snow fall, many rock fragments on or near the soil surface, slightly acid in reaction.

4. Ghara-Toripani Soils (Gh-To)

The Ghara-Toripani soils occur along the Kaligandaki River of the catchment area on moderately steep bench terraces. These soils are moderately

1/ Source: Division of Soil Science and Agriculture Chemistry, Khumaltar.

deep, somewhat poorly drained and are made up of materials derived mainly from schist, phyllite and slate.

Altitude	About 1500 m. Exposure: Northeast.
Surface Soil	Dark grey, friable, silt loam, 10-15 cm. thick, many rock fragments.
Sub-Soil	Greyish brown, friable, silt loam, 20 cm. thick, very many rock fragments.
Substratum	May be hard rock in situ derived mainly from schist and phyllite.
Other Properties	Neutral, medium to organic matter, and nitrogen, high in phosphorus, and very low in potash.
Suitability	
Agriculture	Poor to moderately suitable for farming. At present, the existing crops are paddy, maize and wheat. Due to the agricultural practices many soils of this unit are susceptible to landslide and erosion.
Horticulture	Poorly suitable for orchard development and unsuitable for vegetables.
Pasture	Poor to moderately suitable for pasture development; unsuitable for grazing.
Forest	Highly suitable for forest development. Quick growing tree plantation is very important in the active landslide area. Only a little Alnus nepalensis is growing there at present.
Limitations	Many soil of this unit are under active landslides. Other limitations include steep topography, susceptibility to erosion, rock fragments on or near the soil surface, droughtiness in winter season; low soil fertility and hailstorms.

III. GEOLOGY AND EROSION

GEOLOGY

1. Stratigraphy

Metamorphosed sedimentary rocks of Proterozoic and Paleozoic groups compose the project area (Sheet No. II, 6c).

The area covered by different geological units and the percentage of the total area of the watershed covered by the units and their occurrence in different panchayats is presented in Table No. 1.

Proterozoic Group

The proterozoic group is represented by the rocks of the middle proterozoic subgroup. These rocks are found in the southern half of the catchment. This subgroup is represented in the project area by the rocks of Galang, Khahare and Hilang suites.

Galang Suite (P_2gl): In the Kaligandaki catchment area, this suite is composed of chlorite sericite schists, quartzites and limestones. They are dark green, light to dark brown, and rarely black, or dark grey in color. These highly weathered and often finely fractured rocks have a northwest to southeast trend. They are moderately consolidated. This suite is found in the southern part of the territory. Its thickness is about 1500 meters.

Khahare Suite (P_2kh): This suite is represented by quartzites, schists and sandstones. The quartzite is white to greyish white, whereas the schists and sandstones are brown to dark brown, rarely pinkish in color.

The rocks are high to moderately weathered, moderately consolidated and finely fractured. Lying on the rocks of Galang Suite, they have a normal contact with them. A normal contact of this suite with the rocks of the Hilang suite is also seen in its northern edge. The thickness of the Khahare suite is estimated to be about 5500 meters.

Hilang Suite (P_2hl): The Hilang suite, in the project area is found in the central part in Darmija, Dhoba and Baraha Panchayats. It is represented here by white to brownish white, light yellow limestones and dolomites. These rocks are moderately consolidated, slight to moderately fractured and slightly weathered.

This suite has a contact in the north with the Himal suites of the Cambrian and Ordovician systems which overlay it.

This suite has an east-west trend and its thickness is about 3500 meters.

Paleozoic Group

Paleozoic rocks in the lower Kaligandaki catchment areas are found in the northern part. This group is composed of rocks belonging to Cambrian, Ordovician, Silurian and Devonian systems.

Cambrian and Ordovician Systems

Himal Suite (C+Ohm): The Himal suite is represented by grey granitized schists and quartzites with bands of limestones. These rocks are high

Table 1

Areas and percentages of different geological units of middle of upper-Kaligandaki watershed.

	Geological Units	Area in sq.km.	Percentage of the total area
1.	Galang suite (PR_2gl)	38.25	4.05
2.	Khahare suite (PR_2kh)	256.04	27.12
3.	Hilang suite (PR_2hl)	81.23	8.61
4.	Himal suite(C+Ohm)	421.6	44.67
5.	Silurian system (S)	62.7	6.64
6.	Devonian system (D)	71.6	7.58
7.	Recent alluvium (IVal)	12.54	1.33
	Total	943.96	100

to moderately consolidated and slightly fractured.

This suite is located in Kuine Mangale, Darmija, Dana and Baraha Panchayats. The suite lies on the denuded surface of the rocks of the Hilang suite. The Himal suite has an east-west trend, and its maximum thickness is estimated to be about 9000 meters.

Silurian System(s) (S)

The Silurian system consists of white to light yellow limestones. The limestone is highly consolidated, moderately fractured and slightly weathered. No karst formation was seen in the territory.

This suite is located in Darmija, Kuine Mangale and Dana Panchayats. Its thickness is not uniform, and varies from 0 to 3000 meters.

Devonian System (D)

The Devonian system is represented by argillo-sericite schists and phyllites. These light-to-dark-brown, greyish brown rocks are found in the north of Darmija, Kuine Mangale and Dana Panchayats. They are weak to moderately consolidated, highly weathered and finely fractured. The thickness of the Devonian system is about 3000 meters.

Cenozoic Group

Quarternary system

Recent alluvium (IVal): These are generally sands, gravels, boulders and different sand-clay horizons. They occur along the river beds. The thickness is variable and was not measured in the catchment area.

2. Structure

The geological structure of the area is governed by a large anticline at the south and a syncline at the north. The axis of both syncline and anticline strike 15°-20° East.

Kowang syncline has slightly inclined flanks with their average inclination 20°-25° with local variations between 15° to 35°.

Pipale anticline has a very steep northern flank, whereas its southern flank is almost flat. The average inclination of the northern flank is about 35°-40° with local variations from 20° to 25° up to 70°-75°. The flat southern flank has local variations from 10° and 30°.

The synclinal and the anticlinal structures of the area are complicated by numerous small anticlines and synclines which in most cases are structures of lower classes. But the tendency of the macro faults remains unchanged.

No major fault could be traced because of the insufficiency of the observations.

Along some rivers such as Ghar Khola, Ghaleli Khola and Rukse Khola, are macro faults of sublongitudinal trend. Both vertical and horizontal components of the faults are not large, though at some places they were easily noticed.

3. Geological History of the Lower Kaligandaki Catchment

The geological history of the lower Kaligandaki catchment can be traced from the middle proterozoic period.

In the Galang time of the middle proterozoic period the entire Kaligandaki catchment area was underwater. It was a shallow basin (depth varying from around 50 to 250 meters). The basin was quiet, and hence fine silty material was deposited on the bottom.

Limestone was formed as a result of chemical processes occurring at the bottom of the basin.

In the Khahare time, the basin was similar in shape. At this same time the middle Himalaya geosyncline started folding, but no big mountains formed and the whole area remained under the existing basin. As a result of folding the basin became shallow at some places, where coarse material was deposited. In the deep parts of the bottom, sedimentation of silty materials continued.

At the end of Khahare time, Pipale anticline was formed as a sub-longitudinal island in the Proterozoic basin. From this time, the continental history of the southern part of the catchment area began.

In the Hilang time, the area covered by the basin was decreased. It became a moderately shallow basin, where sedimentation of chemical limestones and dolomites took place.

In the Cambrian and the Ordovician periods, the basin was receding further. Its southern boundaries shifted to the north. The conditions of sedimentation were similar to those of Hilang time, but it was more shallow at the upper part of the continental shelf, where sedimentation of coarse to medium material (quartz, sand and silt) took place. But at the lower side of the continental shelf, carbonate material was deposited.

The depth of the basin during these periods did not remain constant but periodically changed. The conditions of sedimentation also changed with a change in depth. Those changes in depth gave rise to the formation of the bands of limestone.

In the Silurian time, the conditions of sedimentation remained similar

but the basin was more deep than in the Cambrian and the Ordovician periods. The water pool was more quiet during the process of its recession. At the bottom of this calm basin, limestone forming material was deposited.

At the end of the Silurian period, the territory started folding and a huge syncline was formed, where the Silurian basin existed before. In the Silurian time, the basin was almost absent. It existed only in the eastern and the western parts. These two water pools were connected by a narrow channel. The basins and the channel were very deep, where fine argillic material was deposited. The conditions of sedimentation remained similar. It was a quiet basin, though its depth was decreasing constantly. At last, at the end of the Devonian period the basin was gone.

After the Devonian period, the territory was folded many times, though the exact time of folding is not known.

This area has been highly influenced by the foldings of the place in the Tertiary period in the higher Himalayan.

The rocks of the area are highly metamorphosed. Schist of the Cambrian and Ordovician was granitized and the argillic rocks of the Devonian period and the Galang suite were sericitized and chloritized.

In the Tertiary period, the formation of the Himalayas gave rise to the formation of the sublongitudinal faults, which have mostly vertical components. The northern flank is, in all cases, uplifted in comparison to the southern flank.

After the formation of the high Himalayas, the monsoon period started.

The formation of the Kaligandaki River is very closely related with the formation of the high mountains, which are inclined to the south. The gradual decreasing of height from the higher Himalayas to the lower terai formed a gradient, as a result of which, the rivers started flowing from the north to the south.

The territory was denuded from the end of the Devonian period. During this long period, many landslides as well as other major and minor types of erosion took place. As a result of this erosion, the area was flattened. The rivers denuded the banks and formed flat or slightly inclined alluvial terraces along their routes.

<u>Erosion</u>: Erosion in the Myagdi-Kaligandaki catchment is complicated not only because the area is situated at different altitudes and hence different climatical regions, but also because many factors are

acting together to promote erosion. These factors are: lithology, geological structure, tectonics of the area, hydrology, geomorphology, relief, slope, etc. All these factors have been described earlier. In this sesion we will discuss the particular types of erosion occurring in the area.

Sheet erosion: Sheet erosion, in the Middle-Upper Kaligandaki watershed is very high. The main reason for the high occurrence of this type of erosion is the high average annual percipitation. The rate of percipitation varies from place to place and the average annual precipitation is not constant for all the territory of the watershed. Slope is another dominant factor behind sheed erosion and the area is characterized by steep slopes.

A map of potential sheet erosion has been made on the basis of slope and land use (presented by Sheet No. 12c). The sheet erosion classification of the territory is shown in Table 2.

Table No. 2 - Sheet Erosion Classification

Slope \ Land use	Pasture (Range)	Forest	Cultivated area
Below 5°	CLASS IV		
5° - 16°		CLASS III	CLASS II
16° - 25°	CLASS III	CLASS II	CLASS I
Above 25°	CLASS II		

Table 3 presents the areas covered by different erosion classes and the percentage of the total area of the watershed.

Rill and gully erosion: Rills and gullies are highly developed in the watershed. The main causes of this type of erosion are the high average annual precipitation, general high relief, steep slopes and snow-capped mountains of the catchment. The rills and gullies of the area are generally very deep. Their density in steep slopes is high in comparison to that in rolling to moderately steep slopes. In the fans, they are generally wide and shallow. Perennial melting of snow is one of the main causes of the rills and gullies.

Table 3 - Area and Percentages of Different Erosion Classes

Units	Area sq. km.	Percent of the total area +
Class I - Highly eroded	430.13	45.57
Class II-High to moderately eroded	229.37	24.30
Class III-Moderate to slightly eroded	53.38	5.66
Class IV-Slightly eroded	14.38	1.52
Rock out crops	25.15	2.66
Snow covered area	191.55	20.29
Total	943.96	100

Bank and bottom erosion: Bottom erosion in the watershed is, though prominent, not of great importance. Since the rivers flow on the bedrocks, it is not noticeable.

Bank erosion is very high along some rivers of the watershed. Very often it has been the main cause of landslides. The main river of the area is that of Kaligandaki, which is much larger in Myagdi than in Mustang District. In the Middle-Upper-Kaligandaki watershed, it is tributed by a number of perennial rivers such as Rahughat, Sansar, Pandar, Dhaske Khahare, Ghar, Ghaleli, Beg, Ghatte, etc. These rivers are generally narrow, steep, deep and very often they form gorges. They have a high current and hence cause much erosion. The discharge in these rivers does not remain constant, but changes according to the season, reaching its maximum in summer. Some active landslides are connected with bank erosion of the watershed. The Kaligandaki River flows across the general trend of the rocks and has a wide riverbed.

Landslides: Landslides of small masses are very common in the catchment. They are generally connected with the high rate of precipitation during the rainy season. In the high mountains, landslides are connected with the over-accumulation of snow but these landslides are not dangerous for the terrain as they are located far from the cultivated areas and villages. Snowslides are very common at the higher altitudes. The main reason for the development of active landslides in the

lower as well as the intermediate altitudes is deforestation. These slides are generally accelerated by human action rather than natural.

In the vicinity of Ghar Khola are a number of active landslides with their volumes sometimes exceeding 50,000 cu. m. On the right bank of the Ghar Khola marks of former landslides are visible. The main reason of active landslides on the left bank is the lithology of the bedrock, which is composed of phyllites and schists.

In Tallo Sikha, in the vicinity of Ghatte Khola, potential landslide is located in phyllites and schists; its volume is estimated to be around 100,000 cu. m. In the areas adjoining to the slide, about 2 to 3 meter cracks were noticed on the 2nd May 1979. The area is known to have been activated after 1961 A.D.

An active landslide is also located at the left bank of Gar Khola, at the meeting point of Dhaske Khahare Khola and Gar Khola in Sikha Adarsha Panchayat. Its volume is estimated to be about 300,000 cu. m. The area is known to be activated about 28-30 years ago.

At the right bank of Dhaske Khahare Khola at Chhalim Danda, another potential landslide has been found. It is not large but it is dangerous for the cultivated areas of the Danda. Such landslides are very common in this Panchayat.

All the above mentioned landslides are very dangerous both for human populations and the cultivated areas, as the landslides are located very close to the villages of Sikha, Ghara, Phalate and Chitre. The Panchayat is loosing cultivated lands year by year through landslides.

Some seasonal rivers of the Panchayat are noticeable, because their existence is very dangerous for the villages. Among such rivers is a seasonal river in the vicinity of Ghar Village, which is very steep and wide. It brings a lot of stones and boulders with it after every rainfall, very often demolishing houses and causing numerous slides in the cultivated area of the village.

In Panchayats other than Sikha Adarsha, no bedrock sliding had been noticed, though small landslides in the alluvial soils are common throughout the catchment area.

A map of landslides is made on the basis of slope, lithology, relief, land use and the observations of the Soil and Geological Survey Team of APROSC in the spring of 1979. This map is presented in Sheet No. IV, 10c. The classification of the territory is shown in Table 4.

Table 4 - Landslide Classification

Rock Classes / Slope	Highly erodable			erodable		
Above 36°	C[1/]	I	(P[2/] + F[3/])	←--C	II	(F + P)
25° - 36°		II		C		(F + P)
16° - 25°	C		(F + P)	C	III	(F + P)
Below 16°	C			IV		(F + P)

N. B.: In this table, schists, schists with quartzites and sandstone are classified as highly erodible rocks whereas limestones and dolomites are classified as erodible rocks.

Active slides territories are not included in the table since these areas are rare in the watershed.

Table 5 presents the areas covered by different landslide classes, their occurrence in different Panchayats and their percentage of the total are of the watershed.

1/ C = Cultivated area
P = Pasture
F = Forest

Table 5 - Area Under Different Landslide Classes

Units	Area, sq. km.	Percent of the total area	Panchayats
Class I - Highly sliding	581.29	61.58	All but Ghatan
Class II - Moderately sliding	259.33	27.47	All
Class III - Slightly sliding	36.93	3.92	All but Jhee, Ghatan, Bhagbat Begkhola, Hi' :han Mandali, Barana, Dana
Class IV - Non-sliding	64.41	6.82	Kuine Mangale, Ramche, Histhan Mandali, Sikha Adarsha, Baraha, Dana
Active sliding Territories	2.00	0.21	Sikha Adarsha
Total	943.96	100.00	

Conclusions and Recommendations

Conclusions: The following are conclusions on erosion of the project area:

a. The area is characterized by high sheet erosion, rill and gully erosion as well as bank erosion.

b. The main reason for the high erosion hazard is the high rate of precipitation and the high average annual precipitation.

c. Active landslides are generally located in Sikha Adarsha Panchayat along the Ghar Khola River. Although these are not large masses, they are dangerous for villagers as well as for the cultivated areas.

Recommendations: In view of all these factors, the following are recommended in the project area:

a. Considering the high erosion hazard, deforestation should be prohibited.

b. Highly eroded slopes should be reforested to decrease erosion hazard.

c. Measures should be taken to protect the areas adjacent to active landslides. Afforestation is recommended for this purpose.

d. Embankments should be constructed along the rivers with high bank erosion, especially along the Ghar Khola River in Sikha Adarsha Panchayat.

e. Cultivation in the areas adjacent to the active sliding territories should be either prohibited or better managed.

f. Precautions should be taken to prevent the active sliding areas from further sliding and from other types of erosion. The most important factor here is water flow, which should be diverted from these areas. Plantation of shurbs and grasses can, to some extent, prevent these areas from further erosion.

g. Cultivation on steep slopes should be well managed to protect these areas from erosion.

IV. USE AND MANAGEMENT OF THE SOILS

Agriculture

Rice: The Dandakot, Dhaskhore-Poon Hill and Sikha soils are unsuitable for rice cultivation. The Gharsoona soil is poorly suited for rice. The Ghara and Pangdar soils are poor to moderately suitable for rice. The only moderately suitable soil unit for rice is Toripani.

Maize: The Dandakot and Dhaskhore-Poon Hill soils are unsuitable for maize. The poor to moderately suitable soil units for maize are the Ghara, Kaulegaunda and Pangdar. The highly suitable soils for maize are the Gharsoona Shikha, Nagi and Toripani.

Millet: The Dandakot, Dhaskhore-Poon Hill, Ghara-Toripani soils are unsuitable for millet. The poor to moderately suitable soil for millet is Kaulegaunda and the highly suitable soil units are Gharsoona, Sikha and Nagi.

Barley: The Dandakot, Kauligaunda-Toripani, Dhaskhore-Poon Hill, Ghara-Toripani Pangdar and soils are unsuitable for barley cultivation. The Gharsoona, Sikha Nagi soils are highly suitable for barley.

Wheat: The Dandakot-Kaulegaunda, Dhaskhore-Poon Hill, Gharsoona-Sikha and Pangdar soils are unsuitable for wheat. The highly suitable soils for wheat are the Ghara Toripani and Nagi.

Naked Barley: The Dandakot, Kanleganda-Toripani, Dhaskhore-Poon Hill Ghana-Toripani Nagi, Pangdar and Nagi are unsuitable for naked barley. The suitable soil units for naked barley are Gharsoona and Sikha.

Potato: The Dandakot, Kanlegaunda, Dhaskhore-Poon Hill Ghara, Nagi and Pangdar soils are unsuitable for potato. The suitable soil units are the Gharsoona Sikha and Toripani.

Horticulture

The Ghara and Poon Hill soils are poorly suited for fruit cultivation.

The Dhaskhore and Kaulegaunda soils are poor to moderately suitable for horticulture development. The Nagi-Pangdar and Toripani soils are moderately suitable for peach, plum, pear and citrus fruits and for the vegetables such as cole crops, radish and broad leaf mustard. The moderate to highly suitable soil units for peach, plum, pear, walnut, and apple are Dandakot, Gharsoona-Sikha and Nagi.

Pasture

The Dhaskhore and Gharsoona soils are poorly suitable for pasture development; Ghara, Nagi and Sikha soils are poor to moderately suitable. The Dandakot-Kaulegaunda Toripani soils are moderately suitable for pasture development but the Kaulegaunda soils are poorly suited for grazing. The highly suitable soil units for pasture development are the Poon Hill and Pangdar.

Forest

The Toripani soils are poorly suited for forest development. The Gharsoona and Pangdar soils are poor to moderately suitable for forestry. The Nagi soils are moderately suitable for forest plants. The Dandakot and Sikha soils are moderate to highly suitable for forest growth. The highly suitable soil units for forests are the Dhaskhore-Poon Hill, Ghara and Kanlegaunda.

Fertility Status

Fertility status of the soils of Myagdi district is shown in Table 6. In general the soils of the upper middle Kaligandaki catchment area of Myagdi vary from strongly acid to neutral in pH.

The Poon-Hill soils are strongly acid in reaction. The Toripani and Sikha-Nagi soil have medium acidity. The Dandakot, Ghara, Gharsoona-Pangdar soil, are slightly acid. The Dhaskhore soils are neutral in pH.

The organic matter content of the soils varies from medium to high and very high. The Dhaskhore-Kanlegaunda soils are medium in organic matter. The Ghara-Toripani, Gharsoona-Sikha, and Poon-Hill soils are high and very high in the organic matter content.

The nitrogen content in the soils varies from medium to high. The Dandakot, Kaulegaunda-Toripani Ghara-Toripani, Dhaskhore-Gharsoona and Sikha-Pangdar soils are medium to high in nitrogen. The amount of phosphorus varies from medium to high and very high. The Ghara and Gharsoona soils are medium in phosphorus. The Dandakot-Kaulegaunda-Toripani, Poon-Hill and Sikha and Pangdar soils are high and the Dhaskhore and Nagi soils are very high in phosphorus content.

The soil of the upper middle Kaligandaki catchment (Myagdi) varies from low to high in potassium content. The Dhaskhore and Poon-Hill soils are low in potash. The Ghara, Toripani, Gharsoona and Sikha soils are medium in potash. The Dandakot-Kaulegaunda and Pangdar soils are high in potash.

Table 6 - Fertility Status of the Soils of Myagdi District

Soil Units	pH	O.M.	N	P_2O_5	K_2O
Dandakot, Dk	Slight acid	very high	Medium	High	High
Dhaskhore, Dh	Neutral	Medium	Medium	Very high	Low
Ghara, Gh	Slight acid	High	Medium	Medium	Medium
Gharsoona, Gr	Slight acid	High	Medium	Medium	Medium
Kaulegaunda, Ka	" "	Medium	High	High	High
Pangdar, Pg	Slight acid	-	-	High	High
Poon-Hill, Po	Strongacid	Very high	Medium	High	Low
Nagi, Na.	Med.acidic	-	-	Very high	High
Toripani, To	Med. acid	High	High	High	Medium
Sikha, Si	Med. acid	High	High	High	Medium

APPENDIX I - DESCRIPTION OF SOILS AND ANALYTICAL DATA

Technical descriptions and analytical data available for the main soils recognized in the mapping units are presented in this section. Each class is classified in terms of soil taxonomy. The nomenclature of the USDA Soil Survey Manual (USDA, 1951) and the FAO Guidelines for Soil Description (FAO 1977) have been followed.

Texture is determined according to feel and the color notation follows the Munsell Color Charts (1954). pH is determined in 1:1 soil/water ratio with pH meter and nitrogen by Bray's or Olsen's method, depending upon soil pH, and potassium by flame photometer (Jackson, M. L. 1962).

The classification of soils are mainly based on morphological description of soils with a few analytical data at the time of report writing. Therefore, the classification is considered provisional. It may also be mentioned that only two village panchayats, namely Ghatam and Sikha, had been surveyed by the APROSC Soil Survey Team in 1978. In addition, some informations, was available at the Division of Soil Science and Agriculture Chemistry. Therefore, the soil maps have been organized by using very short information of soils in the Ecological Map of Nepal - I region Annapurna, Dhaulagiri by Doberey, J. F. and Jest, C. 1974. The exact location of all soil boundaries should not be looked for.

1. Dandakot Series

This series is a moderately deep, moderately well drained soil developed on moderately steep to steep bench terraces made up of soil materials derived mainly from slate, schist and phyllite. It is under a forest vegetation consisting of Pinus roxburgi, Rhododendron spp., Schima Wallichii, Castanopsis indica, Barberis asiatica, Lynolia ovalifolium, Myrica nagi, Saroja Nepalenes, Irrs. etc. This soil is classified as a loamy skeletal, mixed, mesic family of Mollisol.

Typical Profile

Location:	Site 8, near Toripani Village, Ghatan Panchayat 1920 m. a.s.l.; Northeast exposure.
O_1 2-0 cm	Raw and decomposing leaf and plant remains.
A_1 0-13 cm	Brown (10 YR 5/3) dry, very dark greyish brown (10 YR 3/2) moist silt loam; weak to medium subangular blocky breaking into fine to medium crumb; friable moist; slightly sticky non-plastic wet; many rock fragments; abundant medium to coarse roots; pH 62; abrupt smooth boundary.

B 13-32 cm — Brown (10 YR 5/3) dry, very dark greyish brown (10 YR 3/2) moist silt loam; single grain, slightly sticky non-plastic wet; many rock fragments; abundant medium to coarse roots; pH 61, clear smooth boundary.

Analytical Data

Lab.	Horizon	Depth cm	pH	P_2O_5 Kg/ha	K_2O kg/ha	% 0.0	% N	C/N	O.M%
M 19	A_1	2-0 0-13	6.2	176.0	149.5	2.06	0.126	16.34	3.54
M 20	B	13-32	6.1	112.0	32.5	1.01	0.119	8.48	1.73
	C	32-62							

2. Dhaskhore Series

This series is moderately deep, moderately well drained soil developed on steep slope made of soil materials derived mainly from schist and phyllite. It is under a forest vegetation dominantly of Quercus semecarpifolia, Rhododendron arboreum and Barberis asiatica.

This soil is classified as a loamy skeletal, mixed, frigid family of Inceptisol.

Typical Profile

Location: Site 4, near Dhaskhore Danda, Sikha Panchayat 2745 m. a.s.l.; Southwest exposure.

O_1 3-0 cm — Decomposing leaf and twigs.

A_1 0-10 cm — Dark brown (10 YR. 3/3) moist; loam; massive; very friable moist; non-sticky, non-plastic wet; few rock fragments; medium to coarse roots common; pH 51, clear smooth boundary.

B 10-28 cm — Dark brown (10 YR 4/3) moist; silt loam, massive; friable moist; non-sticky, non-plastic wet; many rock fragments; medium to coarse roots common; pH, abrupt smooth boundary.

C 28-59 cm — Brownish yellow (10 YR 6/6) moist; very fine sandy loam to loam; massive, friable moist; non-sticky, non-plastic wet; very many rock fragments of weathered schist, few coarse roots; pH 58.

Analytical Data

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M%
O	O_1	3-0							
M 10	A_1	0-10	5.1	88.0	134.0	2.64	0.14	18.85	4.54
M 11	B	10-28	5.4	220.0	91.0	1.96	0.315	6.22	3.37
M 12	C	28-59	5.8	96.0	26.0	0.76	0.035	21.71	1.30

3. Ghara Series

This series is a moderately deep somewhat poorly drained soil developed on moderately steep bench terraces made up of soil materials derived mainly from schist and phyllite. These soils are mainly in maize, wheat and paddy cultivation.

The Ghara series is classified as a loamy skeletal mixed, thermic family of Entisol.

Typical Profile

Location: Site 1, near Ghara Goun, Sikha Adarsa Panchayat, 1520 m. a.s.l.; Northeast exposure.

Ap 0-14 cm Dark olive grey (5 YR 3/2) dry, dark grey (5 YR 4/1) moist; silt loam; massive friable moist; slightly sticky, slightly plastic wet; many rock fragments; fine to medium roots common, pH 69; clear wavy boundary.

Ac 14-44+ cm Greyish brown (2.5 YR 5/2) moist; many distinct fine and medium reddish brown mottles; silt loam; massive weak, friable moist; slightly sticky, slightly plastic wet; very many rock fragments of weathered phyllite and schists; fine to medium roots common; pH 70.

Analytical Data

Lab No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M %
M 1	Ap	0-14	6.9	64.0	19.5	1.06	0.154	6.88	1.82
M 2	Ac	14-41+	7.0	32.0	42.0	0.72	0.147	4.89	1.23

4. Gharsoona Series

This series is a moderately deep, well drained soil developed on moderately steep slope made up of soil materials derived mainly from schist and phyllite. These soils are mainly in barley, naked barley, maize and potato cultivation.

This soil series is classified as loamy skeletal, mixed, mesic family of Entisol.

Typical Profile

Location: Site 3, near Dhase Khore Village, Sikha Panchayat, 2130 m. a.s.l.; Southeast exposure.

Ap 0-19 cm — Very dark grey (10 YR 3/1) moist; loamy sand; massive; friable moist; non-sticky, non-plastic wet; many rock fragments; abundant fine to medium roots; pH 62; diffuse boundary.

A_3 19-69 cm — Very dark greyish brown (10 YR 3/2) moist; sandy loam; friable moist; weak to medium subangular blocky breaking into fine crumb; non-sticky, non-plastic wet; many rock fragments; fine roots common pH 63; clear broken boundary.

C 69-95+ cm — Strong brown (7.5 YR 5/8) moist; loamy sand; massive; non-sticky, non-plastic wet; very many rock fragments of weathered schist; concretions probably of Fe and Mn,; pH 63.

Analytical Data

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M %
M 7	Ap	0-19	6.2	160.0	253.5	1.87	0.21	8.90	3.21
M 8	A3	19-69	6.3	144.0	221.0	0.96	0.147	6.53	1.65
M 9	C	69-95+	6.3	160.0	169.0	0.42	0.077	5.45	0.72

5. Kaulegaunda Series

This series is a shallow, moderately well drained soil developed on rolling to moderately steep bench terraces made up of soil materials derived mainly from schist and slate. These soils are mainly in maize and millet cultivation.

This soil series is classified as a loamy skeletal, mixed, thermic family in Entisol.

Typical Profile

Location: Site 7, near Kaulegaunda, Ghatan Panchayat, 1540 m. a.s.l.; Southeast exposure.

Ap 0-10 cm Greyish brown (10 YR 5/2) dry, dark greyish brown (10 YR 4/2) moist; silt loam; massive, non-sticky, non-plastic wet; many rock fragments; fine to medium roots common; pH 66; clear wavy boundary.

B 10-25 cm Greyish brown (10 YR 5/2) dry, very dark greyish brown (10 YR 3/2) moist; loam; massive; slightly sticky, non-plastic wet; many rock fragments, few fine roots; pH 64; abrupt boundary.

C 25+ cm May be loamy sand materials with many fragments

Analytical Data

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M %
M 17	Ap	1-10	6.6	320.0	617.5	1.44	0.168	8.57	2.47
M 17	B	10-25	6.4	128.0	221.0	0.53	0.098	5.40	0.91

6. Pangdar Series

This series is a moderately deep, moderately well drained soil developed on steep slope made up of soil materials derived mainly from schist. These soils are mainly in maize, wheat, barley and millet cultivation.

This soil classified as coarse loamy, mixed, mesic family of Alfisol.

Typical Profile

Location: Site 5, near Pangdar Village, Sikha Panchayat., 2409 m. a.s.l.

AP 0-0 cm Olive grey (5 YR 4/2) moist, loamy sand; massive; friable moists slightly sticky non-plastic wet; many rock fragments; pH 6.4: abrupt smooth boundary.

B_{21} 9-33 cm Olive grey (5 YR 4/2) moist; silt loam; friable moist; granular, slightly sticky non-plastic wet; many rock fragments; pH 6.5; abrupt smooth boundary.

B_{22} 33-53 cm Olive (5 YR 5/3) brown (7.5 YR 5/4) moist; silt loam; friable moist; weak subangular blocky; slightly sticky, slightly plastic wet; very many rock fragments, pH 6.9.

Analytical Data

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	%C	%N	C/N	O.M%
580	Ap	0-9	6.4	15.46					
581	B21	9-33	6.5	6.18	80.64				
582	B22	33-53	6.9	19.58	59.13				

Source: Division of Soil Science and Agricultural Chemistry, Khumaltar.

7. Poon Hill Series

This series is a deep, moderately well drained soil developed on moderately steep slopes made up of soil material derived mainly of phyllite and schist. These soils are under a forest vegetation predominantly of Abies, Spectabilis, Rhododendron spp., etc. This soil is classified as a fine loamy, mixed, frigid, family of Inceptisol.

Typical Profile

Location: Site 5, near Poon Hill, Sikha Panchayat, 10,200 m. a.s.l.; Southeast exposure.

O_1 2-0 cm — Decomposing grass and plant remains.

A 0-15 cm — Very dark greyish brown (10 YR 3/2) dry, very dark grey (10 YR 3/1) moist; loam; medium to strong subangular blocky breaking into fine to medium crumb; non-sticky, non-plastic wet; few rock fragments; fine to coarse roots common; pH 5.0; clear smooth boundary.

B_2 15-41 cm — Dark grey (7.5 YR 4.0) moist; loam; prismatic angular blocky; breaking into course to medium crumb; slightly sticky, non-plastic wet; many rock fragments; few fine to medium roots; pH 5.7; clear weavy boundary.

C(f) 41-110 cm — Dark grey (7.5 YR 4.0) reddish yellow (7.5 YR 6/6) moist; loam/silt loam; blocky; slightly sticky, non-plastic wet; very many rock fragments.

Analytical Data

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	%C	%N	C/N	O.M.%
M 13	A	0-15	5.0	132.0	97.5	3.86	0.119	32.43	6.63
M 14	B_L	15-41	5.7	32.0	32.5	0.96	0.126	7.61	1.65

8. Nagi Series

This series is a shallow, poorly drained soil developed on bench terraces made up of soil materials derived mainly from schist. These soils are mainly in maize, millet, barley and wheat cultivation.

This soil is classified as a fine silty mixed, mesic family of Nefisol.

Typical Profile

Location: Site PB 44, near Nagi Village Panchayant 2442 m. a.s.l.

Ap 0-12 cm — Very dark greyish brown (10 YR 3/2) moist; silt loam; massive; friable moist; slightly sticky, slightly plastic wet; few rock fragments; pH 5.6; abrupt smooth boundary.

B_2t 12-40 cm — Yellowish brown (10 YR 5/4) moist; silty clay loam; massive, firm moist, very sticky, very plastic wet; many rock fragments; pH 5.8.

Analytical Data

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
2596	Ap	0-12	5.6	305.0	413.95				
597	B_2t	12-40	5.8	16.48	225.79				

Source: Division of Soil Science and Agricultural Chemistry, Khumaltar.

9. Toripani Series

This series is a moderately deep, poorly drained soil developed on moderately steep slopes made up of soil materials derived mainly from schist, phyllite and slate. These soils are mainly in paddy, wheat, maize and potato cultivation.

This soil is classified as a fine loamy mixed, thermic family of Inceptisol.

Typical Profile

Location: Site 9, near Toripani Village, Ghatan Panchayat, 1787 m. a.s.l.; Southeast exposure.

Ap_1 0-11 cm Light brownish grey (10 YR 6/2) dry, dark greyish brown (10 YR 4/2) moist; few medium faint brownish yellow mottles; silt loam; weak subangular blocky breaking into fine crumb friable moist, is non-sticky, non-plastic wet; few rock fragments; fine roots common; pH 5.9; clear smooth boundary.

B_{21} 11-31 cm Greyish brown (10 YR 5/2) dry, dark grey (10 YR 4/1) moist; common fine distinct brownish yellow mottles; silt loam weak angular blocky; breaking into fine crumb; friable moist non-sticky, non-plastic wet; few rock fragments; many fine roots, pH 6.0; abrupt smooth boundary.

B_{22} 31-57+ cm Greyish brown (10 YR 5/2) dry, dark greyish brown (10 YR 4/2) moist; common medium distinct brownish yellow mottles; silt loam, angular blocky breaking into fine crumb; firm moist; many rock fragments; few fine roots, pH 6.5.

Analytical Data

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M%
M 21	Ap_1	0-11	5.9	80.0	104.0	2.100	0.259	8.10	3.61
M 22	B 21	11-31	6.0	16.0	39.0	1.62	0.224	7.23	2.78
M 23	B 22	31-57+	6.5	80.0	110.5	1.07	0.126	8.49	1.84

10. Sikha Series Si

This series is a moderately deep, moderately well drained soil developed on moderately steep slopes made up of soil material derived mainly from schist and phyllite. These soils are mainly in maize, millet, naked barley and potato cultivation.

This soil is classified as a coarse loamy, mixed mesic family of Mollisol.

Typical Profile

Location: Site 2, near Sikha Gharsoona, Sikha Adarsh Panchayat, 2134 m. a.s.l.; Northeast exposure.

Ap 0-15 cm Dark brown (10 YR 4/3) dry; dark brown (10 YR 3/3) moist; gravelly silt loam; weak subangular blocky, breaking into fine crumb; firm moist, non-sticky, non-plastic wet; common fine to medium roots; many rock fragments; pH 6.2; diffuse boundary.

B 15-48 cm Dark brown (10 YR 4/3) moist, dark greyish brown gravelly (10 YR 4/2) mottles; silt loam; strong subangular blocky, breaking into fine crumb; friable moist; slightly sticky, non-plastic wet; few roots; few rock fragments; pH 6.1; clear and smooth boundary.

A_{1b} 48-66 cm Dark greyish brown (10 YR 4/2) moist; loam; strong subangular blocky breaking into fine crumb; friable moist, non-sticky, non-plastic wet; very few rocks; few rock fragments; pH 6.7; diffuse and wavy boundary.

B2 66-80+ cm Dark greyish brown (10 YR 4/4) moist; silt loam; medium subangular block breaking into fine crumb; friable moist; slightly sticky non-plastic wet; few rock fragments; pH 5.9.

Analytical Data

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
M 3	Ap	0-15	6.2	64.0	169.0	1.26	0.147	8.57	2.16
M 4	B	15-48	6.1	48,0	42.0	1.22	0.175	6.97	2.09
M 5	A_{1b}	48-66	6.7	32.0	19.5	1.89	0.21	9.00	3.25
M 6	B_2	66-80+	5.9	32.0	32.5	1.05	0.126	8.33	1.80

REFERENCES

1. Climatic Records of Nepal, 1977, Department of Irrigation, Hydrology and Meteorology, HMG/Nepal.
2. FAO, 1977 Guidelines for soil description, Soil Resource Development and Conservation Service, Land and Water Development Division FAO, Rome.
3. Dobremez, J. F. and Jest, C., 1970. Carte ecologique du Nepal I. Region Annapurna-Dhaulagiri. Laboratoire de Biologie vegetale. Grenoble, France.
4. Stainton, J. D. A., 1972. Forest of Nepal, London, John Murray.
5. Talalov, V. A., 1972. Geology and Ores of Nepal. Final Report Plate No. I.
6. UNDP/FAO, 1975. General Soil Survey of Bagmati and Narayani zones. Increasing use of high-yielding crop varieties and fertilizers, central Nepal, AG:DP/NEP/70/512.
7. USDA, 1975. Soil Taxonomy: A Basis System for Making Interpreting Soil Surveys. USDA Handbook No. 18 with supplement of 1962.

CHAPTER V

SOILS AND GEOLOGY OF UPPER KALIGANDAKI CATCHMENT AREA

(MUSTANG)

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I. PHYSICAL AND ENVIRONMENTAL FEATURES

Location and Extent

The upper Kaligandaki catchment area (Mustang) is located in the Dhaulagiri Zone of the western development region of Nepal. It shares borders with Tibet to the north, Myagdi district to the south, Manang district to the east and Dolpa district to the west. The catchment area lies between 83°28'3" and 84°8'11" east longitude and 28°33'36" and 29°19" north latitude. The total area comprises 3176 sq. km. with a population projection of 14,957 in 1979.

Climate

The Trans-Himalayan zone of Nepal is not exposed to the monsoon rains, but forms rather an arid, semi-desert zone with low precipitation and scarce vegetation. The upper watershed of the Kaligandaki River falls in this region. Mustang lies completely in the rain-shadow and probably forms the desert area of the whole of Nepal with less than 300 mm. of annual rainfall. Southward, Jomsom receives 303 mm. and Marpha receives over 2500 mm. Further south, the total rainfall is reduced, probably because of less orographic effect, with Tatopani receiving only about 1300 mm. Muktinath, lying at a higher altitude (4000 m) in the upper Jhong Khola Valley receives 369 mm., slightly more than nearby, but lower, Jomsom (Department of Irrigation, Hydrology and Meteorology 1977).

Seasonal distribution of precipitation also varies within the region. About 85 percent of the annual precipitation falls at Tatopani. Pre- and post-monsoon precipitation accounts for up to 30 percent, with less than 25 percent of the precipitation occurring in the winter.

Maximum 24 hour rainfall intensities vary up to 300 mm. during the monsoon. Although no snow fall records are available, areas north of and at higher altitudes than Jomsom receive increasingly greater shares of annual precipitation as snow.

The only temperature data for the Mustang region are from Jomsom. Here the January mean minimum temperature drops to 2.6°C, and the July mean maximum is 25°C. An extreme low of 10°C has been recorded, and frost occurs in seven months of the year. The mean annual temperature is about 12°C. Significantly higher temperatures occur southward in the Kaligandaki River Valley. Above the timberline, the mean annual temperature is mostly below 0°C.

No wind records exist for the region. However, high wind velocities are commonly observed in the Jomsom, Kagbeni and Lomantang Valleys, where

summer winds funnel northward, bringing the monsoon rains and snows, and winter witnesses a reversal of prevailing winds as the cold air of the Tibetan Plateau drains southward. The wind could be one of the main alternative resources of energy for this region if proper technology could be employed to tap this resource.

On the basis of altitude, three types of climates prevail in this region. They are:

i)	Cool-temperate	(2000 - 3000 m a.s.l.)
ii)	Sub-alpine	(3000 - 4000 m a.s.l.)
iii)	Alpine	(4000 - 5000 m a.s.l.)

Elevation above 5000 m a.s.l. is perpetually covered by snow.

Physiography and Drainage

Two physiographic regions are represented, the Tibetan Plateau and the Inner Himalays to the south. Most of the region lies above 3000 m. with the highest peaks in excess of 7500 m. The landscape is dominated by the broad geosynclinal through the Kaligandaki River and the snow-clad Annapurna and Dhaulagiri ranges walling the trough. The combination of remoteness, high altitudes, rugged terrain, and harsh climate have limited settlement and land use intensity. Most villages occupy the Kaligandaki River Valley or major tributary valleys.

Most parts of the project area are situated above the head of the Kaligandaki River. The Mustang Chu (Khola) originates north of the Himalayan range and drains in to the Kaligandaki River. Many permanent and temporary tributaries are draining this upper plateau area. The Tange Khola and the Mustang Khola especially drain the northeast parts of this location, while the Chilling Khola, the Samar Khola and the Sangdok Khola drain the northwest parts of the plateau. All the tributaries merge into the Mustang-Chu and after Kagbeni these rivers become the Kaligandaki River. The Kaligandaki River drains about 90 percent area of the catchment. Among the tributaries, the Kagbeni Khola, the Dambush Khola, the Chadziou Khola are the important drainage tributaries of the upper Kaligandaki catchment area. The Kaligandaki River flows through Dhaulagiri, Gandaki and Lumbini zones and finally merges into the Marayani River of the Narayani zone.

Drainage of the Kaligandaki River is considered not to be a problem because of the low precipitation and low probability of flooding.

Natural Vegetation

The following description of the natural vegetation is in accordance

with the ecological map of J. F. Dobremez and C. Jest (1970).

1. Broadleaved Trees - Pine Forest

   Between Dana and Lete, the natural vegetation is mainly represented by Quercus semecarpifolia and Pinus excelsa. Other important vegetation includes Tsuga Dumosa, Taxus baccata and Abies spectabilis, Spp. of Rhododendron, Sorbus, Evonymus, Vibrnum, and Prunus. Salix and Ribes are also found in abundance.

2. Pine Forest

   Pine forests grow mainly between 2500 to 4200 m. They are found mainly at Lete, Largung, Tukuche and Chim in the upper Kaligandaki catchment area.

3. Sophora - Oxytropis Steppe

   Steppe vegetation consisting of Sophora moorcroftiana and Oxytropis sericopetala is found in the lower part of Upper Kaligandaki catchment area. This is a dry area of constant violent winds. Other notable vegetation includes Berberies mucrifolia, Ephedra gerandiana, Lonicera hypoleuca and Incarvillea arguta.

4. Caragana - Artemisia Steppe

   Up to 4200 m., a type of steppe vegetation very rich in species such as Caragana gerardiana and a certain number of Artemisia sp are found. Other vegetation consists of Rosa serica, Lonicera minutifolia, Spirae bella, Spiraea arcuata, Ribes orientalis, and Berberis angulosa.

5. Caragana - Lonicera Steppe

   Between 4200 to 5100 m. steppe vegetation consists mainly of Caragana brevispina and Lonicera spinosa which provide only poor pasture to yaks inhabitating in the northern part of Himalaya.

Land Use

Current land use of the Upper Kaligandaki Catchment area is described as follows:

Forest: About 103.24 km^2 area of the catchment area is under forest, which is nearly 6.60 percent of the total area. The important natural vegetation of this region has already been discussed. The southern part of the project area is more dense with pine forest than the northern area. Between Dana Lete, the natural vegetation is mainly Quercus semecarpifolia and Pinus excelsa. This is the densest forest area compared to other sites. The central part of the project area has thicker forest than the higher northern

plateau. The area south of Jomsom provides high quality and dense forest stands. Above Jomsom, the alpine forests are scattered in patches. Between Samar and Chhunga, there exists a moderately thick pine forest. Several areas in higher altitudes contain scarce vegetation, giving the impression of a desert.

Cultivated Lands: The cultivated land occupies the lowest area in the Kaligandaki catchment basin. About 36.83 km^2 are under farming, which is only 2.35 percent of the total area. The climatic difference in the project area between the north and south naturally results in a different cropping pattern. In the comparatively warm humid south, maize and millet are produced. The farther north one goes, the more the cultivation of crops diminishes. Paddy is not grown in the trans-Himalayan part of the project area. Instead, wheat, buckwheat and naked barley are grown. In the extreme north, only wheat is grown.

Population densities are low throughout the region. Intensive agriculture is practiced mostly in the river valleys that have adequate irrigation facilities. The limited amount of crop land is due primarily to the lack of irrigation and water development in this region. Additional fertile soils, mostly on river terraces are available, but to date remain uncultivated due to the lack of developed water resources.

Pasture Lands: 547.67 km^2 nearly 34.56 percent of the total area, is under pasture. Pasture land occupies the second largest area in the catchment, after rock out-crops. The Upper Kaligandaki catchment area has great scope for developing improved pasture. At present, almost all the area is under wild pasture. Crop farming and livestock and husbandry are widely practiced in Lete, Kobang, Marpha, Jomsom, Kaisang, Kagbeni and up to Muktinath. But mostly, the higher plateau areas, such as Samar, Chhunga, Charang, Marang and Lo-Mantang, predominate in animal husbandry. Wild grazing is very common.

Snow-Covered Land: The higher mountain ranges such as Annapurna, Nilgiri and Tukuche, are located within the project area. As a result, the altitudinal differences within the project area are very high. Most of the catchment area is temporarily covered with snow especially from November to April. The higher the altitude, the more snow cover. The total area permanently occupied by snow is estimated to be 89.88 km^2, or about 5.74 percent of the total catchment area.

Rock Outcrops: More than half of the area of the Upper Kaligandaki

Catchment is under rock outcrops. This is an area of nearly 889.20 km^2, comprising 56.8 percent of the total area. Comparatively higher altitudes have large areas of rock outcrops.

Others: These categories include gravels, stones, rivers, gullies and landslides. About 2.35 km^2 of land, nearly 0.15 percent of the total area, is covered by these categories.

II. GENERAL NATURE OF THE SOILS

A. Methodology

Mapping and Classification of the Soils: The soil survey was done on a broad reconnaissance scale, with the primary objective of identifying and recommending the inventory needs for intestigating and planning sectoral projects. Lack of time was one of the main obstacles in the soil survey.

Topographical maps were not available for the far northern parts of the upper Kaligandaki catchment area. For the rest of the area, topographical maps with a scale of 1:63,360 were used. Besides this topographic map, NH 44-16 (1:250,000) prepared by U.S. Army, and an Ecological map of the Annapurna-Dhaulagiri area (1:250,000) prepared by J. F. Dobremez and C. Jest (1970) were also used while preparing soil maps.

Thirteen pits were dug and described in detail according to the Soil Survey Manual and Soils were classified according to Soil Taxonomy (USDA, 1975). Soils were examined in soil pits and notes on topography, vegetation, geology and other physical features were recorded on field sheets. During field work, use was made of the FAO Guidelines for Soil Descriptions (FAO, 1977).

Special correlation boxes developed by Charter and Brammer (Brammer, 1965) were used for soil correlation as well as for retention of representative soil profiles in the soil museum.

During the field work, soil samples were collected for laboratory analyses. The samples were analyzed for pH, organic matter, nitrogen, phosphorus and potassium for use in soil classification.

Description of the mapping units follows. See Sheet No. I.

B. Description of Mapping Units

1. Chhunga-Marang-Muktinath-Samar Soil (Ch-Ma-Mu-Sa)

The Chhunga-Marang-Muktinath-Samar soil unit occurs in the central part of the mapped area on easy rolling bench terraces to steep slopes. These soils are shallow, moderately deep to deep, moderately well drained to well drained and are made up of materials derived mainly

from alluvium/colluvium, slaty phyllite and schist materials. Soil texture varies from sandy loam, silt loam or sandy clay loam.

Chhunga Soil

Altitude	3350 to 3650 m. Exposure: Variable.
Surface Soil	Pale brown to dray greyish brown, friable, sandy loam to loam, 10-24 cm. thick, many rock fragments
Sub-Soil	Yellowish brown to dark yellowish brown, friable, sandy loam to loam, 30-100 cm. thick, many rock fragments.
Substratum	May be light yellowish brown silt loam with many rock fragments.
Other Properties	Strong to moderately alkaline, low in organic matter, medium in nitrogen and phosphorus, and high in potash.
Suitability	
Agriculture	Unsuitable except for very short duration crops in a few places.
Horticulture	Poor for orchard development; in some places apple and cole crops, peas, etc. are grown.
Pasture	Moderate to highly suitable for pasture. These soils are utilized for grazing goats, sheep and, to some extent, cows. About 50 percent of this soil unit is under natural pasture.
Forest	Poor for forest development. In some places, few forest trees are observed.
Limitations	Cool to cold arid climate, snow fall (about half of the year), high wind velocity, susceptibility to channel erosion from melting snow, many rock fragments on or near the soil surface, and strongly alkaline pH.

Marang Soil

Altitude	3350 to 3650 m. Exposure: Southeast.
Surface Soil	Dark greyish brown to very dark grey, friable, loam/silt loam, 15-20 cm. thick, few rock fragments.
Sub-Soil	Dark greyish brown to very dark friable, silt loam, 60-90 cm. thick, few rock fragments.
Substratum	May be: a) poorly sorted alluvial/colluvial materials from large boulders to silt, b) silt loam materials with many rock fragments mainly from phyllite and schist.

Other Properties	Moderately alkaline, medium in organic matter, high in nitrogen, very high in phosphorus and potash.
Suitability	
Agriculture	Moderately suitable for wheat and buckwheat; about 90 percent of this area is under cultivation.
Horticulture	Moderately suitable for apple and strawberries, radish and cole crops (some of them recently introduced).
Pasture	Moderately suitable for pasture; some areas have thorny bushes which are consumed by domestic animals.
Forest	Moderately suitable for alpine and subalpine forest.
Limitations	Cool to cold arid climate; snow fall (snow covers the area for about 6-7 months of the year), high wind velocity, susceptibility to erosion, many rock fragments on or near the soil surface; moderately alkaline pH.
Muktinath Soil	
Altitude	About 3500 m. Exposure: Northwest.
Surface Soil	Black, friable, sandy clam loam, 15 cm. thick; few rock fragments.
Sub-Soil	Black, firm, sandy clay loam, 80 cm. thick, few rock fragments.
Substratum	Moderately alkaline, medium in organic matter and potash, high in nitrogen and phosphorus.
Suitability	
Agriculture	Moderately suitable for buckwheat, naked barley (uwa), barley, wheat and potato. About 30 percent of this soil unit is under these crops.
Horticulture	Moderate to highly suitable for apple, cabbage, cauliflower and radish. Presently farmers are not growing fruits and vegetables.
Pasture	Highly suitable for pasture. The major portion of these soils are under natural pasture. Range management could be developed.
Forest:	Moderately suitable for alpine and subalpine forest. In some places, popular trees are planted and they are in good condition.
Limitations	Cool to cold arid climate (a main restriction). Susceptible to erosion, snow fall (snow covers the area for about 4 months of the year), high wind velocity, moderately alkaline pH.

Samar Soil

Altitude	About 3500 m. Exposure: Northeast.
Surface Soil	Dark brown, friable, loam 30 cm. thick, few rock fragments.
Substratum	May be hard rock in situ.
Other Properties	Moderately alkaline, very high in organic matter, high in nitrogen and phosphorus and medium in potash.
Suitability	
Agriculture	Poor to moderately suitable for buckwheat. Only about 5 percent of the soils of this unit was under buckwheat cultivation at the time of the field survey in May 1979.
Horticulture	Moderately suitable for apple, cole crops and radish. At present no activities are being carried out for horticultural development.
Pasture	Highly suitable for pasture. Livestock such as goats, sheep, and yaks are concentrated in the area.
Forest	Moderate to highly suitable for forest. One forest nursery has been established near Samar village.
Limitations	Snow fall, (snow covers the area for about half of the year), high wind velocity, susceptibility to erosion, droughtiness both in winter and summer; moderately alkaline pH, moderately steep topography, cool to cold arid (one of the crucial limiting).

2. Chhairo-Marpha-Syang Soil (Cr-Mr-Sy)

The Chhairo-Marpha-Syang soil unit occurs along the Kaligandaki River in the central part of the mapped area on flat to gently undulating river terraces to easy rolling bench terraces. These soils are shallow to moderately deep, moderately well drained to well drained and are made up of colluvial materials derived mainly from phyllite and schist. Soil texture varies from loam to silt loam.

Chhairo Soil

Altitude	About 2600 m. Exposure: West.
Surface Soil	Light grey, firm, loam 10 cm. thick, many rock fragments.
Sub-Soil	Grey, firm, silt loam, 2.5 cm. thick, many rock fragments.
Substratum	May be, a) poorly sorted alluvial/colluvial

	materials from large boulders to silt, b) silt loam materials with many rock fragments mainly from phyllite and schist.
Other Properties	Moderately alkaline, very high in organic matter, high in nitrogen and phosphorus and low in potash.
Suitability	
Agriculture	Poor.
Horticulture	Poor to moderate.
Pasture	Highly suitable for forage crops. At present, the existing forage-crops are wheat grass, lucerne, clover, rye grass and others.
Forest	Moderate to highly suitable for forest. Reforestation would be of crucial importance to this unit.
Limitations	Cool and arid climate, snow fall, (about four months in a year) high wind velocity, many rock fragments on or near the soil surface, moderately alkaline pH.
Marpha Soil	
Altitude	About 2600 m. Exposure: Southeast.
Surface Soil	Dark grey, friable, loam to silt loam; 20 cm. thick; few rock fragments.
Sub-Soil	Dark grey, friable, silt loam, 50 cm. thick, few rock fragments.
Substratum	May be dark grey silt loam with poorly sorted alluvial/colluvial materials.
Other Properties	Moderately alkaline, medium in organic matter and nitrogen, high in phosphorus and low in potash.
Suitability	
Agriculture	Moderately suitable for barley, buckwheat, naked barley and potato.
Horticulture	Highly suitable for fruits such as apple, grape, peach, plum, walnut, apricot, strawberries and vegetables like broad leaf mustard, cauliflower, cabbage, Kholkhol, peas and carrots. The Marpha Horticulture Farm is located in this area.
Pasture	Moderately suitable for forage crops and grazing.
Forest	Moderately suitable for forest development.
Limitations	Cool, semi-arid climate, droughtiness in both winter and summer, susceptible to erosion, high velocity of wind, hailstorms, snow fall, soil alkalinity, low potash status.

Syang Soil

Altitude	About 2600 m. Exposure: East
Surface Soil	Very dark grey, friable; silt loam; 15-20 cm. thick; few rock fragments.
Sub-Soil	Very dark grey, friable, silt loam, 45 cm. thick, few rock fragments.
Substratum	May be stones and boulders of phyllite.
Other Properties	Moderately alkaline, very high in organic matter, high in nitrogen, phosphorus and potash.
Suitability	
Agriculture	Moderate to highly suitable for barley, naked barley and buckwheat.
Horticulture	Moderate to highly suitable for apple, peach, plum, apricot, walnut and grape. Suitable vegetables include broad leaf mustard, cauliflower, cabbage, knolkhol, radish. At present, there is intensive arable farming in these soils.
Pasture	Poor to moderately suitable for pasture.
Forest	Poorly suitable for forest.
Limitations	Snow fall, high wind velocity, susceptibility to erosion, droughtiness in both winter and summer moderately alkaline pH, cool, arid climate (a main limiting factor).

3. Kaisang-Tukche Soil (Ka-Tu)

The Kaisang-Tukche soil unit occurs in the southern part of the catchment aand the eastern side of Cr-Mn-Sy soil unit are on flat to undulating river terraces to steep hill slopes. These soils are shallow to moderately deep, well drained and are made up of alluvium/colluvium materials derived mainly from phyllite and schist. Silt texture varies from gravelly loam to gravelly silt loam or silt loam.

Kaisang Soil

Altitude	3350 m. Exposure: Northwest.
Surface Soil	Greyish brown, friable, gravelly loam, very many rock fragments, 9 cm. thick.
Sub-Soil	Light yellowish brown, friable, gravelly silt loam, very many rock fragments, 50 cm. thick.
Substratum	May be alluvium/colluvium materials.
Other Properties	Moderately acid, very high in organic matter, high in nitrogen, phosphorus and medium in potash.

Suitability

Agriculture	Unsuitable for farming.
Horticulture	Moderate to highly suitable for apple, grape, apricot and walnut; suitable vegetables include cole crops, peas, potato and radish.
Pasture	Moderately suitable.
Forest	Highly suitable for forest development.
Limitations	Cool to cold arid climate (a main limiting factor). Susceptibility to erosion, droughtiness in winter and summer, many rock fragments on or near the soil surface, snow fall (snow covers the area nearly half of the year).

Tukche Soil

Altitude	About 2550 m. Exposure: Southeast.
Surface Soil	Dark greyish brown, friable, loam to silt loam, 10-15 cm. thick, many rock fragments.
Substratum	May be stones and boulders of phyllite and schists.
Other Properties	Moderate to strongly alkaline, high in organic matter, nitrogen, phosphorus and potash.

Suitability

Agriculture	Highly suitable for naked barley and potato; moderately suitable for wheat and maize.
Horticulture	Moderately suitable for orchard development.
Pasture	Moderate to highly suitable for range development.
Forest	Poor to moderately suitable for forest development
Limitations	Cool, arid climate, snow fall (about four months in a year) high-wind velocity, susceptibility to erosion, many rock fragments on or near the soil surface, moderate to strongly alkaline pH.

4. Mantang-Morang Soil (Mt-Ma)

The Mantang-Morang soil unit occurs in the northern part of the mapped area on flat to undulating terraces. These soils are shallow, moderately well drained and are made up of materials derived mainly from alluvial/colluvial material. The soil texture is silt loam.

Mantang Soil

Altitude	About 3650 m. Exposure: Northeast.

Surface Soil	Dark greyish brown, friable, silt loam, 25 cm. thick, few rock fragments.
Substratum	May be, a) poorly sorted alluvial/colluvial materials with many rock fragments or b) hard rock *in situ*.
Other Properties	Moderately alkaline, medium in organic matter, high in nitrogen, very high in phosphorus and potash.
Suitability	
Agriculture	Moderately suitable for naked barley and buckwheat.
Horticulture	Moderately suitable for apple.
Pasture	Highly suitable for pasture development. About 40 percent of the soils of this series is under natural pasture.
Forest	Poor to moderately suitable for forest trees. Popular trees, still in very good condition, were planted on the bank of the Lomantang Khola.
Limitations	Cool to cold climate; susceptibility to erosion, droughtiness in winter and summer; many rock fragments on or near the surface; snow fall (snow remains nearly half of the year), high wind velocity, moderately alkaline pH.

Manang Soils

These soils have been described under mapping unit Chhunga-Marang-Muktinath-Samar (Ch-Ma-Mu-Sa).

III. GEOLOGY AND EROSION

A. GEOLOGY

1. Stratigraphy

The area consists of metamorphosed sedimentary rocks of Paleozoic, Mesozoic and Cenozoic groups and of granite bodies (Sheet No. II). The Paleozoic group is represented by rocks of all three divisions. All the systems of the Mesozoic group are represented in the area.

Quarternary rocks and soils are widespread in the catchment. In the northern part, one-third of the area is covered by quarternary alluvium. The granite bodies have existed from the Tertiary period.

Paleozoic Group

The paleozoic group consists of a complex of the Cambrian and the Ordovician as well as Silurian, Devonian, Carboniferous and Permian systems. This group is located in Lete Kunje, Kowang, Tukuche, Marpha,

on the right bank of the Kaligandaki River in Kagbeni, Chhusang, and Dhami, and on the left bank of the same river in the north of Surkhang Panchayat.

Cambrian and Ordovician Systems

The above complex is represented by the Himal suite, which occurs at the southern end of the catchment.

Himal Suite (C + O hm): This is a complex formation of grey granitized schists and quartzites with bands of limestone. These rocks are high to moderately consolidated, slightly weathered and fractured.

The suite has a normal contact in the west with the Silurian rocks, whereas the Devonian rocks lie on its denuded surface. It has an east-west trend.

The Himal suite is found in Lete and in the southern part of Kunje Panchayat. Its maximum thickness is about 9000 meters.

Silurian System (S)

The Silurian system is represented by white to light yellow limestone. The limestone is highly consolidated, slightly fractured and slight to moderately weathered. Karst was not noticed in this rock. It has an average east-west trend.

This system is located in Lete and Kunje Panchayats. Its maximum thickness is 3000 meters, but at some places it is completed denuded. The system lies normally on the rocks of Himal suite, and it has a normal contact with the Devonian rocks which lie on it.

Devonian System (D)

The Devonian system consists of agrillo-sericite schists and phyllites. These light to dark-brown, greyish brown rocks are found in Kunje, Kowang, Tukuche, Marpha, Kagbeni and Chhusang Panchayats. They have a NW-SE trend. The system is located at the right bank of the Kaligandaki, except in Kunje Panchayat, where it is located at the left bank of the river.

The Devonian rocks are weak to moderately consolidated, highly weathered and finely factured. The system is highly developed in the catchment. It lies normally on the Silurian rocks, but very often the Permian rocks lies on its denuded surface. In some places, it has a normal contact with the Carboniferous rocks, lying on the rocks on the Devonian system. Its thickness is about 3000 meters.

Carboniferous System (C)

The Carboniferous system is represented by white to yellowish-white, high to moderately consolidated, moderately fractured and moderately weathered limestones. They mostly have a normal contact with both the underlying and the overlying rocks. Very rarely do they have a denuded contact with the Silurian rocks. Where the Devonian rocks are absent, they have an abnormal contact.

This system is located in Kunje, Dhami and Chhoser Panchayats. Its maximum thickness is around 1500 meters.

Permian System (P)

This system consists of metamorphosed shales, phyllites and schists. These rocks are moderately consolidated but they are highly weathered and fractured. All these rocks are generally brown in color. They are located in Kowang, Tukuche, Marpha, Dhami and Chhoser Panchayats.

This system normally lies on the Carboniferous rocks and generally has a normal contact with the Triassis rocks. In Dhami Panchayat only, it has a denuded contact with the Jurassic rocks. Its maximum thickness is about 1500-2000 meters.

Mesozoic Group

The Mesozoic group is represented by the Triassic, Jurassic and Cretaceous systems. This group is widespread in the territory. It is located in Kunje, Kowang, Tukuche, Marpha, Jomsom, Jharkot, Muktinath, Chhusang and Gurkhang Panchayats on the left bank of the Kaligandaki, and on the right bank of the Chasang Kaligandaki in Lomanthang Panchayats.

Triassic System (T)

In the upper Kaligandaki catchment, the Triassic system is represented by limestones (mainly organic) and quartzites with rare bands of phyllites. In general, these rocks are light colored, very often white. They are high to moderately weathered. They are found in Marpha, Dhami, Surkhang and Chhoser Panchayats.

The Triassic system has a normal contact with the overlying Permian and the Jurassis rocks respectively. Its maximum thickness is about 3500 meters.

Jurassic System (J)

This system is represented by the lower and the middle divisions and

is found in Surkhang and Chami Panchayats. Moreover, these rocks are found in combination with the cretaceous rocks in Chhusang, Muktinath and Jharkot Panchayats. They are widespread in the catchment.

Lower Jurassic Division (J 1)

Rocks of the lower Jurassic division are found in Surkhang, Ghami, Chhusang, Muktinath and Jharkot Panchayats. These rocks are represented by litic limestones and sandstones. These moderately consolidated rocks are slight to moderately fractured and slightly weathered. The limestone is generally white to yellowish-white in color, while sandstone is brownish. The sandstone is generally composed of quartz sand with clay cement.

The thickness of the division is about 2500 meters.

Middle Jurassic Division (J 2)

Brown to reddish-brown, greyish-brown congolomerates are the main components of this division, which is found in Chhoser Panchayat. The conglomerates are moderately consolidated, slightly weathered and slightly fractured. The thickness of this is about 1500 meters (maximum).

Integrated Jurassic and Cretaceous System (J+K)

The Integrated Jurassic and Cretaceous system is located in Chhusang and Muktinath Panchayats. These are shales, glaukonitic sandstones and conglomerates. These rocks are light to dark green, brown and dark grey to black in color. They are generally slight to moderately consolidated, moderately fractured and moderately weathered. Dark green to black shale is high to moderately consolidated. The estimated thickness of this system is about 6000-7000 meters.

Cretaceous System (K)

Cretaceous rocks occur on the northern side of the catchment, but at some places on the left bank of the Thak Khola, the system is also located in the central and the northern part of the territory. The system is widespread in the project area. It occurs in Jomsom, Surkhang, Marpha, Charang, Lomanthan, Dhami and Chhonhup Panchayats.

The system is represented by dark green, dark greenish grey glaukonitic sandstones, which are moderately consolidated, slightly fractured and slight to moderately weathered. Generally, the rocks of the Cretaceous system are on steep to very steep slopes, but they are

high to moderately stable in their initial position. The system has a sublongitudinal trend. Its thickness is about 3000 meters.

Cenozoic Group

Quarternary System (IV al)

Quarternary alluvium is highly developed in the Kaligandaki catchment area. These rocks are generally developed along the river beds, but in the north and in the far north of the project area, they occur almost everywhere. More than 50% of the far north area is occupied by this system.

In the northern area (Chhunga and beyond), the alluvium is represented by unconsolidated conglomerates, which are composed of pebbles, gravels and boulders of granite, and are cemented by clay. These rocks are brown to red and often form canyons. These canyons are highly stable in the catchment.

South of Chhunga Village, the size of the granite pieces decreases; hence, medium to fine conglomerate and gravellite are formed, though the character of the cement remains the same. These rocks are similar to the northern conglomerates in color and form similar canyons in the central part of the watershed. These fine to medium conglomerates are found from the south of Chhunga Village to Chaile Village.

In the south of the catchment and in the central part, the character of the alluvium changes and it is represented by shale conglomerates, sands and other sand clay horizons.

In Jharkot Panchayat, this alluvium is represented by conglomerates which are composed of sandstone-gravel, quartzite-gravel and pebbles.

The quarternary system is generally not thick, but its thickness changes, varying from zero to several hundred meters.

Intrusive Rocks

Intrusive rocks are located in the far northeast and the far northwest in the catchment basin. These rocks are represented by narrow granite bodies, which mainly consist of quartz, feldspar, tourmaline, and mica (mainly muscovite). These granite bodies are located in Chhonhup and Chhoser Panchayats.

The time of the intrusion of these rocks is still under question though it is clear that intrusion occurred after the Cretaceous period. It can be speculated that this occurred in the Tertiary period, when the territory was folding (at the final stage of the geosynclinal regime).

According to the geological map of Nepal (Iatalov, 1972), the granites are parts of the granite bodies of southern Tibet (China).

The granite bodies are intruded in the rocks of the Cretaceous system,hence they must be younger than the existing rocks of that system.

2. Structure

The upper Kaligandaki catchment area is structurally complex. The geological structure of the catchment is dominated by a large number of synclines and anticlines. With the exception of the far southern part of the territory, the two sites of the Kaligandaki River have different structures. These two sides appear to be separated by a big fault along the river.

The far southern part of the territory there is a large syncline, whose axis lies in the Devonian rocks. Both its flanks have an inclination of about 20-25 degrees with local variations between 10° and 30°. Its axis strikes from northwest to southeast. The influence of this syncline is high in the south, whereas in the north, its influence is cut off by an anticline lying along the Silurian rocks. The southern flank of the anticline is gently inclined to the south, though its northern flank is steep. The anticline is seen only on the left bank of the Kaligandaki whereas on the right bank, no Silurian rock or anticlinal axis is noticed. In the areas north of the anticline, the axis on the sides of the river shifts to a north-south direction.

A steep syncline was noticed in the Permian rocks in the north of this anticline. Its axis strikes parallel to the axis of the anticline. Its flanks have an average inclination of about 40°, with local variations between 25° and 60°. This synclinal axis is shifted to the north. The Tukuche anticline has cut off the influence of this syncline and we find the rocks inclined to the other side, which forms the axis of the anticline. This axis is seen in the rocks of the Permian period. It is parallel to the southern synclinal axis, and its flanks are very steep. The average inclination of the southern flank is about 30° with local variations between 20° and 45°. The northern flank is more steep, with an average inclination of about 60°, with local variations between 40° and 80°-85°.

A slightly inclined syncline occurs in Marpha Panchayat in the rocks of the Triassic period. The flanks are slightly inclined to both sides,

with average inclination of about 10°-10°, and local variations between 5° and 20°.

The effect of the Tukuche anticline is cut off by the axis of a slightly inclined syncline in the rocks of the Triassic period in Marpha Panchayat. The synclinal axis is parallel to the Tukuche anticlinal axis. This synclinal behavior is noticed only some kilometers in the north, which is diverted by a steep anticline in the Permian rocks of northern Marpha. The axis of the anticline is parallel to the synclinal axis, but the average inclination both of its flanks is about 80°-85°. Its northern aspect is a little steeper than the southern one. This anticline can be called the Nilgiri anticline, as it extends up to the Nilgiri mountains.

A number of synclinal and anticlinal axes were observed in Jomsom, Jharkot and Chhusang Panchayats. These axes have a similar NW to SE trend. Their flanks are very slanted, with local variations between 10° and 30°. Some of the northern flanks are rarely very steep with variations of their amounts of dip up to 60° and above. These folds have a high influence in the land form of the area, though the morphology of the area is highly altered by glacial erosion.

These minor and major folds are altered in the north by the anticline of the Triassic rocks in Surkhang Panchayat. Though the axis of the anticline is parallel to the above mentioned axes, its flanks are steep to very steep. Its southern flank is inclined to the south with an average inclination of about 40° and local variations between 30° and 40°-45°. However, the northern flank is steeper.

The rest of the structure in the northern part of the territory is unknown since the area has not been surveyed.

The geological structure of the right bank of the Kaligandaki River is described as follows going north to south.

In Dhami Panchayat, there is an anticlinal axis in the Permian rocks. Its axis is slightly diverted from NW to the north and the northern and eastern flank is very steep with an inclination of about 60°-65°. The influence of the anticline is cut off by a synclinal axis of the Triassic rocks in Dhami Panchayat, which has a trend parallel to the axes of the other bank. Its northern flank is steep but the southern flank is rolling to moderately steep, and is further complicated by a number of synclines and anticlines of II grade.

In Chhusang, Kagbeni and Marpha Panchayats, the Devonian rocks have been smashed by a huge number of small anticlines and synclines that have very slight to slightly inclined flanks. In some very rare cases, they are very steep, with inclinations well above 50 degrees.

In the southern part of Marpha Panchayat there is a synclinal axis. These anticlines and synclines have rolling to moderately steep flanks. This axis occurs in the pormian rocks and is parallel to all the mentioned above.

About two kilometers south of this syncline, there is an anticlinal axis whose flanks are moderately steep to steep with local variations between 30° and 60°. This anticlinal axis occurs in Devonian rocks. The parts close to the rivers are inclined at an angle of about 30°-35°. In the southern part of the same Panchayat, a synclinal structure cuts off the influence of this anticline. The anticline has a rolling southern flank whereas its northern flank is moderately steep.

All the above mentioned structures are complicated in the north by three megafaults, two of them striking NW to SE and the third striking west to east. These faults have not been well studied.

Two comparatively small bodies are intruded in the rocks of the Cretaceous system. As determined by an examination of the sediments brought by the Mustang Chu River, these are tourmaline-granite bodies, with "sherl" as one of their main components. The precise time of intrusion is unknown, although it is clear that it happened after the Cretaceous period. These granite bodies are the southern ends of the Tibetan granites.

3. Geological History

The geological history of the upper Kaligandaki watershed can be traced from the Cambrian period up to the modern age.

The basin, which existed in the beginning of Paleozoic era, continued up to the end of the Mesozoic era. However, the area covered by the water pool was receding and by the end of the Mesozoic era, the basin had completely unnisted.

In the Cambrian period, the basin was shallow where sedimentation of coarse to medium material took place. The depth and the regime of the basin changed a number of times, creating good conditions for sedimentation of carbonate materials. As the formation of the Mahabharat range was proceeding in the south, the basin was disappearing from the

southern part of the territory at the end of the Ordovician period.

In the Silurian period, the basin was warm and quiet, and sedimentation of carbonate material (calcium carbonate) took place. The surface area of the basin kept receding in the Silurian period, at the end of which the southern boundary of the sea had shifted a number of kilometers to the north.

In the Devonian period, the basin was shallow and quiet and fine to medium material was deposited. The rivers feeding the basin in the period were also quiet. The river materials were being brought from the south, where Paleozoic and the Precambrian mountains already existed.

The conditions of sedimentation in the Carboniferous period was similar to those of the Silurian time and the deposits at the bottom of the basin were similar.

In the Permian period, the shape and size of the basin changed a number of times, though the conditions of sedimentation remained similar and deposition of fine clay to medium sized material took place. The climate of the area was cold, hence, no carbonate formation occurred.

The basin disappeared from the right bank of the territory especially after the Devonian period.

The basin was changing its size and depth in the Triassic period, when coarse, medium and carbonate material was settled. The boundary of the basin was also oscillating in the Triassic period.

In the beginning of the Jurassic period, the basin was shallow and carbonate as well as coarse-grained materials were sedimented. The climate of the region in that period was changing, alternating from cold to warm and humid climates. During this time, the materials of Oolitic limestone formations (carbonate material) were setteled at the bottom of the basin.

The regime of the rivers feeding the basin was not quiet. These rivers brought very coarse to coarse materials that were deposited at the basin bed. These materials were gravels, boulders of coarse sands, from which conglomerates were formed.

In the integrated Jurassic and Cretaceous periods, the sediments were changing their character according to the conditions of the sedimentation process. The deposits were clay, silt and sand materials, from which shales, glukonitic sandstones and congolmerates were formed. The basin was inhabited by ammonites, belemnites, etc. These fauna are found in abundance in the shales.

In the Cretaceous period, the basin was shallow, and sedimentation of coarse-grained material took place. By the end of the cretaceous period, the basin had disappeared from the territory. This occurred as a result of foldings of the Alpine foldings of the Mesozoic era.

The history of the Kaligandaki river can be traced from the formation of the high mountains, which began to serve as a drainage for marine water in the Tertiary period, and later as a drainage of the waters from melted snow as well as for rain water.

In the beginning, the Kaligandaki River was a zig-zag line, following fault lines and weak areas. It started eroding land and its modern shape was formed as a result of this erosion.

Later on the mountains rose very high and the accumulation of snow increased as a result of this river, together with its tributaries, started receiving more water, which led to cause more erosion. The weight of the accumulated snow became unbearable for the weak, silt-cemented rocks, which gave rise to the formations of big active landslides. These occurred in directions of siltation.

Large lands of alluvial terraces were formed in places where the Kaligandaki River and its tributaries had formerly eroded.

4. Geomorphology

The geomorphology of the area is closely related to processes which occurred in the past, some of which are still occurring. In the project area, three main processes helped to form the present shape of the territory.

a. Folding of the territory in the past: The final stage of folding of the territory occurred in the Tertiary period, as a result of which many mountains were raised in the area. This was the end of the geosynclinal regime in the area. After the mountains were formed, they began to be denuded in complex ways by water, wind, sun radiation, snow, etc.

b. Alluvial processes: Alluvial processes are responsible for the formation of the large pockets of alluvial terraces and valleys. The formation of the alluvial terraces and valleys coincided with the formation of the Kaligandaki River, which occurred just after the folding of the territory in the Tertiary period and the formation of the high mountains with snow covered peaks. The river then served as a drainage for the melted snow.

c. Glacial: Glacial processes were one of the main agents of erosion in the watershed. Glacial movements denuded and flattened the steep mountains, as a result of which concave and convex landforms were created.

At present the following geomorphological units are recognized in the project area:

i) Flat, horizongal or easy rolling alluvial terraces: These areas are scattered in the catchment area. They are located in intermediate, high and very high altitudes in the watershed. Alluvial processes are negligible in high and very high terraces, whereas in the intermediate terraces, these processes are significant. In the intermediate terraces, the glacial processes are negligible. Rills and gulleys are highly developed in these terraces. In the high and very high terraces, rill and gulley erosion is very high; whereas in the intermediate terraces, sheet erosion is very high, although rill and gulley erosions are not uncommon. Aolian processes in the intermediate terraces are negligible.

ii) Eluvial and colluvial fans: These fans are located in all the Panchayats of the watershed. Soil depth in these fans is shallow. The fans are very rocky and are not suited to cultivation. They are generally covered with grasses or rare bushes. The dominant geological process in the unit depends upon the altitude at which a given fan is situated.

iii) Alluvial steep to very steep slopes: These slopes are either undergrowth or are barren, but they are not cultivated anywhere in the catchment area. The geological processes occurring in the unit are similar to those of unit ii, with the only difference that the colluvial layers do not stay in the unit. The soil depth is very shallow in the unit. This unit is located in all Panchayats of the watershed.

iv) Flat or easy rolling to rolling plateaus: These plateaus occur in all Panchayats of the project area and are located on hill tops. This units is generally covered with snow. Landslides, connected with unit iii are very common. The unit has medium to shallow soil depth. These are the alpine pastures of the catchment.

B. EROSION

The following types of erosion occur in the Mustang-Kaligandaki

watershed.

a. Sheet erosion: Sheet erosion is very common in the catchment area. This erosion process is a complex of aolian, fluvial, and glacial sheet erosion as well as aero-fluvial and aero-glacial processes. The velocity of wind from Tukuche Panchayat to the northern boundary of the catchment is very high. Though no record is available, it is clear that high velocity wind is one of the main agents of sheet erosion.

Rainfall is the main agent of fluvial sheet erosion. But as stated earlier, most of the watershed lies in a rain shadow area, where the average annual rainfall and the rate of precipitation is not high; hence, fluvial sheet erosion, though not negligible, is very low. However, it is very high in Marpha Panchayat, where the average annual precipitation is about 2500 mm.

In winter, glacial sheet erosion is very high in the territories lying at altitudes above 12,000 feet. Generally this type of erosion occurs during the movements of glaciers.

Aero-fluvial and aero-glacial erosion are respectively combinations of aolian with fluvial and aolian with glacial processes. In these types, wind is the dominant factor but fluvial and glacial processes complicate the aolian process, protecting the soil from aolian erosion on the one hand but themselves erode the soil on the other.

In the southern Panchayats of the catchment area (Kowang, Lete, and Kunje Panchayats), fluvial sheet erosion is dominant and wind erosion is negligible, but in some places, glacial erosion is prominent.

b. Bank erosion: Bank erosion along the rivers is very high throughout the catchment area. The Kaligandaki, the main river of the territory has numerous tributary rivers that generally have a perennial flow. The discharge in the rivers is high in summer and the rivers do not freeze over in winter. The rivers have a high gradient and high erodibility. The main reason for the increment of discharge is the high rate of melting snow in summer in comparison to that in winter along with rainfall during the same period. The main rivers feeding the Kaligandaki are Dam, Yak, Narsing, Kyugoma, Cha Lungba, Jhong, Yamkim, Kaiku and Lete. Very high bank erosion occurs along

the Lete Khola. The western bank of the Kaligandaki in Jomsom Panchayat at Jomson proper and at Chhiro in Marpha Panchayat is highly eroded, which is dangerous for the cultivated lands of Chhro Village and for the livestock farm of Marpha Panchayat.

Both the right and left banks of the Mustang Khola are highly eroded and the river bed is very wide.

c. Rill and gully erosion: Rills and gullies are highly developed in the catchment area. They are largely connected with the melting of snow from the high mountains. Another main reason for this type of erosion is that the area is composed of weak and soft rocks with high erodibility, and the soil formed from these rocks is also highly erodible.

The second main factor of rill and gully erosion is rainfall. Rill and gully erosion in the project area is also aided by the high relief, which is a dominant factor for all types of erosion.

d. Landslides: Landslides are relatively rare in the project area. Active landslides are found in the Lete Panchayat. These slides, although they are where there are not large masses, are very dangerous for the inhabitants of the area. Landslides of very small masses are common along the banks of the Kaligandaki River. Some active landslides were seen near the Kaisang Military Camp in Marpha Panchayat. Generally, these landslides are located in soft alluvial soils and no bedrock sliding was noticed in the watershed. Thus the slope of the territory are generally stable, but stone falls are common in the project area.

Landslides connected with the weight of the accumulated snow at the tops of the high mountains are very common. These landslides generally involve large masses, but they are not dangerous for human population or for the cultivated areas since they occur far from human settlement. Snowslide was seen in the southeast of Kaisang when the territory was surveyed by the RCU team on May 6, 1979. Snowslide is predictably very common in the high mountains of the project area.

Conclusions and Recommendations

Conclusion: In view of all the above mentioned factors, it is clear that the most dominant type of erosion for the central and the northern parts of the project area and for the areas lying at higher altitudes is wind erosion

(aolian erosion), which is combined with glacial erosion at higher altitudes. In the southern Panchayats, water (fluvial) erosion is dominant.

Recommendations:

a. As wind erosion is dominant in the central and the northern parts of the catchment, wind breakers should be constructed in these parts of the watershed. This could be done by planting rows of poplar there and by instituting controlled and well managed pastures of appropriate shrubs and grasses. Similar measures could help prevent the formation and acceleration of rills and gullies.

b. Bank erosion is very high in Lete Panchayat, where it has become the main agent of active landslides along the Lete and Kaligandaki Rivers. Some embankments should be constructed to protect this area from landslides. Similar types of landslides near the Kaisang Military camp could be controlled through aforestation.

c. As mentioned above, the velocity of wind in the catchment is very high. This could be used to generate suitable types of energy such as el ctricity.

IV. USE AND MANAGEMENT OF THE SOILS

Agriculture

The Chhiro soil unit is poorly suited for agricultural development; soils of this unit are under improved forage crops and forest trees. The other important reasons limiting its use to agriculture are shallow depth, low water holding capacity of soils, susceptibility to erosion, droughtiness in both summer and winter, rock fragments on or near the soil surface, high alkaline content and low soil fertility. On regions of upper Kaligandaki catchment, the frigid and arid climate is one of the main factors which affects germination, growth, flowering, fruiting and grain formation of the crops. Suitabilities for various crops have been determined (see description under mapping units) and are described as follows:

Rice. In the upper Kaligandaki catchment area, the relatively low altitude soil units are Chhairo, Marpha and Sayng. These soils are also unsuitable for rice cultivation mainly due to climate topography, soil texture, high pH, and lack of irrigation. In this area, rice cultivation does not occur.

Maize and millet: Both these cereal crops are unsuitable in the soil units, for the same reasons as rice is unsuitable.

Wheat: Wheat is the most important cereal crop of the Trans-Himalayan regions. Undoubtedly, wheat is the only crop that covers the valuable

cultivatable terraces in the upper Kaligandaki catchment area. Mantang, Mustang and Muktinath soil units are highly suitable for wheat, a moderate to highly suitable soil unit is Chhunga, and Ghilling soil is moderately suitable for wheat.

Barley: Ghilling, Muktinath and Syang units are highly suitable for barley cultivation. The Marpha unit is moderately suitable for this crop.

Buckwheat: Highly suitable units for buckwheat are Marang, Mantang, Muktinath and Syang. Moderately suitable soils for this crop are Marpha and Samar.

Naked Barley: Mantang, Muktinath and Syang units are highly suitable and Marpha soils are moderately suitable for naked barley cultivation.

Potato: Moderate to highly suitable soil units for potato cultivation are Ghilling, Muktinath and Marpha.

Fertility Status of Soils: In general, the soils of the northern parts of the upper Kaligandaki catchment area are slight to strongly alkaline (pH 7.7-8.7). The organic matter of the soils range from low to very high. The Chhunga soil unit contains low organic matter; Marpha, Mantang and Muktinath soils come under the medium categories whereas Ghilling, Marang, Chhairo, Samar and Syang soils are high to very high in organic matter.

In the project area the nitrogen content of soils varies from medium to high. Chhunga and Marpha soil units are low in organic matter and the other soil units are high in this nutrient.

The amount of phosphorus in the soils of the upper Kaligandaki catchment ranges from high to very high. Among all the soil units, Chhairo, Marpha, Muktinath, Samar and Syang are high in organic matter and the remaining soil units (Chhunga, Ghilling, Marang and Mantang) are very high in phosphorus.

The amount of potash ranges from low to very high in the soils of the project area. Chhairo and Marpha soils are low in this nutrient. Ghilling, Muktinath and Samar series are medium; Chhunga and Syang are high and Marang and Mantang are very high in potash (See Table 1).

Horticulture

In the upper Kaligandaki catchment area, the Marpha soil unit is highly suitable for fruit and vegetable cultivation. The existing fruits that have good yields are apple, peach, plum, walnut, apricot and strawberry. Cauliflower, cabbage, knolkhol, carrot, broad leaf mustard and radish are the common vegetables of this area. Muktinath and Syang soils are moderate to highly suitable for fruit farming. Ghilling, Marang, Mantang and Samar soil

units are moderately suitable for fruits and vegetables. Poor to moderately suitable soil units are Chhunga and Chhiro.

Pasture

Nearly 34.56% of the soils of the upper Kaligandaki catchment area is under wild pasture. Nearly 80% of the catchment area is highly suitable for pasture. Except for Chhairo soils, all the other soils (Chhunga, Marang, Mantang, Muktinath and Samar) are under wild grasses and are highly suitable for range management. Most of the soils of Chhiro are under improved forage crops.

Most parts of the Chhunga, Marang, Mantang, Muktinath and Samar units are under grazing. This is due to the fact that animal husbandry is the most dominant occupation of the catchment area. A major portion of these units is covered by wild pastures which are used for grazing. The domesticated animals are donkeys, mules, horses (for transport) and cattle (for manure, draught and milk). Yaks and their cross-breeds, and goats and sheep are also common in these regions. Although goats play an important role in animal husbandry in the project area, goat raising should not be encouraged from the point of view of soil conservation.

Ghilling soils are moderate to highly suitable for range management. The Marpha unit is moderately suitable for the pasture development whereas the Syang unit is poorly suited.

Forest

In the upper Kaligandaki catchment area, the soils are moderate to highly suitable for forest development. Chhunga, Chhairo, Marang, Marpha and Muktinath soils are in need of reforestation. As the other soils, the Chhairo and Marpha soils and in the area south of Jomsom, the density of pine trees and junipers is in many places, still great enough for natural regeneration. Mainly on the southern slope, dense forests can be found, but father north, the forests diminish quickly.

There are only a few areas left that are marked as forest (e.g. "subforest") in the east of Tangba. This area consists of scattered trees. There is a northern zone of "junipers" around Samar Village which, however, ends about 5 km. north of Samar. The Syang unit is poorly suited for forest development and Mantang is poor to moderately suitable.

Table 7 - Nutrient Status of the Soils of Mustang District

Soil Units		Organic Matter		P_2O_5	K_2O
Chhunga, Ch	Moderate to strong acidic	Low	Medium	Medium	High
Chhairo, Cr	Moderate alkaline	Very high	High	High	Low
Kaisang, Ka	Moderately acidic	Very high	High	High	Medium
Marang, Ma	Moderately alkaline	Medium	High	Very High	Very High
Marpha, Mr	Moderately "	Medium	Medium	High	Low
Muktinath, Mu	Moderately "	Medium	High	High	Medium
Mantang, Mt	Moderately "	Medium	High	Very High	Very High
Samar, Sa	Moderately "	Very high	High	High	Medium
Syang, Sy	Moderately "	Very high	High	High	High
Tukuche, Tu	Moderately "	High	High	High	High

APPENDIX I - DESCRIPTION OF SOILS AND ANALYTICAL DATA

Technical descriptions and available analytical data for the main soils recognized in each mapping unit are presented in this section. Each soil is classified according to the system of Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys, (USDA, Agr. Handbook No. 436). The nomenclature of the USDA Soil Survey Manual (USDA, 1951) and the FAO Guidelines for Soil Description (FAO, 1977) have been followed.

Texture is determined according to feel and the color notation follows the Munsell Color Charts (1954). pH is determined in a 1:1 soil/water ratio with a pH meter and nitrogen is determined by standard micro-Kjeldahal method. Available P_2O_5 was determined colorimetrically by Bray's or Olsen's method depending upon soil pH. Potassium has been determined by flame photometer (Jackson, M. L. 1962).

The classification of soils is mainly based on a morphological description of soils along with a few analytical data available at the time of writing. Therefore, the classification is considered provisional.

1. Chhunga Series

A well drained soil developed on moderately steep to steep slope made up of soil materials derived mainly from alluvium/colluvium and phyllites. It falls mainly in the pasture area. Among the important vegetations, Caragana brevispina, Lonicera spinosa and alpine meadows of graminaceae and cyperaceae families are noted.

Chhunga series is classified as loamy skeletal, mixed, frigid family of Rendollic eutrochrept.

Typical Profile

Location:	Site 7, near Chhunga, Chilling Panchayat, 3350 m. a.s.l., Southeast exposure.
A -15 cm	Very pale brown (104 YR 7/3) dry, pale brown (104 YR 6/3) moist; loam; massive; friable moist; non-sticky, non-plastic wet; many rock fragments; few fine roots; pH 8.6; diffuse boundary.
B 15-120+ cm	Yellowish brown (104 YR 5/4) dry, dark yellow brown (104 YR 4/4) moist; loam; massive; friable moist; non-sticky, non-plastic wet; many rock fragments; abundant fine to medium roots; pH 8.7.

Analytical Data

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	N/C	O.M.%
Mu 13	A	0-15	8.5	48.0	416.0	0.53	0.126	4.20	0.91
Mu 14	B	15-120+	8.7	176.0	84.5	0.29	0.084	3.45	0.49

2. Chhairo Series

A well drained soil developed on flat to gently undulating river terraces made up of alluvial/colluvial materials derived mainly from phyllite and schist. These soils are mainly in cultivated pasture. Important pasture crops are lucenve, clover, rye grass and wheat grass.

The Chhairo series is classified as a loamy skeletal, mixed, mesic family of Aquic (Lithic) Ustifluvent.

Typical Profile

Location: Site 10, near Agriculture Development Office, Chhairo, Marpha Panchayat, 2550 m. a.s.l.; West exposure.

A_1 0-8 cm Light grey (10 YR 7/2) dry, dark greyish browh (10 YR 4/2) moist; loam, medium to weak subangular blocky, breaking into fine crumb firm moist; non-sticky, non-plastic wet; many rock fragments; abundant fine roots; pH 7.7; gradual boundary.

Bc 8-29 cm Grey (10 YR 5/1) moist; common distinct yellowish brown patchy mottles; silt loam; strong to medium sub-angular blocky, breaking into coarse medium crumb, firm moist; slightly sticky non-plastic wet; many rock fragments; pH 8.0.

C 29+ cm Stones and boulders

Analytical Data

Lab. No.	Harizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
Mu 21	A	0-8	7.7	176.0	97.5	4.07	.266	15.30	7.00
Mu 22	Bc	8-29	8.0	96.0	32.5	1.71	.126	13.57	2.94

3. Kaisang

A shallow, well drained soil developed on steep hill. Slopes made up of materials derived mainly from alluvium/colluvium. These soils are mainly under forest.

This soil is classified as a loamy skeletal, mixed, frigid family of Entisol.

Typical Profile

Location:	Site 11, near Kaising Camp, Mustang district, 3350 m. a.s.l.; Northwest exposure.
O_1 2-0 cm	Fresh litters
A_1 0-9 cm	Greyish brown (2.5 YR 5/2) dry, dark greyish brown (10 YR 4/2) moist, gravelly loam; medium to weak sub-angular blocky breaking into fine grains; friable moist, non-sticky, non-plastic wet; many rock fragments, few fine roots; pH 8.3; clear weavy boundary.
C 9-60 cm	Light yellowish brown (2.5 YR 6/4) moist; gravelly silt loam; strong angular blocky breaking into fine to medium crumb; friable moist; non-sticky, non-plastic wet; very many rock fragments; common-fine to coarse roots; pH 7.8.

Analytical Data

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
Mu 13	A_1	0-9	8.3	96.0	110.5	2.23	0.196	11.37	3.83
Mu 14	C	0-60	7.8	64.0	299.0	0.33	0.105	3.14	0.56

4. Marang Series

A moderately deep soil developed on rolling bench terraces made up of materials derived mainly from alluvium and colluvium. These soils are mainly in wheat, buckwheat and sesame cultivation.

Marang series is classified as coarse loamy, mixed, frigid family of Aridic Haploboroll.

Typical Profile

Location:	Site 5, near Marange Village, Charang Panchayat, 3650 m. a.s.l.; Southeast exposure.

Ap 0-12 cm — Greyish brown (10 YR 5/2) dry, very dark grey (10 YR 3/1) moist; silt loam, medium to weak subangular blocky breaking into fine to medium crumb; friable moist; non-sticky, non-plastic wet; few rock fragments; abundant fine to medium roots; pH 8.2; diffuse boundary.

B_1 12-32 cm — Very dark grey (10 YR 3/1) moist; silt loam, medium to weak subangular blocky breaking into fine to medium crumb; slightly sticky slightly plastic wet; few rock fragments; fine to medium roots common, pH 8.3; abrupt smooth boundary.

B_2 37-67+ cm — Dark grey (10 YR 4/1) moist; silt loam; medium to weak angular blocky breaking into fine to medium crumb; friable moist; slightly sticky slightly plastic wet; few rock fragments; fine to medium roots common; pH 8.3.

Analytical Data

Lab. No.	Horizon	Depth. cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
Mu 9	Ap	0-12	8.2	224.0	520.0	1.53	0.23	6.62	2.63
Mu 10	B_1	12-37	8.3	80.0	455.0	0.83	0.175	4.85	1.46
Mu 11	B_2	37-67+	8.3	160.0	364.0	0.48	0.098	4.89	0.34

5. Marpha Series

A moderately deep soil developed on easy rolling bench terraces made up of materials derived mainly from alluvium/colluvium. These soils are mainly in vegetable (mustard, cole crop, peas) and fruit (apple, peach, apricot, walnut, grape, plum) cultivation.

The Marpha series is classified as a coarse silty mollic mixed, mesic family of Fluventic Haplustoll.

Typical Profile

Location: Site 9, near Marpha Horticulture Farm, Marpha Panchayat; 2600 m. a.s.l.; Southeast exposure.

Ap 0-9 cm — Grey (5 YR 5/1) dry, dark grey (10 YR 4/1) moist; loam; medium to weak subangular blocky breaking into fine crumb, friable moist; non-sticky, non-plastic wet; few rock fragments, few fine roots, pH 8.4; diffuse boundary.

A_3 9-18 cm — Grey (5 YR 5/1) moist, silt loam; strong and medium subangular block; breaking into fine crumb; friable moist; slightly sticky non-plastic wet, few rock fragments, fine roots common, pH 8.3; diffuse boundary.

B 18-65 cm — Dark grey (5 YR 4/1) moist, silt loam; strong to medium subangular blocky breaking into fine crumb; friable moist; non-sticky, non-plastic wet; patchy thick cutans along the vertical ped faces; few rock fragments; fine to medium roots common. pH 8.1; diffuse boundary.

C 65-89+ cm — Dark grey (5 YR 4/1) moist; fine prominent yellowish brown mottles; silt loam; slightly stick, non-plastic wet; few rock fragments, few fine roots; pH 8.2.

Analytical Data

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	%C	%N	C/N	O.M.%
Mu 17	Ap	0-9	8.4	128	52.0	0.91	0.210	4.33	1.56
Mu 18	A_3	9-18	8.3	80.0	32.5	0.73	0.070	10.42	1.25
Mu 19	B	18.65	8.1	48.0	45.5	1.17	.105	11.14	2.01
Mu 20	C	65.89+	8.2	96.0	26.0	0.26	0.056	4.64	1.44

6. Mantang Series

A shallow soil developed on flat to gently undulating terraces made of materials derived mainly from alluvium and colluvium. These soils are mainly in wheat, buckwheat and naked barley cultivation.

The Mantang series is classified as a sandy skeletal Entisol, mixed, frigid family of Typic Ustatherit.

Typical Profile

Location: — Site 4, near Lo Mantang, Lo Mantang Manchayat, 3650 m. a.s.l; Northeast exposure.

Ap 0-21 cm — Light brownish grey (10 YR 6/2) dry, dark greyish brown (2.5 YR 4/2) moist; silt loam; medium to weak to subangular blocky, breaking into medium to fine crumb; friable moist; slightly sticky, non-plastic wet; few rock fragments; fine to medium roots common; pH 8.3; abrupt smooth boundary.

C 21-31 cm — Light yellowish brown (10 YR 6/4) moist; sand; single grain; loose moist and dry; non-sticky, non-plastic wet; many rock fragments; pH 8.5.

Analytical Data

Lab. No.	Horizon	Depth cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
Mu 7	Ap	0-21	8.3	306.0	585.0	0.97	0.182	5.32	1.67
Mu 8	C	21-31	8.5	112.0	312.0	0.18	0.098	1.83	0.31

7. Muktinath Series

A moderately deep soil developed on rolling terraces made up of materials derived mainly from slaty phyllite. These soils are mainly in wheat, buckwheat, barley, naked barley and potato cultivation. Important vegetables include radish and cole crops. Apple is also grown on these soils.

The Muktinath series is classified as a fine loamy mixed, frigid family of Cumulic Haploboroll.

Typical Profile

Location: Site 1, near Muktinath Village, 3500 m. a.s.l.; North-west exposure.

Ap 0-9 cm — Black (10 YR 2.5/1) moist, sandy clay loam, massive; slightly sticky slightly plastic wet; friable moist; few rock fragments, medium to coarse roots common, pH 8.3; diffuse boundary.

B 9-83+ cm — Black (10 YR 2.5/1) moist, sandy clay loam; weak, sub-angular blocky, slightly sticky non-plastic wet; firm moist; few rock fragments; medium to coarse root common, pH 8.1.

Analytical Data

Lab. No.	Horizon	Depth. cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
Mu 1	Ap	0-9	8.3						
Mu 2	B	9-83+	8.1	112.0	136.5	0.79	0.453	1.73	1.36

8. Samar Series

A moderately deep to deep soil developed on moderately steep slopes made up of materials derived mainly from phyllite. These soils are mainly in natural pasture. Important vegetation exists.

The Samar Series is classified as a coarse silty mixed, frigid family of Pachic Haploboroll.

Typical Profile

Location:	Site 2, near Samar Village, Chhusang Panchayat, 3500 m. a.s.l.; Northeast exposure.
O_1 3-0 cm.	Litter, mainly loose under composed leaves and twigs.
A_1 0-26 cm	Dark brown (10 YR 4/3) dry, dark brown (10YR 3/3) moist; loam; granular; non-sticky, non-plastic wet; few rock fragments; abundant medium to coarse roots; pH 8.0; diffuse boundary.
B 21 26-63 cm	Dark brown (10 YR 4/3) dry, dark brown (10 YR 3/3) moist; silt loam; granular, non-sticky, non-plastic wet; few rock fragments; medium to coarse roots common; pH 8.3; clear wavy boundary.
B_{22} 63-97+ cm	Dark yellowish brown (10 YR 4/4) dry, dark brown (10 YR 3/3) moist; silt loam; medium to weak subangular blocky, breaking into coarse to medium crumb; non-plastic wet; few to many rock fragments; few medium to coarse roots; pH 8.5.

Analytical Data

Lab. No.	Horizon	Depth. cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
Mu 1	A_1	0-26	8.0	112.0	117.0	2.238	0.238	9.36	3.83
Mu 2	B_{21}	26-63	8.3	80.0	45.5	1.68	0.298	7.05	2.88
Mu 3	B_{22}	63-97	8.5	64.0	6.5	0.42	0.091	4.61	0.72

9. Syang Series

A moderately deep soil developed on easy rolling river terraces made up of materials derived mainly from alluvium. These soils are mainly in barley, naked barley, buckwheat, fruits (apple, peach) and vegetable (broad leaf mustard, cole

crops) cultivation.

The Syang series is classified as loamy, skeletal mixed, mesic family of Pachic Haplustoll.

Typical Profile

Location: Site 12, near Syang, Marpha Panchayat, 2600 m. a.s.l., East exposure.

Ap 0-17 cm Very dark grey (7.5 YR 3/0) moist; silt loam; medium weak subangular blocky, breaking into medium to fine crumb; friable moist; slightly sticky, non-plastic wet; few rock fragments; few fine roots; pH 7.9; diffuse boundary.

B 17-59 cm Very dark grey (7.5 YR 3/0) moist; silt loam; medium weak angular blocky, breaking into medium to fine crumb; friable moist; slightly sticky, non-plastic wet; few rock fragments; fine to medium roots common; pH 8.4; diffuse boundary.

C 59+ cm Stone and boulders

Analytical Data

Lab. No.	Horizon	Depth. cm	pH	P_2O_5 kg/ha	K_2O kg/ha	% C	% N	C/N	O.M.%
Mu 25	Ap	0-17	7.9	64.0	403.0	4.22	0.332	12.71	7.25
Mu 26	B	17-59	8.4		279.5	1.76	0.217	8.11	2.99

10. Tukuche Series

A moderately deep soil developed on flat to gently undulating river terraces made up of alluvial and colluvial materials derived mainly from phyllite and schist. These soils are mainly in maize, barley, potato and fruit (apple) cultivation.

The Ghiling series is classified as a loamy over sandy skeletal mixed, mesic family of Typic.

Typical Profile

Location: Site 13, near Ghiling Village, Tukuche Panchayag, 2550 m. a.s.l.; Southeast exposure.

Ap 0-9 cm Light brownish grey (2.5 YR 5/2) dry, dark greyish brown (2.5 YR 4/2) moist; loam; medium to weak subangular

blocky, breaking into fine crumb; friable moist; non-sticky, non-plastic wet; many rock fragments; fine roots common; pH 8.6; diffuse boundary.

A_3 9-48 cm — Light brownish grey (2.5 YR 6/2) dry; dark greyish brown (2.5 YR 4/2) moist, silt loam; strong to medium sub-angular blocky; breaking into fine to medium crumb slightly sticky, non-plastic wet; many rock fragments; fine roots common; pH 8.3; abrupt smooth boundary.

IIc, 48-67 — Gravelly sand.

IIc2 67+ cm — Stones and boulders.

Analytical Data

Lab. No.	Horizon	Depth. cm	pH	kg/ha	kg/ha	% C	% N	C/N	O.M.%
Mu 27	Ap	0-9	8.6	256.0	156.0	1.48	0.063	18.41	1.99
Mu 28	A_3	9-48	8.3	112.0	45.0	1.16	0.287	6.37	3.14

REFERENCES

1. Climatic Records of Nepal, 1977. Department of Irrigation, Hydrology and Meteorology, HMG/Nepal.
2. FAO, 1977. Guidelines for Soil Description. Soil Resource Development and Conservation Service, Land and Water Development Division, FAO, Rome
3. Dobremez, J. F. and Jest, C., 1970. Carte ecologique du Nepal I. Region Annapurna-Dhaulagiri. Laboratoire de Biologie vegetable. Grenoble, France.
4. Stainton, J. D. A., 1972. Forest of Nepal, London, John Murray.
5. Talalov, V. A., 1972. Geology and Ores of Nepal. Final Report Plate No. I.
6. UNDP/FAO, 1975. General Soil Survey of Bagmati and Narayani Zones. Increasing Use of High-Yielding Crop Varieties and Fertilizers, Central Nepal. AG: DP/NEP/70/512.
7. USDA, 1975. Soil Taxonomy: A Basic System of Making Interpreting Soil Surveys. USDA Handbook No. 18 with Supplement of 1962.

CHAPTER VI

RECOMMENDATIONS

Soil survey and classification is essential as the basis for planning the wise use and management of soils. There is a substantial need for detailed soil surveys, particularly of first and second order, in the four RCUP areas, as well as in other areas where knowledge of the soil resources is needed to plan development projects.

One of the objectives for conducting RCUP soil surveys is to promote and strengthen a national soil survey program in Nepal. To strengthen national efforts, to train staff, to promote cooperation and to assist in improving the quality of soil surveys, the development of a Memorandum of Understanding is very important. A draft example is presented as attachment #1 in Annex N. The Memorandum would: 1) provide for cooperative efforts in the development and utilization of soil surveys in Nepal, 2) assure that all phases of the soil survey program are given adequate attention, and 3) strive for maximum utilization of resources of all parties working toward a common goal. The Memorandum would provide for agreement by the parties involved to 1) make cooperative surveys according to sound scientific and technical standards in accord with a national system of classification, correlation and nomenclature, 2) to continually improve the quality and usefulness of surveys to maximize their potential use, 3) to establish and update priorities of areas needing surveys, 4) to inform the public regarding progress and uses of published soil surveys, 5) to cooperate in developing educational materials about soils and their use, and 6) to provide for the formation of a technical committee, publications policy, and other general provisions incident to a Memorandum of Understanding.

The RCUP staff will provide administrative and technical direction and coordination to field survey crews working in the four project areas. The RCUP staff will also coordinate the survey program with the Department of Agriculture, Department of Forests, Department of Soil and Water Conservation, APROSC, and other RCUP technical and operational support personnel.

The Soil Science Advisor will provide technical advice for the overall administration and direction of the soil survey program. This advice will include coordination requirements, the design, development, implementation and operation of the RCUP soil survey so that it will meet and promote the objectives of the developing National Soil Survey Programs.

The soil survey field crews should have as co-soil survey leaders, HMG and U.S. Peace Corps B.Sc. Soil graduates. One Technical Assistant should be assigned to each crew.

The procedure for carrying out soil surveys should be as follows:

Premapping Activities: A plan of soil survey operations will be prepared for

each of the four project areas. Each plan outlines the work to be done and an estimate of the time to complete it, including goals for both mapping and supporting soil survey activities. Consideration should be given to:

--coordinating woodland, range, biology, and engineering with soil surveys;

--maintaining scientific and cartographic quality;

--training soil scientists;

--training users of soil surveys, both within and outside RCUP so that maximum use will be made of information assembled in the soil survey.

Initial Field Reconnaissance: Active participants should include the RCUP field soil scientist, APROSC soil scientists, survey crew, and specialists in forestry, range and geology. The reconnaissance work should be guided by the basic purpose of the RCUP and the interpretations of the soil survey that are required to meet the needs of RCUP.

Design of Mapping Units: The mapping unit should undergo considerable field testing to determine their mappingability, especially in terms of reliability of delineations. Enough areas should be mapped during this testing phase to determine complexity of mapping unit patterns, and the kind and extent of inclusions. This information is required to assess the need to design complex mapping units.

Initial Field Review: A field review will be scheduled after the tentative mapping legend has been field tested.

Field Mapping Procedures: Basic field procedures and mapping techniques used in the RCUP surveys will include:

--an initial field review;

--a descriptive legend to identify, classify, and correlate the soils by the field soil scientists during test mapping;

--conventional and special symbols legend;

--make duplicate copies of field sheets for record keeping and use by cooperators.

Sampling Soils: Soil sampling is a continuing process from beginning to end of a field survey. Soils are identified, characterized, classified and behavior predicted on the basis of data from selected samples, observations and experiences.

Determine Interpretations: Soil interpretations are developed for the uses expected to be important or potentially important to users of soil survey information. The following listing are types of interpretations that can be developed for detailed planning purposes:

--use and management of the soils

--yields per hectare of crops and pasture

--land capability classification by major management concerns of erosion,

wetness, soil related problems, and climate

--rangeland productivity and characteristic plant communities

--woodland management and productivity

--woodland understory vegetation

--wildlife habitat potentials

--recreational development

--engineering properties and classifications

--physical and chemical properties of the soils

--soil and water features

--sanitary facilities

--building site development

--construction materials

--water management

The land use planning that evolves from this process is to be a collaborative one with dialogue occurring between project technicians and local people/land users.

APPENDIX D

WATERSHED MANAGEMENT REPORT

Prepared by: Gary White/SECID

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WATERSHED MANAGEMENT REPORT

The Problem

Environmental degradation in Nepal is proceeding at an alarming rate. The human implications of such degradation are clear, the results being reduced crop yields, increased landslides and floods, downstream reservoir and stream sedimentation, and the reduction of available natural resources for economic development. For a growing nation whose population lives mostly at subsistence level, the current situation is intolerable, and His Majesty's Government of Nepal (HMG) as well as numerous donor agencies have attempted solutions. For various reasons, most recent attempts at watershed improvement have fallen short of intended goals. First, most efforts have been too small in scope to treat a problem of such magnitude. Second, many efforts have been single-pronged with narrow-ranged goals, such as afforestation, population resettlement, nursery development, or the construction of erosion control structures. Watershed degradation and its impacts are much too complex to be reversed by any one type of corrective measure. And third, recent attempts have failed to integrate social considerations into the solutions to the extent necessary.

The Resource Conservation and Utilization Project (RCUP) developed by HMG with the help of the U.S. Agency for International Development (USAID) is an attempt to attack the critical and complex problems of watershed degradation through a series of integrated technical and social plans designed for local landscape and culture variations. The four project regions chosen, Kulekhani, Gorkha, Mustang, and Myagdi, represent a cross-section of natural and cultural landscapes in Nepal. The RCUP in these regions is designed to begin immediate correction of watershed problems and to provide models for nation-wide resource improvement and conservation.

Watershed improvement and management in Nepal are major challenges for several reasons. First, natural denudation rates are high in this region of young, rugged, and unstable mountains (Simons, 1979), upon which is superimposed a harsh monsoon-drought climatic regime. Second, but equally important, high population densities and growth rates place great demands on the land to provide resources, especially food, fodder, and fuel. The ability of the landscape to provide such resources is decreasing as population pressures increase. Under these natural and cultural constraints it is not surprising that seemingly every

hectare of land below the snowline has been cultivated, grazed, lopped, burned, cleared, or otherwise utilized by man and his livestock. Few nations on earth are so inhospitable, yet so thoroughly settled, as Nepal.

Watershed degradation has initiated a series of chain effects and undersirable feedback loops, causing a downward spiral of land productivity. For example, cutting, lopping, and burning of forests exposes soils to direct rainfall impact, which initiates soil erosion. Erosion removes humus and weathered material from the surface, reducing the soil's capability to regenerate trees, in addition to lowering its capacity to sustain useful forage and food crops. The reduction of soil infiltration lowers ground water reserves, causing springs to dry up and lowering baseflow stream discharges. Soil washed downslope becomes stream sediment which chokes floodplains, reduces fish populations, increases flood stages, fills impoundments, and degrades river quality downstream, even into other nations (e.g., India and Bangladesh). Undesirable cultural feedback loops are also generated. Reduced land productivity forces utilization of more distant and often marginal lands, inducing even more denudation. Breaking these disastrous chains requires attacks at every front. The long-term goals of the RCUP watershed management plan are to halt watershed degradation, upgrade resources to sustained high levels, and reduce human pressures on the land through better management and the introduction of alternate economic activities.

The remainder of this report treats: previous watershed projects in Nepal; the RCUP watershed management approach and philosophy; methods employed by the RCUP design team; descriptions and specific proposed projects within each of the four Project regions; issues; limitations and benefits; the projected budget; and a cost-manpower matrix.

Review of Watershed Management Projects in Nepal

The establishment of the Department of Soil and Water Conservation (DSWC) within the Ministry of Forestry at the beginning of the current 5-year plan initiated a major in-country effort to study Nepal's watershed degradation problems and provide solutions. The DSWC has proceeded admirably, despite budgetary and manpower constraints, to establish local programs of watershed study and improvement. In addition, HMG has solicited and obtained considerable

financial and professional aid from numerous donor agencies. For a detailed discussion of DSWC-related projects and activities, refer to Soil and Water Conservation System (DSWC, 1977).

The following is a list of significant completed or on-going DSWC-related projects:

--DSWC/FAO/UNDP Integrated Watershed Management Project (IWMP); torrent control and land use development project; a master plan of soil and water conservation for Nepal; to be completed in 1979.

--Survey, Project Formulations, and Implementation in Bering, Bagmati, Trisuli, Lothar, Trijugar, Karnali, Koshi, Samakhusi, Lamidate, Phewatal, Rupatal, Begnashtal, Khorke, Itram, Jhupra, and Tinau Khola catchments.

--Research, Publication and Extension: by radio, pamphlets, demonstrations, community development programs, public gatherings.

--Agricultural Resource Inventory Program; DSWC/USAID joint effort; remote sensing center proposed to begin operation in 1980.

--Training Center Establishment; DSWC/British effort, to train soil and water conservation technicians; 2-yr training program.

--Volunteer Programs: American Peace Corps and Swiss Volunteers.

--Resource Conversation and Utilization Project (RCUP); design phase is subject of this report; implementation phase scheduled for 1980.

--Other bi-lateral and multi-lateral assistance; includes Swiss, British, Germans, Americans Indians, Canadians, World Bank, UN/FAO, etc.

Watershed Management Approach and Philosophy

The RCUP approach to watershed management is the multi-objective, partial-solution philosophy proposed by Rieger, et al. (1976). The multiple objectives include, but are not limited to: treatment and upgrading of forest, range, and agricultural resources; the introduction of new conservation management techniques; demonstrations and trials with new species of flora and livestock; development of alternative economic activities to agriculture, such as cottage industries; and the development of energy resources.

Demonstration projects are vital to the RCUP approach in winning villager acceptance of new techniques. Most of the proposed watershed management projects should be located near population clusters where the need is greatest and where the visibility is highest. Thus, these projects will serve the dual purposes of watershed improvement and demonstration.

To compliment these activities, a number of experimental test sites should be established to develop new techniques for local conditions and to test various alternative approaches. Results from these tests will provide a sound basis for long-term planning decisions. Synthesized with these tests will be results of similar experimentation both within and outside Nepal, in an effort to reduce duplication.

It is expected that some projects will be less successful than planned, so that it will be necessary to have built-in systems of maintenance, follow-up, and project modification. No project can stand on its own after initiation without continual maintenance, whether of structures, plots, equipment, fencing, etc. In addition, follow-up studies of each project will be required to evaluate project performance to date, and to extract those elements of success or failure for further action. A product of follow-up will be project modification in which each project is continually upgraded and revised based on follow-up evaluations and breakthroughs in technology.

Watershed management and conservation techniques utilized by the RCUP must, of necessity, be inexpensive, cost-effective, non-technical to the degree possible, and must make maximum use of local materials and labor supplies. To optimize available funds and manpower, it will be necessary to coordinate watershed management activities with all appropriate HMG ministries and departments, and with related projects of other donor agencies.

The RCUP watershed management strategy will be to focus most early attention on upper drainages in each project region. Watershed reclamation must begin near the divides, because it is here that precipitation inputs of energy are most easily manipulated. Further downslope, water becomes increasingly concentrated and more difficult to control. The watershed divides in the four Project regions are also the areas least impacted by human activities, so that they are the most likely areas to be in ecologically sound condition. This strategy does not preclude the early treatment of watershed problems downslope, however. In areas of critical problems, especially where life or valuable property is threatened, immediate steps must be taken to correct the situation.

Related to the above strategy is the use of biological vs. mechanical watershed management techniques (see Issues, p. 64, of this report). The former are usually cheaper to institute and maintain, and have a better chance for success. It is recommended that biological techniques, especially natural and artificial revegetation, be emphasized throughout the Project duration and

especially in the upper drainages. Mechanical techniques, such as check dams, gabions, and stone structures, are both expensive and of limited long-term value. Such measures should be concentrated in those areas where flooding, erosion, and landsliding are major threats. They should also be concentrated near villages where they receive maximum visibility. Later in the project period, the increasing effectiveness of biological control measures should lessen the need for mechanical treatments. This strategy will require considerable patience and education of the villagers since it takes several years for natural and artificial vegetative regeneration to become effective.

For the RCUP to be successful, immediate detailed resource monitoring and inventories must be instituted. It is clear that the volume and scale of most current resource information in the Project areas is inadequate. These resource data will be vital to long-term planning modifications of early project efforts.

Survey Methods Used in Watershed Management Design

The period between late March and late June, 1979, was spent in Nepal designing the Watershed Management Report of the RCUP Project Paper. Field visits varying between 5 and 11 days were carried out in the Kulekhani, Gorkha, Mustang, and Myagdi regions. These were primarily reconnaissance trips to gain a familiarity with local environmental and land-use patterns. Some filed data were collected and specific projects designed. The field reconnaissance was supplemented by airplane or helicopter overflights of each region.

Library studies were undertaken to locate and digest all relevant Nepal watershed studies and projects. Included in this phase was air photo interpretation of the Kulekhani region. To date no comprehensive air photo coverage exists for the other three regions. For these, the study of available topographic maps had to suffice.

There were various meetings with HMG departments and donor agencies involved in watershed management, such as HMG Departments of Irrigation, Hydrology, and Meteorology; Forestry; and Soil and Water Conservation; as well as with agencies of such foreign donors as Canada and Switzerland.

Project Region Descriptions

Kulekhani Region

Geography

The Kulekhani region lies immediately southwest of the Kathmandu Valley within the Outer Himalyan mountains. It encompasses approximately 211 km^2, most of which is in the drainage basin of the Kulekhani Khola. A total population of 36,000 gives this region an average density of 172 people/km^2, although densities vary considerably with relief (APROSC, 1979a).

Highway access is provided via the paved Tribhuvan Rajpath which makes a north-south transect through the region in the west. A graded dirt road connects from the highway southeast to the Kulekhani Dam project. Other access is provided primarily by trails.

Most villages are situated within the stream valleys, although several have hillside or hilltop locations. Settlement and cultivated cropland are concentrated in valleys and on peripheral hillslopes, whereas the higher altitudes are less densely settled and utilized.

Geology and Geomorphology

The Kulekhani region lies within two physiographic provinces: the Mahabharat Lekh to the south, which is part of the Outer Himalaya; and the Midland to the north (APROSC, 1979a). The Mahabharat Lekh is structurally geosynclinal, with the axis trending ESE, controlling the alignments of principal mountain ridges and valleys. Rocks include ridge-forming granites, as well as quartzites and softer phyllite schists. The southern rim of the geosyncline is a thrust nappe abutting against the Siwalik Range to the south (Sharma, 1977b). Structural surfaces are often steeply dipping and provide abundant landslide surfaces. The major tributaries, the Sim, Naliban, Tasar, and Sankha Mul Kholas, flow in ESE-trending structural valleys, but the trunk stream Kulekhani Khola swings southward across the structure, breaching the Mahabharat Lekh in a steep gorge at the Kulekhani damsite. Altitudes in the Mahabharat Lekh exceed 3500 m, and the mountains contain the steepest terrain of the region, most slopes exceeding 25°.

The Midland to the north of the Kulekhani Khola is in softer rocks, namely, phyllite schists, limestones, sandstones, and slates, which account

for its greater degree of topographic maturity, lower relief (most slopes under 25°), and deeper weathering horizons. Relief increases from the Kulekhani Khola northward to the boundary ridge where altitudes exceed 2000 m in several locales.

Soils and Vegetation

Soils are thin and poorly developed in the Mahabharat Lekh, being forest podzols of relatively low fertility and, when denuded, high erodibility. In the lowlands of the Midland, deep, rich alluvial and *in situ* soils provide excellent cropland and pasture. Northward, these soils thin and are subject to more intense mass wasting and erosion with altitude.

Forests are the native vegetation of the entire region, with subtropical broadleaf forests in the lowlands giving way to mixed forests in the uplands. However, in the lower and intermediate altitudes most native vegetation has been removed from cropland and pasture. Cutting, lopping, and burning activities are causing an upslope retreat of the forests, but ridgelines still contain relatively good stands of timber.

Hydrology

The Kulekhani Khola and its tributaries drain 36 km^2 in a drainage pattern which is dendritic in the north but becomes structurally controlled to the south. The gradient of the trunk stream is 41 m/km. In the west near Palung, the upper Kulekhani Khola, locally called the Sankha Mul Khola, occupies a broad floodplain of coarse materials layed during low-frequency, high-discharge floods. Here the channel is braided and tends to change course frequently. Downstream, the river becomes entrenched and the floodplain disappears, and at the Kulekhani damsite, the antecendant river course flows through a deep gorge.

The mean annual discharge of the Kulekhani Khola at the damsite is 123 million m^3/yr, equivalent to 3.9 m^3/sec or 3.1 m^3/sec/100 km^2. Seasonal fluctuations in discharge fall between the mean low discharge of about 1 m^3/sec in March to nearly 12 m^3/sec in the monsoon season (APROSC, 1979a). The 100-yr flood is estimated to approach 1,000 m^3/sec.

There are no data on sediment yields for the Kulekhani watershed, but estimates of up to 700 $m^3/km^2/yr$ are given (APROSC, 1979a). These high yields relate to the high intensity monsoonal rains of which 90% is estimated to run off the surface (Sharma, 1977b), carrying sediment from natural and man-induced landslide scars and denuded soils.

The Kulekhani Dam, upon completion, will create an impoundment 74 m deep, extending upstream past Markhu. Its purpose is to generate hydroelectricity, and secondarily to enhance recreation resources. The Kulekhani Khola below the dam will be reduced to periodic small releases, flood overflow releases, and seepage from the impoundment. Most of the reservoir water will be diverted through penstocks for power generation. The life expectancy of the reservoir is only 50 yr due to high siltation rates. A concern of the RCUP is to reduce siltation so as to extend the life of the reservoir.

Meteorology

Only two weather stations, Daman and Markhu, are operated within the Kulekhani watershed. Data from these stations reveal average annual precipitation values of between 1500 and 2500 mm, of which about 80% falls during the monsoon (June-September). Most of the remainder falls in the so-called pre-monsoon (April-May) and post-monsoon (October-November) periods. Winter is distinctly dry. All precipitation falls as rain except some snowfall in the highest elevations. Maximum 24-hr rainfall intensities exceeding 180 mm have been recorded during the monsoon.

Sketchy evaporation records reveal maximum rates in the pre-monsoon of over 200 mm/month, dropping to less than 50 mm/month during the monsoon and in winter.

Daman temperature records show seasonal fluctuations in mean monthly temperatures between 5.6°C in January and 17.0°C in June. Summer mean maximums reach 23.5°C, whereas winter mean minimums drop to -1.5°C. Relative humidities reach lows of about 60% in winter-spring, climbing to 91% during the monsoons (Department of Irrigation, Hydrology, and Meteorology, 1977).

These data indicate that the lowland climates of Kulekhani are subtropical-monsoonal, becoming temperate at higher elevations in the surrounding mountains.

Land Use and Denudation

The peripheral mountain slopes are subject to natural landlsides due to a combination of geology, seismicity, monsoonal rains, and steep slopes. This natural tendency to mass waste is intensified where human disturbances of the vegetation and soils occur. The primary forms of mass wasting include creep, slumps, debris flows, and debris avalanches where weathering mantles are deep and are mostly rockslides and debris slides in the less weathered, steeper terrain. Landslide frequency increases during the monsoons, and is potentially catastrophic where high-intensity rainfall combines with dipping structural planes, steep slopes, and earthquakes. Examples of large-scale slides are found in the northward-dipping rock units of the Palung Panchayat. Subsequent runoff and erosion from these scars has created torrents downstream which have deposited coarse materials in wide floodplains on the Sankha Mul Khola, all told destroying as much as 50 ha of cultivated land (APROSC, 1979b).

In the lowland interior, lower gradient slopes reduce natural mass wasting to a minimum, but small-scale slumps and caving are noted on poorly constructed crop terrace risers and along the banks of the entrenched Kulekhani Khola.

Estimates of land use provided by APROSC (1979a) are as follows:

Land Classification	Area (km^2)	Percent of Total
Forests	103.71	48.95
Cultivated Lands	81.90	38.66
Pasture Lands	21.21	10.01
Other	5.04	2.38

As mentioned, the forests, mostly on upper slopes, range from degraded where cutting, lopping, and burning are practiced, to high quality near the ridge lines. Man-induced erosion and mass wasting is minimal throughout the forests, but continued degradation will increase denudation rates markedly. Cultivated lands fall into two categories: lowland irrigated terraces where denudation is minimal; and upland dry terraces where denudation rates range from moderate to high, depending on the steepness of slopes cultivated and the quality of terrace construction and maintenance. Barren lands include most of the denuded areas where livestock grazing is practiced. These areas produce the highest levels of denudation, especially along trails, in areas

of gullies, and on slide scars. Barren land is increasing at the expense of the forests.

Although overall denudation rates for the Kulekhani region are probably lower than in many parts of Nepal, the trends of intensified land use promise to accelerate the processes of denudation. The average family depends on the produce of about 4 ha, of which 1 ha is cultivated. With virtually all arable land in cultivation, the projected population growth rate of over 2%/yr will create needs for cultivated lands in marginal areas, expanded range, and further retreat of the forests. Unless these cultural processes are checked, denudation rates will accelerate to dangerous and distructive levels, making the 50-yr lifespan estimate for the dam optimistic.

Gorkha Region

Geography

The Gorkha region lies in north-central Nepal between the Trisuli River and the Tibet border. It is an elongate region drained by the major southflowing Buri Gandaki River, and the Daraundi and Chepe Kholas, all of which are left-bank tributaries of the Trisuli River. The landscape grades from high glaciated mountains in the north to generally lower altitude but high relief terrain southward.

Road access is under construction from Prithvi Raj Marga in the south up to Daraundi Khola Valley to Gorkha. All other surface access in the region is by trails. Villages lie scattered both in the valleys and on the mountains, but the population densities increase generally southward to over 100/km^2, except in the far southwest where densities are somewhat lower.

Geology and Geomorphology

The Gorkha region occupies the Inner Himalaya province except in the Trisuli River area to the far south where it enters the Midland province. Most of the area is unmapped geologically, but the dominant rocks are Paleozoic sedimentary, metamorphic, and igneous facies of geosynclinal origin. Structural trends are largely WNW to ESE, controlling the alignment or rock units and tributary valleys. The region remains seismically active (Sharma, 1977b).

North of Barpak the mountains rise to altitudes of over 500 m, well above the treeline (about 4000 m), and to a limited extent in the far northwest, above the snowline (about 5000 m). Glaciated valleys are noted and small glaciers still exist in favored sites. Southward, average summit altitudes decline to under 3000 m, and valley bottoms are as low as 600 m. Local relief throughout the region is high and slopes are mostly above 36°.

Snow and ice-fed streams, such as the upper Buri Gandaki River and the Chepe, Daraundi, and Machha Kholas, originate and flow through narrow valleys lacking floodplains. Downstream, floodplains built of glacial valley train and non-glacial torrent debris appear, especially in the Daraundi Khola. Over the floodplains the streams have alternately braided and meandering channels, and local course changes appear to be common. Tributary streams, both perennial and intermittent, debark from narrow valleys into the floodplains where they have deposited large alluvial fans which in some cases exceed 100 m high and have radii of several hundred m. These fans are built of torrent deposits which typically force the trunk stream to the opposite side of the floodplain.

Soil and Vegetation

Between the Trisuli River and the Tibet border are found a variety of soils, ranging from deep lateritic and subtropical podzolic soils in the south to forest podzols and tundra soils in the north. Soil depths also very greatly, from deep in the southern, low-gradient areas to shallow or absent on steep slopes and northward into the higher mountains. Erosion and reduction of soil fertility are so widespread in the Gorkha region that few undisturbed soils exist.

Forest native vegetation dominates up to the treeline, with subtropical broadleaf forests giving way to mixed and ultimately coniferous associations. Except in the north, most native forest have been cleared, burned, or lopped, so that few examples of native stands now exist. Above the treeline, scrub growth and tundra plants dominate, offering a good seasonal grazing resource. The influence of grazing on vegetation is not known in this area, but overflights seem to indicate that the tundra is relatively little affected by men.

Hydrology

The principal streams in the Gorkha region arise in the highest mountains in the north, fed by glaciers and snowmelt. Southward, flows are increased by contributions of ground water and springs, and during the monsoon, by surface runoff. Evidence suggests that seasonal river discharges fluctuate greatly in the central and southern portions of the region, based on examination of flood-plain deposits and reports of flood damage. Monsoonal rains bring exceptionally high stages, which at times have destroyed low-lying fields, villages and bridges. Sharma (1977b) states that typical rivers in the Himalaya have ratios of mean maximum to mean minimum flows of about 7:1. However, indications are that certain flood peaks may discharge over 400 times the volume of water than at low baseflow. Such flood peaks are directly related to intense monsoonal rains falling on the man-altered, high denuded landscape. Monsoon surface runoff is estimated to be 70-90% of total precipitation (Sharma, 1977a).

The only hydrologic measurements available are from Daraundi Khola near Gorkha. Here the mean low flow of 7 m^3/sec occurs in January, and mean maximum flows exceed 26 m^3/sec in July (APROSC, 1979c).

No data on sediment yields are available. Glacially-fed streams typically carry a large quantity of silt and clay. Added to this base load is material of sizes ranging up to large boulders carried during flood periods. Sediment yields are presumed to be very high during the monsoon period, perhaps reaching 800-1000 $m^3/km^2/yr$. Yields decline to low values in winter and spring. Recent monsoonal floods have buried formerly productive low-lying fields beneath deep deposits of cobbles, indicating that flood problems are increasing.

Meteorology

With only two weather stations in the Gorkha region, at Gorkha and Seti Bas, it is difficult to make generalizations. These stations have mean annual precipitation totals of 1400 and 1600 mm respectively. Values are believed to decrease in the lowlands generally northward away from sources of monsoonal precipitation, but increase roughly with altitude. Relatively low values (250 mm) occur in the alpine zones (Thapa and Thapa, 1969) where the air is relatively cold and dry. Typically more than 75% of the annual

precipitation falls in the monsoon period, but this is reduced in the higher and more northerly locales. Maximum 24-hr rainfall intensities of 100-140 mm have been recorded for these two stations (Departments of Irrigation, Hydrology, and Meteorology, 1977).

The only temperature records available are from the Gorkha Station. Here the average January temperature is 12.4°C with the mean minimum dropping to 6.3°C. The July mean is 22.8°C with the mean maximum being 27.3°C. It can be assumed that average temperatures decline northward and with altitude (about .7°C/100 m) to a summer mean of about 10°C at the treeline, and a mean annual temperature less than 0°C above the snowline. South of Gorkha in the low-lying valleys, pre-monsoon temperatures reach above 35°C, as witnessed by the RCUP team in May, 1979.

Relative humidities at Gorkha range between 41% in March and 93% in the monsoon period of June and July. Evapotranspiration rates thus are greatest in the pre-monsoon period, dropping to minimum levels during the monsoons, and increasing in the post-monsoon, only to decline again during winter.

Land Use and Denudation

Land use statistics for the Gorkha region are as follows (APROSC, 1979):

Land Classification	Area (km^2)	Percent of Total
Forests	328.55	41.33
Cultivated Lands	307.80	38.72
Pasture Lands	133.08	16.74
Snow-covered	8.24	1.04
Others	17.29	2.17
	794.96	100.00

Above timberline alpine meadows are used for summer pastures, but it is believed that man-induced denudation rates here are minimal. The mountains and valleys south of Barpak are densely settled and land-use intensities are high. Little native vegetation has survived cutting, lopping, burning, and overgrazing. Poorly constructed and maintained dry terraces are widespread, and the pre-monsoon drought precludes the growth of terrace crops, allowing the infrequent pre-monsoon rains to erode considerable sediment. The early monsoon rains probably effect the greatest erosion, since crops are not of

sufficient size to break the impact of raindrops, and the soil is largely exposed. Numerous large slides, some possibly natural, but most man-induced, are found on steep slopes where terraces have been built. Likewise, extensive gullying is found, both on terraced and grazed lands. Generally, the southern portion of the Gorkha region is in an advanced stage of environmental degradation. The vegetation is highly disturbed, soils are eroded, surface runoff has eroded deep gullies, and main streams are choked with sediment. Monsoonal flooding is on the increase, whereas springs, dry up in the pre-monsoon earlier than in the past. Any attempts at watershed rehabilitation must be massive if an appreciable improvement is to be realized.

Mustang Region

Geography

The Mustang region is located in north-central Nepal in the headwaters of the Kali Gandaki River. Two physiographic regions are represented, the Tibetan Plateau to the north and the Inner Himalaya to the south. Most of the region lies above 3000 m, with the highest peaks in excess of 7500 m. The landscape is dominated by the broad geosynclinal trough of the Kali Gandaki River and the snow-clad Annapurna and Dhaulagiri ranges walling the trough.

The combination of remoteness, high altitudes, rugged terrain, and harsh climate have limited settlement and land use intensity. Most villages occupy the Kali Gandaki River valley or major tributary valleys. There is minimal cultivated land beyond a one-hour walk of the villages, and the most extensive land use is livestock grazing.

The only ground access is provided by trails, the most important of which is the old trading route along the Kali Gandaki River between Pokhara and Tibet. Some access is provided by plane and helicopter flights to and from Jomsom. At the time of this writing, the region of Mustang north of Kagbeni was closed to non-citizens of Nepal, and was not visited by expatriot members of the RCUP team.

Geology and Geomorphology

Little of the region has been geologically mapped, but the majority of

rocks are sediments of the Tethysian Zone, bowed into a large N-S structural depression occupied by the Kali Gandaki River. Younger sediments of fluvial origin in the main valley form terraces of various ages and heights above the current flood-plain. Recent alluvium occupies the broad Kali Gandaki River valley. Little seismic activity is noted in this zone (Sharma 1977b).

The Himalayan mountain rim in the south extends well above the snowline in many places, and large glaciers rest amid the peaks. There is little evidence to suggest that these glaciers ever extended much below 4500 m. The ice and snow provide yearlong runoff to the rivers, and monsoon rainfall suplements this flow in summer.

Upper valleys are occupied by glacial moraine and have the characteristic catenary curve profile. At lower altitudes the valleys become V-shaped in response to fluvial erosion. Near and in the trunk valleys flooplains appear, built largely of glacial valley train alluvium. Today these valleys are occupied by underfit streams, indicating the widespread flooding and deposition probably occur less now than in the past.

Soils and Vegetation

Soil types vary with climate and altitude within the Mustang region. South of Jomsom in the main valley, milder and wetter climates have produced relatively deep soils, especially on river terraces and alluvial fans. Considerable fertile cropland is found in the vicinity of Marpha. North of Jomsom, the lowland alluvial soils are coarse and winnowed of their fine fractions, mantled by wind-lag deposits. Tributary valleys such as the Jhong Khola contain fertile stream terrace soils in limited quantities. Elsewhere in the north, soils are typically stoney and thin in response to a lack of dense vegetation and the cold, dry climate.

The best stands of forest, mostly coniferous, are found south of Jomsom on the valley slopes. Northward, a combination of cold temperatures, high winds and low precipitation values limits vegetation to steppe and tundra grasses and low shrubs. Even these are absent in the sterile floodplain of the upper Kali Gandaki Valley.

Hydrology

Most streams are fed by glacial melt, snowmelt, springs, baseflow, and seasonal precipitation. The lack of abundant rainfall plus the more or less steady release of meltwater provides relatively stable river regimes with less flooding than found elsewhere in Nepal. In addition, the low level of human occupance induces little added surface runoff inputs to rivers during storms.

It is believed that the valley train deposits contain large quantities of ground water, especially in the Kali Gandaki River valley north of Jomsom. This resource may offer opportunities for future expansion of irrigated lands.

Stream sediment yields contain moderate levels of clay and silt from the glacial meltwaters. However, the generally low storm quickflow inputs to rivers limit sediment yields. Relatively few active torrents are found, although they occur in some tributary valleys where alluvial fans extend into the trunk valley, such as the right-bank torrent fan about 1 km south of Marpha.

Meteorology

The weather stations in Mustang are mostly low-lying and give a good representation only for the valleys. Annual precipitation values decrease northward away from moisture sources and in the lee of the Himalaya. Parts of the Kali Gandaki lowland north of Jomsom are virtual deserts, such as Mustang which receives less than 300 mm annually. Southward, Jomsom receives 303 mm, and Marpha receives over 2500 mm. Further south, totals are reduced, probably because of less orographic effect, with Tatopani receiving only about 1300 mm. Muktinath, lying at a higher altitude (4000 m) in the upper Jhong Khola valley receives 369 mm, slightly more than in nearby, but lower, Jomsom (Department of Irrigation, Hydrology, and Meteorology, 1977). Annual precipitation is presumed generally to increase with altitude to some limit above which values decline; above the treeline annual precipitation is reduced to near-desert amounts.

Seasonal distributions of precipitation also vary within the region. At Tatopani, 85% of the annual precipitation is monsoonal. Northward the monsoonal share of total precipitation falls to about 50%. Pre- and post-

monsoon precipitation accounts for up to 30%, with winter totals of less than 25% typical. Maximum 24-hr rainfall intensities vary up to 80 mm, occurring during the monsoon. Although no snowfall records are available, areas north of and at higher altitudes than Jomsom receive increasingly greater shares of annual precipitation as snow.

The only temperature data for the Mustang region is from Jomsom. Here, the January mean minimum drops to 2.6°C, and the July mean maximum is 25°C. An extreme low of -10°C has been recorded, and frost occurs in seven months of the year. The mean annual temperature is about 12°C. Significantly higher temperatures occur southward in the Kali Gandaki River valley.

No wind data exist for the region. However, high wind velocities are commonly observed in the main valley from Jomsom northward, where summer winds funnel northward, bringing the monsoon rains and snows, and winter witnesses a reversal of prevailing winds as the cold air of the Tibetan Plateau drains southward. It is believed that this region has considerable potential for the development of wind power for such purposes as the pumping of ground water, the operation of mills, and possibly even electrical generation.

Land Use and Denudation

Population densities are low throughout the region. Intensive agriculture, mostly in the form of irrigated terraces, is limited to the priximity of settlements. Elsewhere, grazing activities dominate. The limited amount of cropland is due primarily to the need to irrigate and the lack of water development in this region. Additional fertile soils, mostly on river terraces, are available, but to date remain uncultivated, awaiting the development of water resources.

The steppe grasslands north of the Jomsom and the alpine meadows at higher altitudes provide abundant grazing lands; however, these resources are not fully utilized at present. South of Jomsom, forests grow in high quality, dense stands, revealing less of the exploitation and degradation seen in the other study regions.

In general, the Mustang region shows little of the land use pressures typical of other regions, and consequently man-induced denudation rates are

probably, relatively low. Some locally intense natural denudation is found in landslide areas, on steep slopes, and in the vicinity of torrents. However, those do not threaten life or valuable property to any significant extent. Perhaps the chief denudation problem is due to wind erosion and sand-blasting in the valley north of Jomsom. The extent to which winds affect human activities is unknown.

The following is a summary of land use in Mustang (APROSC, 1979):

Land Classification	Area (km^2)	Percent of Total
Forests	83.63	6.60
Cultivated Lands	38.74	2.35
Pasture Lands	548.67	28.35
Snow-covered	742.75	5.74
Rock Outcrop	149.38	56.81
Others	2.06	.15
	1565.23	100.00

This data is for only 10 panchayats. Information on the other 6 panchayats is not available.

Myagdi Region

Geography

The Myagdi region lies due south of the Mustang region within the drainage of the lower Kali Gandaki River between Tatopani and Beni, and a main right bank tributary, the Rahughar Khola. The terrain is a highly dissected portion of the Inner Himalaya, with altitudes extending from 835 m at Beni to over 6000 m along the peripheral divides. Everywhere relief is great and most slopes are in excess of 35°.

Warmer and moister climates have given rise to dense native forest vegetation, but increased population densities have also brought extensive clearing and degradation of the native vegetation. Villages cluster both along major rivers and tributaries and on mountain slopes. Accompanying these settlements are irrigated and dry terraces, outlying denuded range lands and retreating forests. Most remaining native forests lie near divides and in limited areas of protected National Forests.

The principal access to this region is by foot trails, some of which

traverse precipitous slopes which greatly impede both human and livestock movements.

Geology and Geomorphology

The Myagdi region occupies the outer portion of the Greater Himalaya. The sedimentary, metamorphic, and igneous rocks controlled by predominant ESE structural trends, are largely unmapped.

Steep V-shaped valleys are occupied by high-gradient streams frequently cascading over falls and rapids. Few floodplains are developed except in the far south near Beni. Natural mass wasting, often in the form of massive rock slides, are common in areas of dipping structure and fractured bedrock. Man-induced slides are of smaller scale but are common on the steepest terraced lands and where intensive grazing is carried out on denuded slopes. Erosion is likewise intense in both the slide areas and on cultivated and grazed lands. Gullies frequently develop on landslide scars and on poorly farmed or overgrazed slopes, growing downslope into deep ravines floored with torrent-layed boulders. These are found to threaten villages and cropland in many areas.

Soils and Vegetation

Soil depth and productivity depend largely on slope steepness and land use intensities. Broadleaf forest soils are deep podzols which, when cleared, are easily eroded. Weathering depths vary from thin to deep on hillsides, and are easily stripped in areas of overgrazing and poor terrace management.

Native vegetation is mostly subtropical broadleaf forest, but little of this remains except near divides and in the remoter areas. Most hillslopes near villages are denuded for fuel, timber and fodder, or are burned off to increase grazing land. At the higher elevations, subtropical forests give way to mixed forests, which due to their remoteness, are more often highergrade stands.

Hydrology

Major streams are fed by glacier and snowmelt, as well as by ground water baseflow and storm runoff. The smaller tributaries, are fed

mainly by baseflow and storm quickflow, both perennial or intermittent. Major valleys are subjected to erratic regimes with high flood peaks where they drain appreciable amounts of disturbed watershed.

Springs are the principal water sources for domestic use and irrigation for many hillside villages. These have tended to decline in discharge in the pre-monsoon drought period due to watershed degradation, since decreasing amounts of precipitation infiltrate into the soil. Seasonal water shortages are acute in several of the villages visited.

River sediment yields are presumed to be high in light of the apparently high rates of overland flow, estimated to be over 70% by Sharma (1977a).

Meteorology

Sparse weather station data for the region reveal annual precipitation values of between 700 and 1400 mm, generally increasing southward and with altitude, especially on south-facing slopes. The percentage of annual precipitation which falls in the monsoon period increases southward, from 58% at Lete, to 66% at Dunai, and 85% at Beni Bazar in the far south. Inversely, winter proportions of total precipitation increase northward from only 5% at Beni Bazar to over 20% in the north. Maximum 24-hr rainfall intensities vary between 40 mm in the north and 150 mm in the south (Department of Irrigation, Hydrology, and Meteorology, 1977).

Land Use and Denudation

Throughout most of the Myagdi region population densities are high and land use intensities are great. This is especially true further south. Irrigated terraces are found where the generally limited water supplies are adequate. These are relatively well maintained and present no major denudation problem. However, dry upland terraces, often found on steep slopes, are vulnerable to pre-monsoon and early monsoon erosion and mass wasting before crops are sufficiently established to protect the soil from rainsplash and sheetwash.

Denuded forest lands used for grazing are widespread, and almost uniformly contribute to high rates of denudation. Barren soils, gullies and ravines, landslide scars, and eroding stock trails are found in abundance on

heavily grazed lands.

The remaining forests present no immediate denudation problems, largely due to inaccesibility. As wood and tree-fodder resources are depleted, it can be expected that the cycle of forest retreat and the initiation of denudation will begin.

The following is a summary of land use in Myagdi (APROSC, 1979):

Land Classification	Area (km^2)	Percent of Total
Forests	300.50	31.84
Cultivated Lands	143.44	15.19
Pasture Lands	285.78	30.27
Snow-covered	165.94	17.58
Rock Outcrop	39.62	4.20
Others	8.68	0.92
	943.96	100.00

Watershed Management Project Descriptions

The following is an outline of major RCU Watershed Management Projects proposed, based on local habitat conditions, needs of the villagers, probability of success, and long-term benefits for the region. The order in which projects are listed for each region is based on a suggested action priority. Rough 5-year and 15-year target values are given for each project for budgetary purposes only, and should not be considered as final.

Kulekhani Region

Terrace Management and Improvement

Poor upland dry terrace construction and management in Kulekhani has resulted in declining crop yields, small landslides, and sheet and gully erosion. It is recommended that no major efforts be concentrated on steep upland terraces which are so poorly situated as to offer little hope for rehabilitation. These will hopefully be abandoned to cultivation if and when land pressures are reduced. Sites for carrying out the terrace project for the first 5 years should include, but are not limited to the areas surrounding:

1. Markhu in Kulekhani Panchayat
2. Chitlang in Chitlang Panchayat
3. Palung in Palung Panchayat
4. Tistung in Thachok Panchayat
5. Kuslechaur in Chitlang Panchayat

The remaining sites for the 15-year project period should be chosen based on future studies.

Terrace improvements recommended are:

1. Regrading treads to level or slightly backsloping to reduce storm overtopping and erosion.
2. Construction of bunds to reduce overtopping.
3. Construction of riser-base drainage ditches with proper lateral spillways leading to drainage diversion ditches (with #2 above).
4. Regrading or stone-lining overly steep and unstable risers, and allowing natural revegetation.
5. Improving peripheral drainage diversion ditches by rerouting, stone or grass lining, baffles, check dams, etc.
6. Terrace livestock control using stone or live fences or guards.

Refer to Table 1 below for a summary.

TABLE I

KULEKHANI TERRACE MANAGEMENT AND IMPROVEMENT

	Targets:	
Activity	5-year	15-year
Tread regrading	10 ha/village=50 ha	200 ha
Bund construction[1]	5000 m/village=25,000 m	50,000 m
Riser-base drainage[2]	1000 m/village=5000 m	10,000 m
Riser stabiliation	1000 m/village=5000 m	10,000 m
Drainage diversion[3]	1000 m/village=5000 m	10,000 m
Livestock control fences[4]	2000 m/village=10,000 m	20,000 m
Livestock control guards[5]	10 ha/village, man-yrs	100 ha, man-yrs

1/ Computed at rate of 500 m of bunds/ha
2/ Computed at rate of 500 m of ditches/ha
3/ Computed at rate of 100 m of ditches/ha
4/ Computed at rate of 100 m of fence/ha
5/ Computed at rate of man-yrs/village

Watershed Protection and Rehabilitation Areas

Springs and small streams which provide drinking water and irrigation should have their source areas protected from human and livestock activities. The drainage basins for these water sources in Kulekhani must be allowed to revegetate naturally in order to increase infiltration, thus insuring a more constant rate of flow at the points where they are utilized. In addition, the control of livestock from these watersheds will provide higher quality drinking water. It is not feasible to protect the entire drainage of each site, so it is recommended that a priority be determined based on field study, with sites utilized primarily for drinking water having the highest priority for protected watersheds. The following activities are recommended:

1. Natural revegetation of watersheds.
2. Fencing (1/2 of total sites), stone or live, to control livestock.
3. Guards (1/2 of total sites) to control livestock.

Refer to Table 2 below for a summary.

TABLE 2

KULEKHANI WATERSHED PROTECTION AND REHABILITATION

	Targets:	
Activity	5-year	15-year
Natural revegetation	30 sites, 3 ha/site=90 ha	115 sites[1], 345 ha
Livestock control fences[2]	8400 m	32,000 m
Livestock control guards[3]	15 sites, man-yrs	57 sites, man-yrs

1/ Determined by APROSC projections;
2/ Computed at rate of 560 m/3 ha plot;
3/ Computed at rate of man-yrs/village.

Trail Improvement

Human and stock trails provide vital transport links, but are often poorly designed and routed, improperly drained, and overused, providing artificial avenues for surface runoff. The result is extensive gullying and stream sedimentation as well as trail destruction. Project sites are the same as for terrace improvement (above) for the first 5 years of the program. The following measures are recommended:

1. Provide drainage along stretches of eroding trail.
2. Regrade or reroute trails where erosion is advanced.
3. Artificially revegetate abandoned trails.
4. Construct stone steps on steep trail segments.

Refer to Table 3 for a summary.

TABLE 3

KULEKHANI TRAIL IMPROVEMENT

	Targets:	
Activity	5-year	15-year
Trail drainage	1000 m/village=5000 m	15,000 m
Regrade/reroute trails	500 m/village=2500 m	10,000 m
Artificial revegetation	100 m/village=500 m	1,000 m
Stone steps	500 m/village=2500 m	5,000 m

Range and Communities Pasture Denudation Control

The broad belt of livestock range found mostly on intermediate hillslopes above the valley bottoms is overgrazed, denuded of vegetation cover, and is undergoing high rates of denudation by landsliding, gullying, and sheet erosion. Many improvements in range fall within the Livestock and Range Management report. However, the following watershed management practices are recommended in the above five villages for the first 5 years:

1. Gully repair by building structures (gabions, stone check-dams, stone-lined channels, steps, brush barriers, etc).
2. Gully bank revegetation (artificial).

3. Gully head drainage diversion ditches.
4. Fencing (stone or live) for livestock control.

Refer to Table 4 below for a summary.

TABLE 4

KULEKHANI RANGE DENUDATION CONTROL

	Targets:	
Activity	5-year	15-year
Gully repair	1000 m/village=5000 m	10,000 m
Artificial revegetation	1000 m/village=5000 m	10,000 m
Drainage diversion[1]	1500 m/village=7500 m	15,000 m
Livestock control fences[2]	1500 m/village=7500 m	15,000 m

1/ Computed at rate of 1.5 m of ditch/m of gully
2/ Computed at rate of 1.5 m of fence/m of gully

Landslide Control

Efforts should be concentrated on areas of high man-induced landslide susceptibility or occurence. Only those potential or actual natural slides which endanger life or valuable property should be treated. The following measures are recommended, for the first 5 years to be concentrated in the Palung, upper Chitlang, lower Markhu, and lower Sisneri Panchayats:

1. Drainage diversions around incipient or actual slide sites.
2. Site stabilization by artificial revegetation.
3. Livestock control fencing (live or stone) for site stabilization by natural or artificial revegetation.
4. Slide structural control (gabions, stone checks, etc.).
5. Slide deposit internal drainage (recommended only where roads or other valuable structures are threatened).

See Table 5 for a summary.

TABLE 5

KULEKHANI LANDSLIDE CONTROL

	Targets:	
Activity	5-year	15-year
Drainage Diversion	5000 m	15,000 m
Artificial revegetation	10 ha	15 ha
Livestock control fences	2000 m	5,000 m
Structural controls	25 structures	50 structures
Slide drainage	2 sites	5 sites

Stream Training and Erosion Control

In general stream training and erosion control on major channels is not recommended for this region under the RCUP. However, such measures should be taken where valuable property or life is endangered, as is the case along the Sankha Mul Khola east of Palung:

1. Gabions to protect stream banks from erosion and to rechannel or confine flood discharges.
2. Riprap bank lining for erosion protection.
3. Floodplain stabilization through tree plantings and buffer strips.
4. Channelization; efforts should be considered to increase the gradient of the braided channel.

Refer to Table 6 below for a summary.

TABLE 6

KULEKHANI STREAM TRAINING AND EROSION CONTROL

	Targets:	
Activity	5-year	15-year
Gabions	300 m	500 m
Riprap	1000	2000 m
Floodplain planting	50 ha	100 ha
Channelization	500 m	500 m

Road Embankment Stabilization

Efforts to stabilize road cuts and fills should be concentrated on small demonstration plots and sites along the new Kulekhani Dam access road and the Tribhuvan Rajpath. The following measures are recommended:

1. Hydroseeding and plantings.
2. Improved roadside drainage.
3. Mass wasting and erosion control structures on cut and fill slopes (gabions, stone and brush barriers, etc.)

Refer to Table 7 below for a summary.

TABLE 7

KULEKHANI ROAD EMBANKMENT STABILIZATION

	Targets:	
Activity	5-year	15-year
Hydroseeding/planting	50 ha	50 ha
Drainage	2000 m	2000 m
Structures	30	30

Gorkha Region

Upland Terrace Improvement

Efforts at terrace improvement should concentrate on those terraces where the likelihood of project success and the promise of significantly increased crop production are greatest. Badly damaged and poorly located terraces should eventually be abandoned and revegetated where possible.

The principal Project sites for the first 5 years should include, but are not limited to, the regions near the villages of: Gorkha, Chorkate, Bamgkot, Shrinathkot, and Barpak.

The following measures are recommended:

1. Regrading treads to level or slightly backsloping.
2. Bund construction.
3. Riser-base drainage ditch and spillway construction (with #2 above).
4. Regrade, line and/or revegetate unstable risers.

5. Peripheral drainage diversion improvement.
6. Terrace livestock control using fences and/or guards.

Refer to Table 8 below for a summary.

TABLE 8

GORKHA UPLAND TERRACE IMPROVEMENT*

	Targets:	
Activity	5-year	15-year
Tread regrading	10 ha/village=50 ha	500 ha
Bund construction[1]	5000 m/village=25,000 m	10,000 m
Riser-base drainage[2]	1000 m/village=5000 m	20,000 m
Riser stabilization	1000 m/village=5000 m	20,000 m
Drainage diversion[3]	1000 m/village=5000 m	40,000 m
Livestock control fences[4]	2000 m/village=10,000 m	20,000 m
Livestock control guards[5]	10 ha/village=50 ha, man-yrs	50 ha, man-yrs

* see footnotes, Table 1

Water Development Projects

There is a widespread shortage of domestic and irrigation water supplies in the Gorkha region. A program of spring improvement, and the construction of impoundments and irrigation delivery structures should be undertaken, to be preceeded by extensive feasibility studies (now underway by APROSC). Thus, no specific sites are here recommended. The following activities are suggested:

1. Spring development and improvement for increased quantities of high quality water.
2. Small tributary impoundments for irrigation, fisheries and possible mini-hydro power.
3. Spring and irrigation delivery canals and/or pipelines.
4. Hilltop rainwater catchment ponds (experimental).

5. Establishment of protected areas on spring and small stream watersheds used for drinking water and/or irrigation:
   a. Natural revegetation of watersheds.
   b. Fencing (1/2 of sites), stone or live, to control livestock.
   c. Guards (1/2 of sites) to control livestock.

Refer to Table 9 below for a summary.

TABLE 9

GORKHA WATER DEVELOPMENT PROJECTS*

	Targets:			
Activity	5-year		15-year	
Spring development	sites		sites	
Impoundments	2 sites		4 sites	
Canal/pipeline delivery	m		m	
Rain catchment ponds	5 sites		15 sites	
Artificial revegetation	sites, 3 ha/sites=ha		sites,	ha
Livestock control fences[2]	m		m	
Livestock control guards[3]	sites	man-yrs	sites,	man-yrs

*See footnotes, Table 2

Range and Community Pasture Denudation Control

The problem of range degradation in the Gorkha region is so widespread that at best only a small portion of land in this use category can be treated. These areas should be selected based on high visibility and demonstration value. The following actions are recommended:

1. Gully and landslide repair using structures.
2. Gully bank and landslide scar revegetation (artificial).
3. Gully and landslide head drainage diversions.
4. Fencing (stone or live) for livestock control.

Refer to Table 10 below for a summary.

TABLE 10

GORKHA RANGE DENUDATION CONTROL*

Activity	Targets: 5-year	15-year
Gully repair	1000 m/village=5000 m	10,000 m
Artificial revegetation	5 ha/village=25 ha	50 ha
Drainage diversion[1]	1500 m/village=7500 m	30,000 m
Livestock control fences[2]	1500 m/village=7500 m	30,000 m

* See footnotes, Table 4

Stream Channel and Floodplain Improvements

In the earlier stages of the RCUP, improvements of trunk streams are not advised except to protect life and valuable property. The following projects are recommended to be concentrated along the Daraundi Khola and Buri Gandaki River:

1. River bank erosion protection using gabions and riprap.
2. Channel diversions from eroding banks. During the RCUP team visit to Gorkha, the skills of local fishermen were noted in diverting stream channels. It is recommended that these local skills be used in the RCUP effort.
3. Floodplain stabilization and rehabilitation through plantings.

Refer to Table 11 below for a summary.

TABLE 11

GORKHA STREAM CHANNEL AND FLOODPLAIN IMPROVEMENTS

Activity	Targets: 5-year	15-year
Gabions	300 m	500 m
Riprap	1000 m	2000 m
Diversions	5	10
Floodplain stabilization	200 ha	500 ha

Mustang Region

Irrigation and Terrace Expansion

A lack of water for irrigation is a major limiting factor in the extent of cropland in this dry region. Potential exists to develop stream flow, and possibly ground water resources as well, in areas where fertile but uncultivated terrace soils are available. Feasibility studies of the following projects are recommended, primarily in the Marpha-Tukche portion of the Kali Gandaki River, along the Jhung Khola between Kagbeni and Jhorkot, and also in the upper Mustang region:

1. Construction of new terraces on arable soils (where water delivery is possible).
2. Test drilling to determine ground water resources in alluviated valleys north of Jomsom.
3. Construction of tributary stream impoundments for irrigation and possible mini-hydro power development.
4. Construction of water delivery canals and/or pipelines (contingent upon location of water sources and demonstration of local needs).
5. Development of experimental windmill ground water pumping stations.

Refer to Table 12 below for summary.

TABLE 12

MUSTANG IRRIGATION AND TERRACE EXPANSION

	Targets:	
Activity	5-year	15-year
New Terraces	100 ha	500 ha
Test drilling	30 bores	?
Impoundments	2	4
Canal/pipeline delivery	3000 m	10,000 m
Windmills	5	?

Snow Management

The management of the snowpack could reduce potential spring snowmelt flooding and increase the ground water resources in the floodplains, thereby smoothing the variations in stream discharge regimes. Snow surveys and studies of the feasibility of snow management should be initiated, especially in the alpine zones in the upper catchments of the Kali Gandaki River and Mustang Khola. The following are recommended:

1. Site location and snow survey initiation to determine snowpacks.
2. Snow fence experimentation to determine optimum sizes, orientations, materials and locations.
3. Snow fencing (contingent upon early successes of 1 and 2 above).

Refer to Table 13 below for a summary.

TABLE 13

MUSTANG SNOW MANAGEMENT

	Targets:	
Activity	5-year	15-year
Site location	--	10
Fence experiments	--	15
Fences (permanent)	--	20,000 m

Myagdi Region

Water Projects

The most critical single need of the villages in the Myagdi region is for domestic and irrigation water. Spring and small stream sources of water have been increasingly drying up during the pre-monsoon period due to watershed degradation and declining infiltration. Also the productivity and stability of many dry upland terraces could be enhanced by the application of irrigation water. Efforts to develop and improve springs should be concentrated in the vicinities of hillside villages, to include in the first 5 years: Kotgaon, Pakhapani, Darmije, Jhingson and Kaulegaura. The following activities are recommended:

1. Improvement of presently used springs.
2. Location and development of new springs, possibly through horizontal drilling.
3. Impoundments for irrigation, fisheries, and possible power generation.
4. Construction of delivery canals and/or pipelines from springs and impoundments.
5. Experimental hilltop water catchment ponds.
6. Establishment and improvement of protected watersheds above spring and stream water-withdrawal points:
   a. Artificial revegetation of badly damaged watersheds.
   b. Natural revegetation of watersheds.
   c. Fencing (1/2 of sites), stone or live, to control livestock.
   d. Guards (1/2 of sites), to control livestock.

Refer to Table 14 below for a summary.

TABLE 14

MYAGDI WATER PROJECTS*

	Targets:	
Activity	5-year	15-year
Spring improvement	30 sites	60 sites
Spring locations	20 sites	100 sites
Impoundments	2	5
Canal/pipeline delivery	10,000 m	50,000 m
Rain catchment ponds	5	20
Artificial revegetation	30 sites, 1 ha/site=30 ha	150 sites, 150 ha
Natural revegetation	30 sites, 3 ha/site=90 ha	150 sites, 450 ha
Livestock control fences[2]	8400 m	42,000 m
Livestock control guards[3]	sites, man-yrs	sites, man-yrs

* See footnotes, Table 2

Trail Construction and Improvement

The rugged terrain of the Myagdi Region has resulted in poor access to some villages and the rapid deterioration of some foot trails. In order to carry out the RCUP in these areas, improved access must be provided. This topic is treated in more detail in the Energy report of the RCU Project Paper. The following watershed management activities are suggested:

1. Trail drainage construction and improvement.
2. Trail erosion control structures.

Refer to Table 15 below for a summary.

TABLE 15

MYAGDI TRAIL CONSTRUCTION AND IMPROVEMENT

	Targets:	
Activity	5-year	15-year
Trail drainage	m/village= m	m
Structures		

Upland Terrace Improvement

Numerous upland dry terraces are poorly constructed and maintained, contributing to low crop yields, mass wasting and erosion, and ultimately to stream sedimentation. Target areas (at least five in first 5 years) should be identified on the basis of likely success, proximity to villages and the availability of local labor. The following activities are recommended:

1. Regrading treads to level or slightly backsloping.
2. Bund construction.
3. Construction of riser-base drainage ditches and spillways.
4. Regrade, line and/or revegetate unstable risers.
5. Peripheral drainage diversion improvement.
6. Terrace livestock control using:
   a. Stone or live fences.
   b. Guards.

Refer to Table 16 below for a summary.

TABLE 16

MYAGDI UPLAND TERRACE IMPROVEMENT*

Activity	Targets: 5-year	15-year
Tread regrading	10 ha/village=50 ha	200 ha
Bund construction[1]	5000 m/village=25,000 m	30,000 m
Riser-base drainage[2]	1000 m/village=5000 m	10,000 m
Riser stabilization	1000 m/village=5000 m	10,000 m
Drainage diversion[3]	1000 m/village=5000 m	10,000 m
Livestock control fences[4]	2000 m/village=10,000 m	20,000 m
Livestock control guards[5]	10 ha/village, 50 ha, man-yrs	ha, man-yrs

*See footnotes, Table 1

Range Denudation Control

The processes of man-induced mass wasting and erosion are accelerating on the degraded ranges of the Myagdi region. It is recommended that five near-village sites be chosen in the first 5 years for intensive range denudation control and rehabilitation. The following activities are recommended:

1. Gully and landslide repair using structures.
2. Gully bank and landslide scar revegetation (artificial).
3. Gully and landslide head drainage diversions.
4. Livestock control fencing (stone or live).

See Table 17 below for a summary.

TABLE 17

MYAGDI RANGE DENUDATION CONTROL*

	Targets:	
Activity	5-year	15-year
Gully/landslide repair	100 m of gully/village, 5000 m	10,000 m
Artificial revegetation	5 ha/village=25 ha	50 ha
Drainage diversion[1]	1500 m/village=7500 m	30,000 m
Livestock control fences[2]	1500 m/village=7500 m	20,000 m

*See footnotes, Table 4

General Resource Inventories and Monitoring

Aerial Photography

A prerequisite to mapping of resources in the four Project areas is aerial photographic coverage. At present, there is available only limited and largely inadequate aerial photography, specifically low-quality and dated black and white 1:20,000-scale coverage of Kulekhani, and some small-scale strip coverage of parts of the Gorkha region. The following acquisitions are recommended:

1. Complete stereo coverage of all four Project regions.
2. 1:10,000-scale, 9 x 9 inch format.
3. Color infrared preferred; black and white acceptible.
4. Fall (post-monsoon) coverage.

The above photography should be provided through contract since such capability does not exist in Nepal.

For follow-up and special purpose coverage, the proposed Agricultural Resource Inventory System (USAID, 1979) will provide small scale 2 1/4 x 2 1/4 Hasselblad photography. This system should be operational by June, 1980 (beginning of Fy 1981).

Satellite Imagery

Landsat has provided the capability of small-scale resource mapping of under-developed regions of the world at frequent (18-day) intervals and in various wavelengths (bands). The following Landsat I and II acquisitions of the Project regions are recommended:

1. All high quality (minimum cloud cover) images, bands IV - VII and false-color IR.
2. 1:1,000,000-scale positive transparencies and prints.
3. Selected 1:250,000-scale enlargement prints of above.

By the time RCUP is implemented, Landsat III imagery will also be available. This coverage is expected to surpass Landsat I and II in resolution and overall quality. The following Landsat III acquisitions are recommended:

1. All high quality (minimum cloud cover) images, bands IV - VII and false-color IR.
2. 1:1,000,000-scale positive transparencies and prints.
3. Selected 1:250,000-scale enlargement prints of above.
4. Computer-compatible tapes of selected images for supervised land classification mapping.

Resource Inventory and Land-Use Maps

Soils Maps

1. Complete coverage of four Project regions, 1:10,000-scale base.
2. Information desirable: soil type, textures, organic content and fertility, depths, infiltration rates and capacities, erodibility, and strength (for construction).
3. Sources of data: aerial photos, extensive field surveys.

Vegetation Maps

1. Complete coverage of four Project regions, 1:10,000-scale base.
2. Information desirable: natural vegetation associations, percent cover.
3. Sources of data: aerial photos, ground truth.

Hazards Maps

1. Complete coverage of four Project regions, 1:10,000-scale base.
2. Information desirable: landslide and prone areas, gullying, flood-prone areas, avalanche areas, soils of low strength, etc.
3. Sources of data: aerial photos, field study, soils maps.

Hydrologic Maps

1. Complete coverage of four Project regions, 1:20,000-scale base.
2. Information desirable: location of perennial and intermittent channels, mean annual discharges, floodplain location, flood-prone areas, channel bed characteristics, etc.
3. Sources of data: aerial photos, field surveys.

Geological Maps

1. Complete coverage of four Project regions, 1:20,000-scale base.
2. Information desirable: rock type and structures.
3. Sources of data: aerial photos, field surveys.

Current Land-Use Maps

1. Complete coverage of four Project regions.
2. 1:10,000-scale base.

3. Information desirable: level II or better classification.
4. Sources of date: aerial photos, ground truth.
5. Second set of maps should be done near end of Project period for comparative study and determination of Project success.

Land Capability Maps

1. Complete coverage of four Project regions.
2. 1:10,000-scale base.
3. Information desirable: level II or better classification of best potential use.
4. Sources of data: aerial photos, extensive field surveys, resource inventory maps (above).

Meteorological Monitoring

The network density and data quality of currently operating weather stations in the four Project regions is inadequate for RCUP watershed management. These stations are widely scattered and have only non-recording equipment. In addition, most have no temperature instruments and none have wind-recording capabilities. Additional weather stations should be established and the current stations upgraded. Table 18 summarizes the recommendations.

Snow surveys should be carried out routinely in winter on designated snow courses at higher altitudes (Meiman, 1976). Measurements of snow depth and water equivalent (using a core sampler) should be taken.

A summary of equipment needs to outfit and upgrade weather stations and projected costs (based on Department of Irrigation, Hydrology, and Meteorology data) are outlined in Table 19.

The HMG Department of Irrigation, Hydrology, and Meteorology has volunteered to set up the new stations, upgrade old stations to RCUP needs (provided the Project purchases the equipment), and train and provide the manpower needed to monitor and service the stations.

TABLE 18

RECOMMENDED UPGRADING AND ESTABLISHMENT OF METEOROLOGICAL STATIONS

Station (Number)	Precipitation: Non Recording	Precipitation: Recording	Temperature: Non Recording	Temperature: Recording	Wind	Snow Surveys
Kulekhani:						
Daman (0905)	C	P	C	P	-	-
Markhu Caon (0915)	C	P	P	P	-	-
Chisapani Gadhi (0904)	C	P	P	P	-	-
*Ratmate	P	-	P	-	-	-
*Chitlang	P	-	P	-	-	-
Gorkha:						
Gorkha (0909)	C	P	C	P	-	-
Jagat (Setibas) (0901)	C	-	P	P	-	-
*Larke Bazar	P	P	P	P	-	P
*Barpak	P	P	P	P	P	-
*Tribeni	P	-	P	-	-	-
Mustang:						
Jomsom (0601)	C	P	P	P	P	P
Thakmarpha (0604)	C	P	C	-	-	-
Muktinath (0600)	C	P	P	P	-	P
Ghami (0610)	C	-	P	-	-	-
Mustang (0612)	C	P	C	P	P	P

TABLE 18 (continued)

Station (Number)	Precipitation: Non Recording	Precipitation: Recording	Temperature: Non Recording	Temperature: Recording	Wind	Snow Surveys
Myagdi:						
Tatopani (0606)	C	-	P	-	-	-
Beni Bazar (0609)	C	P	P	P	-	-
Lete (0607)	C	-	P	-	-	-
Gorapani (0819)	C	-	P	-	-	-
*Pakhapani	P	P	P	P	-	-
*Bwari	P	-	P	-	-	-

* Proposed new station

C Current capability

P Proposed capability

TABLE 19

WEATHER STATION EQUIPMENT NEEDS AND COSTS

Item	Number	Unit Cost (NRs)	Cost (NRs)
Precipitation gauge, non-recording	7	250	1750
Hydrograph, continuous-recording, weekly	12	5500	66,000
Thermograph, continuous-recording, weekly	12	6000	72,000
Maximum-minimum therometer	17	240	3080
Wind speed recording instrument	3	2100	6300
Snow core samplers, scale, rod, etc.	4	1800	7200
Weather shelter	7	1000	7000
Shelter set-up (new)	7	2000	14,000
Shelter improvement	14	500	7000

Hydrologic Monitoring

Stream gauging stations should be established at various locations in each of the Project regions. Two types of stations, one with a continuous-recording gauge, the other for manual measurements, should be established. The continuous-recording stations should be located, subject to field inspection, near the following:

1. Tasar Khola near Markhu; Kulekhani
2. Daraundi Khola, near Taranagar, Gorkha.
3. Kali Gandaki, near Beni, Myagdi.

The above stations each will have continuous-recording stage gauges. The non-recording gauge sites should be chosen based on the following criteria:

1. Near the mouths of major tributaries to trunk streams.
2. At bridge crossings.
3. At sites where channel surveying is feasible.
4. At sites which will likely remain stable through floods.

At least five permanent manual-monitoring stations should be established in each of the four Project regions. Rating curves must be constructed for all sites, and measurements taken as follows:

1. Stage measurements weekly during baseflow periods.
2. Stage measurements hourly or daily during quickflow periods.
3. Suspended sediment samples with each stage measurement.

Table 20 summarizes the hydrological station requirements and costs.

The HMG Department of Irrigation, Hydrology, and Meteorology has agreed to help set up, train, and man these proposed hydrological stations.

TABLE 20

GAUGING STATION NEEDS AND COSTS

Item	Number	Unit Cost* NRs	Cost* NRs
Stage recorder, continuous-recording, weekly	3	20,000	60,000
Suspended sediment hand sampler, DH-48, wading-type	18	1350	24,300
Suspended sediment cable sampler, DH-59	3	4000	12,000
Gauge-house set-up	3	80,000	240,000
Cable set-up (100 m)	3	55,000	165,000
Current meter, hand, wading-type	10	6000	60,000
Current meter, cable-type	3	10,000	30,000
Miscellaneous equipment	-	-	20,000

*Figures provided by Department of Irrigation, Hydrology, and Meteorology.

Runoff Plots

In each of the four Project areas one set of runoff plots (Djorovic, 1977) should be established to measure sediment and runoff yields from similar soils under different cover types. The following are suggested procedures:

1. Locate plots near villages for maximum visibility and demonstration value.
2. Locate plots near weather stations or have rain gauge at each site.
3. Construct as least two plots side-by-side for comparative studies/demonstrations.
4. Data on runoff per ha and weight/volume of soil loss per ha are to be recorded.

Sediment Catchment Measurements

At suitable sites where check dams have been constructed, it will be desirable to keep measurements of sediment accumulations behind the dams. This should be done on a seasonal or at least annual basis at as many sites as possible.

Major Issues in Watershed Management

Biological vs. Mechanical Control of Denudation

During the RCUP design period there has arisen some differences in opinion between HMG and USAID over the applications of biological vs. mechanical control of watershed denudation. HMG maintains that structures, such as check dams, gabions, river training structures, and large impoundments in general should be incorporated within the early stages of implementation of watershed management for two main reasons. First, such structures will help spare the remaining productive land in floodplains, thereby reducing the trend for farmers to move higher into the watersheds for cultivation as lowland acreage is destroyed by floods. Second, mechanical control has more direct and visual impact upon local villagers than biological control, thereby gaining their early confidence that the RCUP will indeed be implemented.

USAID's and this writer's philosophy is to emphasize biological controls of denudation over the erection of structures, for several reasons. First, biological controls, such as planting, natural revegetation, and livestock management, are applicable to wider areas at a lower cost per hectare. Second, biological controls deal with and attempt to solve the root problems of watershed denudation, and not simply treat the symptoms. Third, the application of biological methods in time precludes the need of widespread use of structures. And fourth, impoundments, being capital intensive, are investments which are best protected by upgrading the watershed first, before construction.

These two philosophies are not necessarily mutually exclusive. Neither HMG nor USAID maintains that the RCUP should use one approach to the exclusion of the other. In fact, a mutual understanding has been reached as to the approach the RCUP will take. First, biological methods will be stressed throughout the RCUP implementation period since capital investments will be limited and these methods have the best chances for long-term success. Second, structures, excluding large impoundments, should be applied to those areas of the Project regions in which life or valuable property are threatened by natural or man-induced denudation processes. Third, in light of the lag time required for biological methods to take effect, the establishment of small structures will serve a useful role in gaining the early confidence and acceptance of the villagers. And fourth, large impoundments, whether for hydroelectricity, flood control, and/or irrigation, be considered as part of the long-range watershed management plan, but with financing to come from HMG and other donor agencies.

Manpower Availability

The needs for considerable inputs of trained and unskilled manpower will be a continuing problem in the RCUP implementation. Nepal has a history of skilled manpower shortages, and unskilled labor availability tends to fluctuate greatly with the seasons.

Within the first five years of RCUP implementation, large inputs of highly trained personnel will be required, especially in watershed management, to collect the resource inventory data required to carry out effective long-range planning. It is clear that HMG can supply little of this need; thus, RCUP will be responsible for bringing in expatriot experts to manage early implementation efforts. It is hoped that, meanwhile, HMG

and RCUP can begin training (see Training in RCUP, this Project Paper) of Nepalese specialists who can be phased into the implementation as soon as they are prepared. This will require a major training effort unsurpassed in the history of Nepal.

Unskilled manpower needs will be great throughout the implementation period and beyond. Initially these inputs will be supplied from surplus labor pools during low-activity agricultural seasons, such as in the spring and pre-monsoon periods. Eventually, however, it is believed that a successful RCUP will free some labor as agricultural production and efficiency increases, lessening the strain on village labor supplies.

Need vs. Desires of Villagers

From a purely utopian standpoint, the needs of local villagers in terms of watershed management are straightforward: the land should be upgraded to its optimum ecological stage, and maintained as such indefinitely. However, this state may never be achieved in Nepal where rural population pressures are so intense and landscape degradation so advanced. At best, a general improvement in watershed conditions can be achieved which will decrease degradation and increase resource productivity to some acceptable level below the theoretical optimum.

Thus, RCUP must not only consider the needs of the villagers as perceived by the experts, but also be sensitive to the desires and perceptions of the villagers. The Project simply cannot hope to succeed in any measure without the support of the villagers. If the desires of the villagers do no necessarily coincide with their needs (i.e., best watershed management practices), some middle ground must be sought. The challenge of RCUP will be to begin immediate upgrading of the watersheds with the early support of the villagers, and, where necessary, to change the perceptions of the villagers where such perceptions conflict with good watershed management. Perhaps the best example of where perceptions must be altered is to instill the philosophy that the upgrading of watersheds is a long-term effort which, in some cases, does not pay benefits directly or immediately. Patience will be necessary in this process. Altered perceptions can be achieved through effective demonstration projects and local educational programs. The end result will hopefully be an upgraded and more productive

landscape resided upon by villagers who have an enhanced understanding of land stewardship and who will continue to strive on their own for healthy, productive watersheds.

Analysis of Project Limitations and Benefits

Limitations

Social Limitations

1. Unskilled labor availability. As noted earlier, rural labor pools in Nepal undergo considerable seasonal flux. Minimal labor is available during the monsoon season (June-September) when field preparation, crop planting, and harvesting activities peak. RCUP watershed management activities involving large quantities of unskilled labor must be planned so as to utilize off-season labor pools, especially in late fall through late spring.
2. Unskilled and skilled labor incentives. Some question exists as to the best methods of payment for unskilled labor, whether it be in cash, credits, food or other necessities, or voluntary. Studies are required to find which method or combination will be most successful. Skilled labor incentives involve different problems. Although rates of pay may be at issue, more important are amenities which will keep skilled technicians and professionals in-country, will attract them to field locations, and will keep them there for prolonged periods to provide continuity to RCU Projects. Such incentives may involve hardship allowances, comfortable residences, periodic leave periods, family allowances, etc.
3. Lack of panchayat and district level watershed management infrastructures. To date, there is no effective infrastructure at the sub-national level to implement watershed management activities and education. The RCUP will be responsible for establishing such an infrastructure so that RCUP implementation and post-RCUP continuation of activities are insured.

4. Pressures on natural resources. In nearly all parts of Nepal, landscape degradation is related not so much to ignorance of good management and conservation techniques as to over population and the immediate demands for food, fuel, livestock fodder, and shelter for survival. The main challenge is, therefore, to relieve population pressures. This may best be accomplished by population control, which is being attempted and is not within the mandate of the RCUP. Alternative methods which RCUP must address include increasing resource productivity through introduction of better resource management systems and technology, establishing alternative economic pursuits to agriculture, offering other energy sources, etc. Only when concnerns for survival are eliminated will the villagers be able to afford the luxury of conservation, and they will then be likely to accept such methods readily.

Technical Limitations

1. Shortage of skilled and professional manpower. Nepal has a history of shortages of highly-trained manpower. If the RCUP is to be successful, it will have to construct an immediate and productive system of training at all levels of competence. Only in this way will the RCUP technical and professional slots be filled by Nepalis, which is a principal goal of the RCUP. To achieve this goal, it may at first be necessary to send Nepalis overseas to receive training; meanwhile, expatriot specialists will be needed to get the RCUP underway. It is hoped that in the longrun such training will be within the capabilities of the Tribhuvan University and other in-country education/training centers.
2. Poor local watershed practices. Although local ignorance of good watershed management practices is not the primary problem, as mentioned above, there are practices which for reasons of custom, superstition, or ignorance, have little value and may in some cases be detrimental. It behooves the RCUP to provide local enlightenment through extension, education, and demonstration to replace these practices with better ones.

3. Research gaps. Considerable inventorying and research has been accomplished in watershed management in Nepal; however, a lack of concerted efforts have led to a present state in which may gaps are found in knowledge. Some of the gaps are due to a lack of technology transfer from foreign, and even in-country, areas. There are other research gaps due to a simple lack of study of watershed management technologies suited to local Nepalese habit conditions. Ecologically, the mountains of Nepal are unique, and technology transfer from other mountainous areas of the world is not always successful. Examples of technological gaps in watershed management include terrace technology, gully control techniques, river training methods, and snow management.
4. Limited scope of RCUP. The RCUP effort will be focused on only four regions within Nepal, and will be limited within these regions to areas of concentration. Obviously, the RCUP is not designed to solve all of Nepal's watershed problems even in fifteen years. It is a major challenge to initiate conservation and management projects at key locations in the four Project regions where a maximum of demonstration and technology transfer will take place. Only when the villagers see new techniques and take them back to their villages will the necessary dissemination of watershed management technology take place.

Benefits

Direct Benefits

1. Reduced soil erosion. The most obvious direct benefit of the RCUP will be in reduced soil losses. The primary goal of biological denudation control is to shield the soil and anchor it in place so that soil quality will be maintained.
2. Reduced landslide. Another direct result of RCUP Watershed Management will be the reduction of man-induced mass wasting. Such processes rapidly remove topsoil and overburden, not only lessening the land's ability to sustain vegetation, but also threatening life, cultivated lands, houses, and other structures. New landslide scars also typically initiate local cycles of accelerated erosion through gullying.

2. Reduced landslide. Another direct result of RCUP Watershed Management will be the reduction of man-induced mass wasting. Such processes rapidly remove topsoil and overburden, not only lessening the land's ability to sustain vegetation, but also threatening life, cultivated lands, houses, and other structures. New landslide scars also typically initiate local cycles of accelerated erosion through gullying.
3. Torrent control. Better watershed management will keep the soil in place, improve the vegetative cover, and thus reduce surface runoff into draws where it concentrates and becomes highly effecient in moving debris downslope into river systems. Checking such torrents will stop their encroachment onto adjacent cultivated lands, and decrease the threat to structures such as houses, roads, trails, canals, etc.
4. Flood control. The main perennial stream channels will become more stabilized once upland conservation and rehabilitation measures take effect. This means that discharge regimes will become less erratic, flood peaks will drop, lag times will increase, total quickflow discharges will decline, and baseflows will increase. The above changes will mean fewer destructive floods, the opportunity to reclaim floodplains for cultivation, and the enhancement of stream resources for such uses as domestic and irrigation water, fishing, and power.

Watershed Management Professional
Personnel Requirements

Title: Physical Geographer

Qualifications: Ph.d.; experience and expertise in remote sensing and aerial photo interpretation, geomorphology, and cartography, knowledge of meteorology, climatology, vegetation, soils; competence in all forms of mapping, especially land use. Ability to work under strenuous fields conditions, and to supervise cartographic staff.

Person-years: 8, or about 2 yr/region; required in Nepal first 6 months to set up and supervise early mapping efforts, and for 6 months near end of mapping phase; require one year in U.S. developing computer maps for Project regions.

Scope of Work: Supervision of field and remote sensing data gathering for land use, land capability, and hazards maps; supervision of all resource map cartography; coordination of other watershed management activities.

Title: Soil Scientist

Qualifications: Ph.D., M.S. acceptable, experience and expertise in soils mapping in field and from remote sensing imagery; excellent health and stamina.

Person-years: 8, or about 2 yr/region.

Scope of Work: Supervision of field data collection and mapping, and soils mapping from remote sensing imagery; cooperations with other resource mapping activities; input into land capability map.

Title: Geologist

Qualifications: Ph.D.; experience and expertise in rock-type and structure mapping in field and from remote sensing imagery; knowledge of seismic geology; excellent health and stamina.

Person-years: 8, or about 2 yr/region.

Scope of Work: Supervision of field and remote sensing data gathering for rock and structure mapping; examination of sites for structures to determine stability; input into land capability and hazards maps.

Title: Watershed Hydrologist

Qualifications: Ph.D.; experience and expertise in fluvial hydraulics; stream gauging set-up, monitoring, and statistical analysis; measurement of sediment yields; and set-up, operations and analysis of results from runoff plots; knowledge of meteorology and geomorphology; surveying skills; excellent health and stamina.

Person-years: 12, or about 3 yr/region.

Scope of Work: Set-up of stream gauges and supervision of gauge operations; set-up and supervision of runoff plots; supervision of sediment dam measurements; supervision of hydrologic data mapping; cooperation and coordination with meteorology efforts.

Title: Hydrometeorologist

Qualifications: Ph.D.; experience and expertise in meteorology, climatology, synoptic analysis, and hydrologic cycle; excellent health and stamina.

Scope of Work: Supervision of weather station location, set-up, and operations; analysis of meteorological data; inputs into other resource mapping; coordination and cooperations with hydrology efforts.

References

Anderson, Henry W., Hoover, Marvin D., and Reinhart, Kenneth G. 1976 Forest and Water. Pacific Southwest Forest Experiment Station General Technical Report PSW/18/1976. Berkeley: U.S.F.S.

Chatra Experiment Station. 1976 Annual Report: Results of Runoff and Erosion Experiments. Chatra: Soil Conservation, Research, Demonstration and Training Center.

Department of Irrigation, Hydrology, and Meteorology. HMG. 1977 Climatological Records of Nepal. Vol. I, 1971-1975.

Department of Soil and Water Conservation. HMG. 1977 Soil and Water Conservation System: Program Planning and Budgeting. 25 years projection (1977-2002).

_____. 1978a Analysis of Rates for 035/036. Mimeograph.

_____. 1978b Watershed Condition and Natural Resource Inventory: A Working Paper Work Plan. NEP. 74/020. Mimeograph.

_____. Agricultural Projects Services Center (APROSC). 1979a Kulekhani Inception Report. Draft.

_____. 1979b Kulekhani Panchayat Profile. Mimeograph.

_____. 1979c Miscellaneous hydrological data. Draft.

_____. 1979d RCUP Action Plan Guidelines. Mimeograph.

Department of Soil and Water Conservation. Integrated Watershed Management Project (IWM). HMG. 1979 Status of Phewatal Management Plan. Mimeograph.

Djorovic, M. 1977 "Use of Runoff Plots to Evaluate Soil Loss," in Guidelines for Watershed Management. FAO Conservation Guide No. 1, pp. 143-146.

Eren, T. 1977 "The Integrated Watershed Approach for Development Project Formulation," in Guidelines for Watershed Management. FAO Conservation Guide No. 1, pp 9-14.

Fleming, W.M. 1978 Classification of Catchments in the Western Development Region of Nepal. DSWC Working Paper IWM/WP/10.

Gelder, A. Van. 1978 Evaluation of DSWC Erosion Control Activities. DSWC Working Paper IWM/WP/07.

Green, Robert. 1978 The Construction and Management of Bench Terracing System in the Hill Areas of Nepal. DSWC Working Paper IWM/WP/04.

Heede, B.H. 1977 "Gully Control Structures and Systems," in Guidelines for Watershed Management. FAO Conservation Guide No. 1, pp. 181-222.

Hiller, B. 1977 Report on Soil and Water Conservation in Lothar Catchment Area. DSWC internal report.

Laban, Peter. 1978a Short Notes on a Field Trip to Projects in Nepal Concerned with Soil and Water Conservation. DSWC Working Paper IWM/WP/06.

_____. 1978b Field Measurements on Erosion and Sedimentation in Nepal. DSWC Working Paper IWM/WP/05.

Megahan, W.F. 1977 "Reducing Erosional Impacts of Roads," in Guidelines for Watershed Management. FAO Conservation Guide No. 1, pp. 237-262.

Meiman, J.R. 1976 "Snow Measurement," in Hydrological Techniques for Upstream Conservation. FAO Conservation Guide No. 2, pp. 103-118.

_____. 1978 "Snow Zone Management," in Special Readings in Conservation. FAO Conservation Guide No. 4, pp. 39-49.

Rango, A. 1977 "Application of Remote Sensing to Watershed Management," in Guidelines for Watershed Management. FAO Conservation Guide No. 1, pp. 37-52.

Rieger, Hans C., et al. 1976 Himalayan Ecosystems Research Mission Nepal Report. Heidelberg.

Sharma, Chandra K. 1974a Ground Water Resources of Nepal. Kathmandu: Mani Ram Sharma.

_____. 1974b Land Slides and Soil Erosion in Nepal. Kathmandu: Sangeeta Sharma.

_____. 1977a River Systems of Nepal. Kathmandu: Sangeeta Sharma.

_____. 1977b Geology of Nepal. Kathmandu: Educational Enterprises Ltd.

Sheng, T.C. 1977a "Protection of Cultivated Slopes--Terracing Steep Slopes in Humid Regions," in Guidelines for Watershed Management. FAO Conservation Guide No. 1, pp. 147-180.

_____. 1977b "Wattling and Staking," in Guidelines for Watershed Management. FAO Conservation Guide No. 1, pp. 289-293.

Simons, Daryl B. 1979 Identification and Analysis of Sediment Problems in Nepal. Mimeograph.

Stevens, Merv E. 1976 "Erosion Hazard Classification and Inventory Techniques in Mountainous Areas," in Hydrological Techniques for Upstream Conservation. FAO Conservation Guide No. 2, pp. 13-22.

Thapa, N.B. and Thapa, D.P. 1969 Geography of Nepal. Bombay: Orient Logmans.

Thorud, David, et al. 1979 Land Use Practices for the Conservation and Development of Nepal's Soil and Water Resources. USAID Consultant's report. Mimeograph.

Upadhyaya, Kumar P. 1977 Contour Trenching as a Strategy in Watershed Rehabilitation: Application to Nepalese Condition. MS thesis, Utah State University.

USAID(N). 1979 Agricultural Resource Inventory System. Project No. 367-0134. Mimeograph.

World Bank. 1978 Nepal Forestry Sector Review. 1952-NEP. Restricted.

Attachment I

Fifteen-Year Cost-Personnel Matrix

Proposal Project*	1st 5 year program															Total	2nd 5 year			3rd 5 year		
	Year 1			Year 2			Year 3			Year 4			Year 5									
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		1	2	3	1	2	3
KULEKHANI:																						
Terrace Improvement:																						
Tread regrading 1/	5000	10 ha	5	5000	10 ha	5	5000	10 ha	5	5000	10 ha	5	5000	10 ha	5	25	37500	75 ha	37.5	37500	75 ha	37.5
Bund construction 2/	20	5 km	.02	20	5 km	.02	20	5 km	.02	20	5 km	.02	20	5 km	.02	.10	50	12.5 km	.05		12.5 km	.05
Riser-base drainage 3/	220	1 km	.22	220	1 km	.22	220	1 km	.22	220	1 km	.22	220	1 km	.22	1.10	550	2.5 km	.55	550	2.5 km	.55
Riser stabilization 4/	200	1 km	.20	200	1 km	.20	200	1 km	.20	200	1 km	.20	200	1 km	.20	1.00	500	2.5 km	.5	500	2.5 km	.5
Drainage diversion 5/	200	1 km	.20	200	1 km	.20	200	1 km	.20	200	1 km	.20	200	1 km	.20	1.00	500	2.5 km	.5	500	2.5 km	.5
Livestock fences 6/	670	2 km	7	670	2 km	7	670	2 km	7	670	2 km	7	670	2 km	7	35	1675	5 km	17.5	1675	5 km	17.5
Livestock guards 7/	365	10 ha	.36	365	10 ha	.36	365	10 ha	.36	365	10 ha	.36	365	10 ha	.36	1.8	2740	75 ha	2.74	3650	100 ha	3.65
Watershed Protection:																						
Neutral revegetation 8/	0	18 ha	0	0	18 ha	0	0	18 ha	0	0	18 ha	0	0	18 ha	0	0	0	128 ha	0	0	127 ha	0
Livestock fences 6/	563	1.68 km	5.9	563	1.68 km	5.9	563	1.68 km	5.9	563	1.68 km	5.9	563	1.68 km	5.9	29.5	3953	11.8 km	41.3	3953	11.8 km	41.3
Livestock guards 9/	2200	18 ha	2.2	4400	36 ha	4.4	6600	54 ha	6.6	8800	72 ha	8.8	11000	90 ha	11.0	33.0	26700	218 ha	26.7	41000	345 ha	4.0

1 - Person days of employment, 2 - Unit of work to be done, 3 - Cost (Thousand $)

*Footnotes: See Attachment II.

Attachment 1 (Cont.)

Proposal Project	1st 5 year program															Total	2nd 5 year			3rd 5 year		
	Year 1			Year 2			Year 3			Year 4			Year 5									
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		1	2	3	1	2	3
KULEKHANI: (Cont.):																						
Trail Improvement:																						
Drainage 10/	30	1 km	.03	30	1 km	.03	30	1 km	.03	30	1 km	.03	30	1 km	.03	.15	300	10 km	.3	300	10 km	.3
Regrading/rerouting 11/	300	.5 km	1.15	300	.5 km	1.15	300	.5 km	1.15	300	.5 km	1.15	300	.5 km	1.15	5.75	3000	5 km km	11.0	3000	5 km km	11.0
Artificial revegetation 12/	12.5	.1 km	.05	12.5	.1 km	.05	12.5	.1 km	.05	12.5	.1 km	.05	12.5	.1 km	.05	0.25	63	.5 km	0.25	63	.5 km	0.25
Stone steps 13/	150	.5 km	.15	150	.5 km	.15	150	.5 km	.15	150	.5 km	.15	150	.5 km	.15	.75	375	1.25 km	.38	375	1.25 km	.38
Range Denudation Control:																						
Gully structures 14/	100	1 km	16	100	1 km	16	100	1 km	16	100	1 km	16	100	1 km	16	80	250	2.5 km	40	250	2.5 km	40
Artificial revegetation 15/	85	1 km	.2	85	1 km	.2	85	1 km	.2	85	1 km	.2	85	1 km	.2	1.0	215	2.5 km	.5	215	2.5 km	.5
Drainage diversions 5/	300	1.5 km	.3	300	1.5 km	.3	300	1.5 km	.3	300	1.5 km	.3	300	1.5 km	.3	1.5	750	3.75 km	.75	750	3.75 km	.75
Livestock fences 6/	505	1.5 km	5.3	505	1.5 km	5.3	500	1.5 km	5.3	500	1.5 km	5.3	500	1.5 km	5.3	26.5	1260	3.75 km	13.2	1260	3.75 km	13.2
Landslide Control:																						
Drainage diversions 5/	200	1 km	.2	200	1 km	.2	200	1 km	.2	200	1 km	.2	200	1 km	.2	1.0	750	3.75 km	.75	750	3.75 km	.75
Artificial revegetation 12/	250	2 ha	.6	250	2 ha	.6	250	2 ha	.6	250	2 ha	.6	250	2 ha	.6	3	315	2.5 ha	.75	315	2.5 ha	.75
Livestock fences 6/	135	.4 km	1.4	135	.4 km	1.4	135	.4 km	1.4	135	.4 km	1.4	135	.4 km	1.4	7.0	505	1.5 km	5.3	505	1.5 km	5.3

Attachment 1 (Cont.)

Proposal Project	1st 5 year program															Total	2nd 5 year			3rd 5 year		
	Year 1			Year 2			Year 3			Year 4			Year 5									
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		1	2	3	1	2	3
[illegible]: (Cont.):																						
Landslide Control (Cont.):																						
Structures 16/	100	25	16.5	100	25	16.5	100	25	16.5	100	25	16.5	100	25	16.5	82.5	52	13	8.6	48	12	7.9
Slide drainage 17/	0	0	0	0	0	0	10	1	2.5	0	0	0	10	1	2.5	5.0	10	1	2.5	20	2	5.0
Stream Training:																						
Gabions 18/	0	0	0	1000	100 m	70	1000	100 m	70	1000	100 m	70	0	0	0	210	1000	100m	70	1000	100m	70
Riprap 19/	200	.2 km	.2	200	.2 km	.2	200	.2 km	.2	200	.2 km	.2	200	.2 km	.2	1.0	0	0	0	0	0	0
Floodplain planting 20/	1250	10 ha	3	1250	10 ha	3	1250	10 ha	3	1250	10 ha	3	1250	10 ha	3	15	3125	25ha	7.5	3125	25ha	7.5
Channelization 21/	0	0	0	0	0	0	0	0	0	250	250 m	3.75	250	250 m	3.75	7.5	0	0	0	0	0	0
Road Stabilization:																						
Hydroseeding 22/	25	5 ha	.5	25	5 ha	.5	25	5 ha	.5	25	5 ha	.5	25	5 ha	.5	2.5	0	0	0	0	0	0
Planting 23/	1550	5 ha	3.8	1550	5 ha	3.8	1550	5 ha	3.8	1550	5 ha	3.8	1550	5 ha	3.8	19	0	0	0	0	0	0
Drainage 24/	80	.4 km	4	80	.4 km	4	80	.4 km	4	80	.4 km	4	80	.4 km	4	20	0	0	0	0	0	0
Structures 16/	24	6	4	24	6	4	24	6	4	24	6	4	24	6	4	20	0	0	0	0	0	0

Attachment 1;

Fifteen-Year Cost-Personnel Matrix

Proposal Project	1st 5 year program															Total	2nd 5 year			3rd 5 year		
	Year 1			Year 2			Year 3			Year 4			Year 5									
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		1	2	3	1	2	3
GORKHA:																						
Terrace Improvement:																						
Tread regrading 1/	5000	10 ha	5	5000	10 ha	5	5000	10 ha	5	5000	10 ha	5	5000	10 ha	5	25	112500	225 ha	112	112500	225 ha	112
Bund construction 2/	20	5 km	.02	20	5 km	.02	20	5 km	.02	20	5 km	.02	20	5 km	.02	.10	150	37.5 km	.15	150	37.5 km	.15
Riser-base drainage 3/	25	1 km	.03	25	1 km	.03	25	1 km	.03	25	1 km	.03	25	1 km	.03	25	88	7.5 km	.09	88	7.5 km	.09
Riser stabilization 4/	200	1 km	.2	200	1 km	.2	200	1 km	.2	200	1 km	.2	200	1 km	.2	1.0	1500	7.5 km	1.5	1500	7.5 km	1.5
Drainage diversion 5/	200	1 km	.2	200	1 km	.2	200	1 km	.2	200	1 km	.2	200	1 km	.2	1.0	3500	17.5 km	3.5	3500	17.5 km	3.5
Livestock fences 6/	670	2 km	7	670	2 km	7	670	2 km	7	670	2 km	7	670	2 km	7	35	1675	5 km	17.5	1675	5 km	17.5
Livestock guards 7/	365	10 ha	.36	730	20 ha	.73	1095	30 ha	1.10	1460	40 ha	1.46	1825	50 ha	1.82	5.47	1825	50 ha	1.82	1825	50 ha	1.82
Water Developments:*																						
Spring Development 25/	1280	4	2.8	1280	4	2.8	1280	4	2.8	1280	4	2.8	1280	4	2.8	14	12800	40	28	12800	40	28
Impoundments 26/	0	0	0	0	0	0	1000	1	2.1	0	0	0	1000	1	2.1	4.2	1000	1	2.1	1000	1	2.1
Canal delivery 27/	4000	1 km	8.4	4000	1 km	8.4	4000	1 km	8.4	4000	1 km	8.4	4000	1 km	8.4	42	40000	10 km	84	40000	10 km	84
Pipeline delivery 28/	5000	1 km	25	5000	1 km	25	5000	1 km	25	5000	1 km	25	5000	1 km	25	125	50000	10 km	250	50000	10 km	250

* Data for the water development in Gorkha should be revised after the Water Development Team comes back from the field.

Attachment II (Cont.)

Proposal Project	1st 5 year program																2nd 5 year			3rd 5 year		
	Year 1			Year 2			Year 3			Year 4			Year 5			Total						
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		1	2	3	1	2	3
CORDIRA (Cont.):																						
Water Developments (cont):																						
Artificial revegetation 29/	750	6 ha	1.8	750	6 ha	1.8	750	6 ha	1.8	750	6 ha	1.8	750	6 ha	1.8	9	7500	60 ha	18	7500	60 ha	18
Livestock fences 6/	545	1.62 km	5.7	545	1.62 km	5.7	545	1.62 km	5.7	545	1.62 km	5.7	545	1.62 km	5.7	28.5	5628	16.8 km	58.8	5628	16.8 km	58.8
Livestock guards 9/	365	3 ha	.36	730	6 ha	.73	1095	9 ha	1.10	1460	12 ha	1.46	1825	15 ha	1.82	5.47	5475	45 ha	5.48	9125	75 ha	9.12
Range Denudation Control:																						
Gully Structures 14/	100	1 km	16	100	1 km	16	100	1 km	16	100	1 km	16	100	1 km	16	80	250	2.5 km	40	250	2.5 km	40
Artificial revegetation 15/	85	1 km	.2	85	1 km	.2	85	1 km	.2	85	1 km	.2	85	1 km	.2	1.0	215	2.5 km	.5	215	2.5 km	.5
Drainage diversions 5/	300	1.5 km	.3	300	1.5 km	.3	300	1.5 km	.3	300	1.5 km	.3	300	1.5 km	.3	1.5	2250	11.25 km	2.25	2250	11.25 km	39.4
Livestock fences 6/	505	1.5 km	5.3	505	1.5 km	5.3	505	1.5 km	5.3	505	1.5 km	5.3	505	1.5 km	5.3	26.5	3770	11.25 km	39.4	3770	11.25 km	39.4
Stream Improvements:																						
Gabions 18/	0	0	0	0	0	0	1000	.1 km	70	1000	.1 km	70	1000	.1 km	70	210	1000	.1 km	70	1000	.1 km	70
Riprap 19/	200	.2 km	.2	200	.2 km	.2	200	.2 km	.2	200	.2 km	.2	200	.2 km	.2	1.0	200	.5 km	.2	200	.5 km	.2
Diversions 10/	0	0	0	0	0	0	0	0	0	0	0	0	25	5	.02	.02	15	3	.02	10	2	.01
Floodplain Planting 20/	5000	40 ha	12	5000	40 ha	12	5000	40 ha	12	5000	40 ha	12	5000	40 ha	12	60	18750	150 ha	45	1875	150 ha	45

Attachment 11 (Cont.)

Proposal Project	1st 5 year program																2nd 5 year			3rd 5 year		
	Year 1			Year 2			Year 3			Year 4			Year 5			Total						
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		1	2	3	1	2	3
MUSTANG:																						
Irrigation/Terrace Expansion:																						
New Terraces 31/	20000	20 ha	20	20000	20 ha	20	20000	20 ha	20	20000	20 ha	20	20000	20 ha	20	100	200000	200 ha	200	200000	200 ha	200
Test Drilling 32/	60	6	12	60	6	12	60	6	12	60	6	12	60	6	12	60	0	0	0	0	0	0
Impoundments 26/	0	0	0	0	0	0	1000	1	2.1	1000	1	2.1	1000	1	2.1	4.2	1000	1	2.1	1000	1	2.1
Canal delivery 27/	0	0	0	0	0	0	2000	.5 km	4.2	2000	.5 km	4.2	2000	.5 km	4.2	12.6	7000	1.75 km	14.6	7000	1.75 km	14.6
Pipeline delivery 28/	0	0	0	0	0	0	2500	.5 km	12.5	2500	.5 km	12.5	2500	.5 km	12.5	37.5	8750	1.75 km	43.8	8750	1.75 km	43.8
Windmills 13/	0	0	0	0	0	0	15	1	2	30	2	4	30	2	4	9	0	0	0	0	0	0
Snow Management:																						
Site location 34/	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	---→	20	10	1			
Fence experiments 35/	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	---→		15	15			
Fencing (Permanent) 36/	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	400	2 km	15

Attachment 11 (Cont.)

Proposal Project	1st 5 year program															Total	2nd 5 year			3rd 5 year		
	Year 1			Year 2			Year 3			Year 4			Year 5									
	1	2		1	2	3	1	2	3	1	2	3	1	2	3		1	2	3	1	2	3
YACDI:																						
Water Projects:																						
Spring Improvement 37/	2400	6	6	2400	6	6	2400	6	6	2400	6	6	2400	6	6	30	6000	15	15	6000	15	15
Spring development/ location 25/	1280	4	2.8	1280	4	2.8	1280	4	2.8	1280	4	2.8	1280	4	2.8	14	12800	40	28	12800	40	28
Impoundments 26/		0	0		0	0	1000	1	2.1		0	0	1000	1	2.1	4.2	1000	1	2.1	2000	2	4.2
Canal delivery 27/	4000	1 km	8.4	4000	1 km	8.4	4000	1 km	8.4	4000	1 km	8.4	4000	1 km	8.4	42	40000	10 km	84	40000	10 km	84
Pipeline delivery 28/	5000	1 km	25	5000	1 km	25	5000	1 km	25	5000	1 km	25	5000	1 km	25	125	50000	10 km	250	50000	10 km	250
Catchment ponds (hilltop) 38/	100	1	.3	100	1	.3	100	1	.3	100	1	.3	100	1	.3	1.5	700	7	2.1	800	8	2.4
Artificial revegetation 29/	750	6 ha	1.8	750	6 ha	1.8	750	6 ha	1.8	750	6 ha	1.8	750	6 ha	1.8	9	7500	60 ha	18	7500	60 ha	18
Livestock fences 6/	545	1.62 km	5.7	545	1.62 km	5.7	545	1.62 km	5.7	545	1.62 km	5.7	545	1.62 km	5.7	28.5	5628	16.8 km	58.8	5628	16.8 km	58.8
Livestock guards 9/	365	3 ha	.36	730	6 ha	.73	1095	9 ha	1.10	1460	12 ha	1.46	1825	15 ha	1.82	5.47	5475	45 ha	5.48	9125	75 ha	9.12
Trail Improvement:																						
Drainage 10/	90	3	1	90	3	1	90	3	1	90	3	1	90	3	1	5	150	5	1.7	150	5	1.7
Structures 16/	40	10	6.6	40	19	6.6	40	10	6.6	40	10	6.6	40	10	6.6	33	64	16	10.6	64	16	10.6

Attachment II (cont.)

Proposal Project	1st 5 year program															Total	2nd 5 year			3rd 5 year		
	Year 1			Year 2			Year 3			Year 4			Year 5									
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		1	2	3	1	2	3
MYAGDI (Cont.):																						
Terrace Improvement:																						
Tread regrading 1/	5000	10 ha	5	5000	10 ha	5	5000	10 ha	5	5000	10 ha	5	5000	10 ha	5	25	37500	75 ha	37.5	37500	75 ha	37.5
Bund construction 2/	20	5 km	.02	20	5 km	.02	20	5 km	.02	20	5 km	.02	20	5 km	.02	.10	50	2.5 km	.05	50	2.5 km	.05
Riser-base drainage 3/	220	1 km	.22	220	1 km	.22	220	1 km	.22	220	1 km	.22	220	1 km	.22	1.10	550	2.5 km	.55	550	2.5 km	.55
Riser stabilization 4/	200	1 km	.20	200	1 km	.20	200	1 km	.20	200	1 km	.20	200	1 km	.20	1.00	500	2.5 km	.50	500	2.5 km	.50
Drainage diversions 5/	200	1 km	.20	200	1 km	.20	200	1 km	.20	200	1 km	.20	200	1 km	.20	1.00	500	2.5 km	.50	500	2.5 km	.50
Livestock fences 6/	670	2 km	7	670	2 km	7	670	2 km	7	670	2 km	7	670	2 km	7	35	1675	5 km	17.5	1675	5 km	17.5
Livestock guards 7/	365	10 ha	.36	730	20 ha	.73	1095	30 ha	1.10	1460	40 ha	1.46	1825	50 ha	1.82	5.47	2740	50 ha	2.74	3650	50 ha	3.65
Range Denudation Control:																						
Gully/Slide repair 14/	100	1 km	16	100	1 km	16	100	1 km	16	100	1 km	16	100	1 km	16	80	250	2.5 km	40	250	2.5 km	40
Artificial revegetation 15/	625	5 ha	1.5	625	5 ha	1.5	625	1 ha	1.5	625	1 ha	1.5	625	1 ha	1.5	7.5	1625	13 ha	3.9	1500	12 ha	3.9
Drainage diversion 5/	300	1.5 km	.3	300	1.5 km	.3	300	1.5 km	.3	300	1.5 km	.3	300	1.5 km	.3	1.5	750	3.75 km	.75	750	3.75 km	.75
Livestock fences 6/	505	1.5 km	5.3	505	1.5 km	5.3	505	1.5 km	5.3	505	1.5 km	5.3	505	1.5 km	5.3	26.5	505	1.5 km	5.3	505	1.5 km	5.3

Attachment II (Cont.)

	1st 5 Year Program																					
	Year 1			Year 2			Year 3			Year 4			Year 5			Total	2nd 5 Years			3rd 5 Years		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		1	2	3	1	2	3
INVENTORY/MONITORING																						
Aerial Photography 39/	0	4 9x9 miss	100	0	0	0	0	0	0	40	2 RSC miss	3	0	0	0	103	60	3 RSC miss.	4.5	1005	RSC miss.	7.5
Satellite Imagery 40/	0	LS I, II III	7.5	0	LS III	2	0	LS III	2	0	LS III	2	0	LS III	2	15.5	0	LS III	11.0	0	LS III	11.0
Maps:																						
Soils 41/	6000	Maps 2 rgns.	100	6000	Maps 2 rgns.	100	0	0	0	0	0	0	0	0	0	200	0	0	0	0	0	0
Vegetation 42/	1200	Maps 2 rgns.	20	1200	Maps 2 rgns.	20	0	0	0	0	0	0	0	0	0	40	0	0	0	0	0	0
Hydrology 43/	0	0	0	1200	Maps 2 rgns.	10	1200	Maps 2 rgns.	10	0	0	0	0	0	0	20	0	0	0	0	0	0
Geology 44/	0	0	0	4000	Maps 2 rgns.	60	4000	Maps 2 rgns.	60	0	0	0	0	0	0	120	0	0	0	0	0	0
Land Use 45/	1200	Maps 2 rgns.	20	1200	Maps 2 rgns.	20	0	0	0	0	0	0	0	0	0	40	0	0	0	2400	Maps 4 rgns.	40
Land Capability 46/	0	0	0	0	0	0	1200	Maps 2 rgns.	20	1200	Maps 2 rgns.	20	0	0	0	40	0	0	0	0	0	0
Hazards 47/	1200	Maps 2 rgns.	20	1200	Maps 2 rgns.	20	0	0	0	0	0	0	0	0	0	40	0	0	0	0	0	0
Weather Stations 48/	112	21 Stas	200	0	0	0	0	0	0	0	0	0	0	0	0	200	0	0	0	0	0	0
Stream Guages 49/	0	0	0	375	Setup	650	1350	Sta. Op.	.5	1350	Sta. Op.	.5	1350	Sta. Op.	5	6515	8750	Sta. Op.	2.5	8750	Sta. Op.	2.5
Runoff Plots 50/	0	0	0	120	Setup	4	1440	Plot Op.	2	1440	Plot Op.	2	1440	Plot Op.	15	10	7200	Plot Op.	10	7200	Plot Op.	10
Sediment Catchment Meas. 51/	0	0	0	0	0	0	30	Meas.	1.5	30	Meas.	15	30	Meas.	15	45	150	Meas.	7.5	150	Meas.	7.5

Attachment III (Revised)

Kulekhani Watershed Management Project (Makwanpur)

Proposed Project Schedules

PROPOSED PROJECTS	First Five Years						Second Five Years	Third Five Years	Fifteen Year Total
	1	2	3	4	5	Total of First 5 Yrs			
1. Terrace Improvement	5 ha.	10 ha.	10 ha.	10 ha.	15 ha.	50 ha.	75 ha.	75 ha.	200 ha.
2. Trail Improvement	0 km	1 km	1 km	1 km	2 km	5 km	10 km	10 km	25 km
3. Community water source protection	18 ha	18 ha	18 ha	18 ha	18 ha	90 ha	128 ha	127 ha	345 ha
4. Major gully control on range land	1 km	1 km	1 km	1 km	1 km	5 km	5 km	5 km	15 km
5. Landslide rehabilitation	0 km	1 km	1.5 km	1.5 km	1 km	5 km	3.75 km	3.75 km	12.50 km
6. Stream-bank stabilization a. gabions	-	0.1 km	0.1 km	0.1 km	-	0.3 km	0.1 km	0.1 km	0.5 km
b. riprap	0.2 km	0.2 km	0.2 km	0.2 km	0.2 km	1 km	-	-	-
7. Flood plain tree planting	10 ha	10 ha	10 ha	10 ha	10 ha	50 ha	25 ha	25 ha	100 ha
8. Stream channel control	-	-	-	250 m	250 m	500 m	-	-	500 m
9. Road slope stabilization	0.4 km	0.4 km	0.4 km	0.4 km	0.4 km	2 km	-	-	2 km
10. Climatological stations (new)	-	1	1	-	-	2	-	-	2
11. Climatological stations (old)	-	1	1	1	-	3	-	-	3
12. Stage recorder and cable way	-	1	-	-	-	1	-	-	1
13. Building	-	2	1	-	-	3	-	-	3
14. Catchment ponds (hill top)	-	1	2	2	3	8	8	10	26

Appendix III (Revised) (Cont.)

PROPOSED PROJECTS	First Five Years						Second Five Years	Third Five Years	Fifteen Year Total
	1	2	3	4	5	Total of First 5 Yrs			
1. Terrace Improvement	5 ha	10 ha	10 ha	10 ha	15 ha	50 ha	225 ha	225 ha	500 ha
2. Trail Improvement	0 km	1 km	1 km	1 km	2 km	5 km	10 km	10 km	25 km
3. Community water source protection	20 ha	20 ha	20 ha	20 ha	20 ha	100 ha	100 ha	100 ha	300 ha
4. Major gully control on range land	-	1 km	1 km	1 km	2 km	5 km	2.5 km	2.5 km	10 km
5. Road clope stabilization	0.4 km	0.4 km	0.4 km	0.4 km	0.4 km	2 km	-	-	2 km
6. Stream-bank stabilization a. gabions	-	-	0.1 km	0.1 km	0.1 km	0.3 km	0.1 km	0.1 km	0.5 km
b. riprap	0.2 km	0.2 km	0.2 km	0.2 km	0.2 km	1 km	0.5 km	0.5 km	2 km
7. Flood plain tree planting	40 ha	40 ha	40 ha	40 ha	40 ha	200 ha	150 ha	150 ha	500 ha
8. Diversions	-	-	-	2 km	3 km	5 km	3	2	10
9. Climatological stations (new)	-	1	1	1	-	3	-	-	3
10. Climatological stations (old)	-	1	1	-	-	2	-	-	2
11. Stage recorder and cableway	-	-	1	-	-	1	-	-	1
12. Buildings	3	-	-	-	-	3	-	-	3
13. Catchment pond (hill top)	1	1	2	5	5	14	15	20	49

Attachment III (Revised) (Cont.)

PROPOSED PROJECTS	First Five Years						Second Five Years	Third Five Years	Fifteen Year Total
	1	2	3	4	5	Total of First 5 Yrs			
1. Terrace improvement	10 ha	10 ha	10 ha	10 ha	10 ha	50 ha	75 ha	75 ha	200 ha
2. Trail improvement	2 km	3 km	4 km	4 km	2 km	15 km	5 km	5 km	25 km
3. Major gully control on range land	-	-	1 km	1 km	1 km	3 km	2.5 km	2.5 km	8 km
4. Watershed protection	10 ha	10 ha	10 ha	10 ha	10 ha	50 ha	50 ha	50 ha	150 ha
5. Climatological stations (new)	-	1	1	-	-	2	-	-	2
6. Climatological stations (old)	-	2	2	-	-	4	-	-	4
7. Stage recorder and cableway	-	-	1	-	-	1	-	1	1
8. Buildings	-	3	-	-	-	3	-	-	3
9. Catchment pond (hill top)	-	1	1	1	4	7	4	10	21

Attachment 1:1 (Revised) (Cont.)

PROPOSED PROJECTS	First Five Years						Second Five Years	Third Five Years	Fifteen Year Total
	1	2	3	4	5	Total of First 5 Yrs			
1. Terrace expansion	-	-	10 ha	10 ha	10 ha	30 ha	200 ha	200 ha	430 ha
2. Watershed protection	10 ha	10 ha	10 ha	10 ha	10 ha	50 ha	100 ha	100 ha	250 ha
3. Snow management	-	-	-	1	-	-	1	1	3
4. Wind mills	-	-	1	2	2	5	-	-	5
5. Test drilling	-	6	6	6	6	24	-	-	24
6. Climatological stations (new)	-	-	-	-	-	-	-	-	-
7. Climatological stations (old)	-	1	2	2	-	5	-	-	5
8. Stage recorder and cableway	-	-	1	-	-	1	-	-	1
9. Buildings	-	3	-	-	-	3	-	-	3
10. Catchment ponds	-	-	1	2	3	6	3	10	19

Attachment III (Revised) (Cont.)

PROPOSED PROJECTS	Unit of Accomplishment	First Five Years 1	2	3	4	5	Five Year Total	Second Five Years	Third Five Years	Fifteen Year Total
1. Inventory and Monitoring										
A. Hydrologic Survey	Hectares	0	32,000	100,000	109,585	110,000	351,585	161,077	0	512,662
	Area report	0	0	1	1	1	3	1	0	4
B. Geology Survey	Hectares	32,000	100,000	109,585	110,000	110,000	461,585	51,077	0	512,662
	Area report	0	0	1	1	1	3	1	0	4
C. Soil Survey	Hectares	32,000	100,000	109,585	110,000	110,000	461,585	51,077	0	512,662
	Area report	0	0	0	1	2	3	1	0	4
D. Land Capability Survey	Hectares	Aerial	32,000	100,000	109,585	110,000	351,585	161,077	0	512,662
	Area report	Photography	1	1	1	1	4	1	1	6
E. Erosion Hazard	Hectares	0	32,000	100,000	109,585	110,000	351,585	161,077	0	512,662
	Area report	0	0	1	1	1	3	1	0	4
F. Impact Evaluation	Plots	4	4	4	4	4	20	20	20	60
G. Adaptive Research	Studies	2	2	2	2	2	8	8	8	26
H. Documentation	Photo points	40	80	80	80	80	360	400	400	1160
	Movie	1	1	1	1	1	5	2	2	9
I. Farm Planning	Hectares	0	250	500	700	1,000	2,450	5,000	5,000	12,450
2. Watershed Management										
A. Terrace Improvement	Hectares	10	30	40	40	60	180	575	575	1,330
B. Trail Improvement	Kilometers	1	5	6	6	6	25	25	25	75
C. Community Water Source Protection	Hectares	58	58	58	58	58	290	378	377	1,045
D. Major Gully Control on Range Lands	Number	1	2	3	3	4	13	7.5	7.5	28

Attachment III (Revised) (Cont.)

PROPOSED PROJECTS	Unit of Accomplishment	First Five Years					Five Year Total	Second Five Years	Third Five Years	Fifteen Year Total
		1	2	3	4	5				
E. Land Slide Rehabilitation	Number	0	1	1	2	1	5	5	5	15
F. Streambank Stabilization										
1) Gabions	Kilometer	0	0.1	0.2	0.2	0.1	0.6	0.2	0.2	1
2) Riprap	Kilometer	0.4	0.4	0.4	0.4	0.4	2	0.5	0.5	3
G. Flood Plain Tree Planting	Hectares	50	50	50	50	50	250	175	175	600
H. Stream Channel Control	Meters	0	0	0	250	250	500	0	0	500
I. Road Slope Stabilization	Kilometers	0.8	0.8	0.8	0.8	0.8	4	0	0	4
J. Catchment Ponds (hill top)	Number	1	3	6	10	15	35	30	50	115
K. Climatological Stations										
1) New	Numbers	0	3	3	1	0	7	0	0	7
2) Old	Numbers	0	5	6	3	0	14	2	2	8
L. Stage Recorders	Numbers	0	1	3	0	0	4	2	2	8
M. Snow Management Stations	Numbers	0	0	0	1	0	1	1	1	3
N. Wind Mills	Numbers	0	0	1	1	2	5	3	3	11
O. Test Drilling	Numbers	0	6	6	6	6	24	0	0	24
P. Diversions	Numbers	0	0	0	2	3	5	3	2	10

Attachment II

Basis of Matrix Data Calculations

Footnotes*

1. Tread regrading:
   Moving 3000 m^3/ha of earth 5 m distance, 25% slope; 500 person-days/ha; manual (hand); use of animal power will decrease manpower needs.
2. Bund Construction:
   Bunds 15 x 30 cm; 0.225 m^3 earth moved/m of bund; 1 person-day = 250 m.
3. Riser-Base Drainage:
   Ditch 20 x 65 cm; .13 m^3 earth moved/m of ditch; 1 person-day = 40 m.
4. Riser Stabilization:
   1 person-day = 5 m.
5. Drainage Diversion:
   1 person-day = 5 m; 200 person-day/km.
6. Livestock fences:
   5 strand, 3 m pole spacing; 1 person-day = 3 m fencing; cost = $350/100 m.
7. Livestock Guards (Terraces):
   Plot = 10 ha; 1 guard/plot; 365 person-days/plot/yr, cumulative with time.
8. Natural Revegetation:
   No labor or capital outlay.
9. Livestock Guards (Watershed):
   Plot = 5 ha; 1 guard/plot, 365 person-days/plot/yr, cumulative with time.
10. Trail Drainages:
    30 person-days/km.
11. Regrading/Retouting Trails:
    person-days/km; total cost = $2100/km.
12. Artificial Revegetation (Abandoned Trails):
    125 person-days/ha; 3000 trees/ha; total cost= $300/ha; figures based on m of trail with dimensions 1.5 m wide; 1 ha = 667 m of trail; total cost = $450/km of trail.

* Numbers rounded in some cases.

Attachment II (Cont.)

13. Stone Steps:
300 person-days/km.

14. Gully Structures (Gabions):
12 gabions/gully, $660/gabion (standard size), $8000/gully; 4 person-days/gabion, 50 person-days/gully; average gully = .5 km length.

15. Artificial Revegetation (Gully):
125 person-days/ha; 3000 trees/ha; total cost = $300/ha; figures based on m of gully length; 1 ha = 1500 m gully; total cost = $200/km of gully length; 85 person-days/km.

16. Structures (Gully Gabions):
Cost = $660/gabion (standard size); computation based on number of gabions; 4 person-days/gabion.

17. Slide Drainage (Internal):
Cost = $2500/site; 10 person-days/site.

18. Gabion (Stream):
Average 2 gabions/3 m protection; buried 1 m; total = $700/m; 10 person-days/m protection.

19. Riprap (Stream):
1 person-day/m lining.

20. Artificial Revegetation (Floodplain):
125 person-days/ha; 3000 trees/ha; total cost = $300/ha.

21. Channelization:
1 person-day/m; cost = $15,000/km (manual).

22. Hydroseeding:
Cost = $100/ha; 5 person-days/ha. cost of hydroseeding set = $250 per unit. (Which should be included in supplies)

23. Artificial Revegetation (Roadside):
Cost = $750/ha; 310 person-days/ha.

24. Drainage (Roadside):
Cost = $5000/km; 200 person-days/km.

25. Spring Development:
Cost = $700/site; 320 person-days/site.

26. Impoundments:
Cost = $2100/site; 1000 person-days/site.

27. Canals:
Cost = $8350/km; 4,000 person-days/km.

Attachment II (Cont.)

28. Pipelines:
Cost = $25,000/km; 500 person-days/km.

29. Artificial Revegetation (watershed):
125 person-days/ha; 3000 trees/ha; total cost = $300/ha; 3-ha/site.

30. Channel Diversions:
5 person-days/diversion, manual.

31. New Terrace Construction:
Moving 6000 m^3/ha of earth 5 m on 25% slope; 1000 person-days/ha; manual.

32. Test Drilling:
Cost = $2000/bore; 10 person-days/bore.

33. Windmills:
Cost = $2000/windmill; 15 person-days/windmill.

34. Snow Fence Site Location:
2 person-days/site (professional).

35. Snow Fence Experiments:
Cost = $1000/site.

36. Snow Fencing:
Cost = $7500/km; 200 person-days/km fencing.

37. Spring Improvement:
Cost = $1000/site; 400 person-days/site.

38. Rain Catchment Ponds (Hilltop):
$300/pond; 100 person-days/pond; average 50 m^3 excavation for 1.5 x 8 x 8 pond, using excavated earth for dikes; lined with clay or plastic; proper overflow into stable drainage ditches/channels provided.

39. Aerial Photography:
4 - 9 x 9" missions + photos = $100,000, no manpower needed; 10 - 2 1/4 x 2 1/4" Remote Sensing Center (DSWC) missions + photos = $1500/mission, 20 person-days/mission.

40. Satellite Imagery:
Landsat I and II = $7500: Landsat III (ongoing) = $30,000; no labor needed.

41. Soils Maps:
$50,000/region, 3000 person-days/regions; includes professional, technical, unskilled labor.

Attachment II (Cont.)

42. Vegetation Maps:
$10,000/region, 600 person-days/region; includes professional, technical, unskilled labor.

43. Hydrologic Maps:
$5000/region, 600 person-days/region; includes professional, technical, unskilled labor.

44. Geologic Maps:
$30,000/region, 2000 person-days/region; includes professional, technical, unskilled labor.

45. Land Use Maps:
$10,000/region, 600 person-days/region; includes professional, technical, unskilled labor.

46. Land Capability Maps:
$10,000/region, 600 person-days/region; includes professional, technical, unskilled labor.

47. Hazards Maps:
$10,000/region, 600 person-days/region; includes professional, technical, unskilled labor.

48. Weather Stations:
Labor = upgrading--3 person-days/station; new set-up--10 person days/station;
Materials/Equipment: Total = $20,000.
Station Operations by HMG.

49. Stream Gauges:
Set-up: labor--100 person-days/station (recording), 5 person-days/station (non-recording).
Materials/Equipment--$650,000 total.
Operation: labor--75 person-days/station/yr; upkeep (recording stations)--$150 total/yr.

50. Runoff Plots:
Set-up/plot = 30 person-days; cost = $1000/plot.
Operation = $500/yr/plot; 360 person-days/yr/plot.

51. Sediment Catchment Measurements:
30 stations; 1 person-day/station/yr.
Cost = $50/station/yr.

Attachment III

Phasing of the Central Office Staff (Local)

Inventory and Monitoring

Staff Expertise	Year 1	Year 2	Year 3	Year 4	Year 5	First 5 year Total	Second 5 yr Total	Third 5 Total	Grand Total
1. Team Leader (Chief Soil Conservation Officer Soil Conservation facility)	1	-	-	-	-	1	-	-	1
2. Land use planner (Soil Conservation Officer Agri/Forest Service, Soil Conservation faculty Technical Gazetted II)	1	-	-	-	-	1	-	-	1
3. Soil Scientist (Soil Conservation Officer, Agri/Forest Service, Soil Conservation faculty, Technical Gazetted II)	-	-	1	-	-	1	-	-	1
4. Hydrologist (Soil Conservation Officer, Agri/Forest Service, Soil Conservation Faculty, Technical Gazetted II)	-	-	-	-	-	1	-	-	1
5. Agriculture Engineer (Soil Conservation Officer Agri/Forest Service, Soil Conservation Faculty, Technical Gazetted II)	1	-	-	-	-	1	-	-	1
6. Range/Pasture Specialist (Soil Conservation Officer Agri/Forest Service, Soil Conservation faculty, Technical Gazetted II)	-	1	-	-	-	1	-	-	1
7. Geologist, (Technical Gazetted II)	1	-	-	-	-	1	-	-	1
8. Statistician (Technical Gazetted II)	-	-	-	-	-	-	-	-	-

Attachment III (Cont)

Staff Expertise	Year 1	Year 2	Year 3	Year 4	Year 5	First 5 year Total	Second 5 yr Total	Third 5 Total	Grand Total
9. Civil Engineer (Junior Soil Conservation Officer, Engineering Service, Irrigation faculty, Technical Gazette III)	1	1	-	-	-	2	-	-	2
10. Hydro-Meteorologist (Junior Soil Conservation Office Agri/Forest Service, Soil Conservation faculty, Technical Gazetted III)	1	-	-	-	-	1	-	-	1
11. Conservation Education/Publicity Specialist (Junior Soil Conservation Officer, Agri/Forest Service, Soil Conservation faculty, Technical Gazetted III)	1	-	-	-	-	1	-	-	1
12. Overseers (Non Gazetted Technical I)	2	2	-	-	-	4	-	-	4
13. Soil and Water Conservation Asst. (Non Gazetted Technical I)	4	4	-	-	-	8	-	-	8
14. Junior Cartographers (Non Gazetted Technical I)	-	-	-	-	-	-	-	-	-

Attachment III (Cont.)

Staff and Expertise	Year 1	Year 2	Year 3	Year 4	Year 5	First 5 Year Total	Second 5 Year Total	Third 5 Year Total	Grand Total
Administrative Support									
1. Senior Accountant (Gaz. Accts. Service Class III).	1	-	-	-	-	1	-	-	1
2 Accountants (Non-Gazetted Class I)	2	-	-	-	-	2	-	-	2
3. Administrative Officer (Gazetted Adm. 'II)	1	-	-	-	-	1	-	-	1
4. Administrative Asst. (Non-Gazetted, Class I)	2	1	-	1	-	4	-	-	4
5. Typist (Non-Gazetted Class I)	3	2	-	-	-	5	-	-	5
6. Driver cum Mechanics (N.G. Tech. Class III)									
7. Peons.	3	3	-	-	-	6	-	-	6
TOTAL:	21	13	-	1	-	35	-	-	35

Attachment IIII

Phasing of the Catchment Office Staff

Staff and Expertise	Year 1	Year 2	Year 3	Year 4	Year 5	First 5 year Total	Second 5 year Total	Third 5 year Total	15 years Total
A. Kulekhani-Catchment Conservation Office									
1. Catchment Conservation officer (Forest/Agri Service, Soil Conservation Faculty Gazetted Technical II)	1	-	-	-	-	1	-	-	1
2. Asst. Soil Conservation Officer-land treatment (Forest/Agri Service, S.C. faculty, Gazetted Technical III)									
3. Asst. Soil Conservation Officer-Chanel treatment (Forest/Agri Service, S.C.)	-	1	-	-	-	-	-	-	1
4. Asst. Soil Conservation Officer-Extension, Education and research Forest/Agri Service S.C. faculty Gazetted Technical III)	-	-	-	1	-	-	-	-	1
5. Oversears. (N.G. Tech I)	1	-	½	-	-	1	-	-	1
6. Soil Conservation Tech. (Non-Gaz. Tech. Class I)	2	2	2	1	-	7	-	-	7
7. Accountant (N.G. Acct. I)	1	-	-	-	-	1	-	-	1
8. Administrative Asst.(N.G. Adm I)	1	-	-	-	-	1	-	-	1
9. Storekeeper (N.G. Accountant I)	1	-	-	-	-	1	-	-	1
10. Driver Cum Mechanics (N.G. Tech II)	1	1	-	-	-	2	-	-	2
11. Peons and Guards	2	2	-	-	-	4	-	-	4

Attachment IIII (Cont.)

Staff and Expertise	Year 1	Year 2	Year 3	Year 4	Year 5	First 5 year Total	Second 5 year Total	Third 5 year Total	15 years Total
3. Daraudi Catchment & Conservation Office-Gorkha.									
1. Catchment Conservation Officer (Forest/Agri Service, Soil Conservation Faculty, Gazetted Technical II)	1	-	-	-	-	1	-	-	1
2. Asst. Soil Conservation Officer-Land treatment (Forest/Agri Service S.C. Faculty, Gazetted Technical III)	-	1	-	-		1	-	-	1
3. Asst. Soil Conservation Officer-Channel treatment (Forest/Agri Service; S.C. faculty Tech. III)	-	-	1	-	-	1	-	-	1
4. Asst. Soil Conservation Officer-Extention/Education and research (Forest or Agri/Service, S.C. faculty, Gazetted Tech. III)	-	-	-	1	-	1	-	-	1
5. Overseers (N.G. Tech. I)	1	-	-	-	1	-	-	-	1
6. Soil Conservation Asst. (Non. Gaz. Tech. I)	3	3	4	4	2	17	12	-	29
7. Accountant (N.G. Accountant I)	1	-	-	-	-	1	-	-	1
8. Administrative Asst. (N.G. Adm I)	1	-	-	-	-	1	-	-	1
9. Store Keeper (N.G. Adm I)	1	1	-	-	-	1	2	-	2
10. Driver cum Mechanics	1	1	-	-	-	2	-	-	2
11. Peons and Guards	2	-	2	-	-	4	-	-	4

Attachment IIIi (Cont.)

Staff and Expertise	Year 1	Year 2	Year 3	Year 4	Year 5	First 5 year Total	Second 5 year Total	Third 5 year Total	15 years Total
C. Upper Kali Gandaki Catchment Conservation Office - Myagdi									
1. Catchment Conservation Officer (Forest/Agri. Service, Soil Conservation faculty, Ga. 2 Tech II)	1	-	-	-	-	1	-	-	1
2. Asst. Soil Conservation Officer - Land Treatment (Forest/Agri Service, Soil Conservation faculty Ga. 2. Tech III)	-	1	-	-	-	1	-	-	1
3. Asst. Soil Conservation Officer - Channel Treatment (Forest/Agri Service, Soil Conservation faculty, Ga. 2. Tech III)	-	-	1	-	-	1	-	-	1
4. Asst. Soil Conservation Officer - Extension education & research (Forest/Agri Service, Soil conservation faculty Ga. 2. Tech III)	-	-	-	1	-	1	-	-	1
5. Overseers, Civil Works (NG Tech I)	1	-	-	-	-	1	-	-	1
6. Soil Conservation Asst. (NG Tech I)	2	2	2	2	2	10	4	-	14
7. Admn. Asst. (NG Adm I)	1	-	-	-	-	1	-	-	1
8. Accountant (NG Acct. I)	1	-	-	-	-	1	-	-	1
9. Store Keeper (NG Adm. I)	1	-	-	-	-	1	-	-	1
10. Driver cum Mechanics (NG Tech II)	-	-	-	-	-	-	-	2	2
11. Peons & Guards	2	-	-	-	2	4	-	-	4

Attachment IIII (Cont.)

Staff and Expertise	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5	First 5 years Total	Second 5 years Total	Third 5 years Total	15 Years Total
D. Kali Gandaki Catchment Conservation Office									
1. Catchment Conservation Officer (Forest/Agri Service, Soil Conservation faculty, Ga. 2 Tech. II)	1	-	-	-	1	-	-	-	1
2. Asst. Soil Conservation Officer - Land Treatment (Forest/Agri Service, Soil Conservation faculty, Ga. 2 Tech III)	-	1	-	-	-	1	-	-	1
3. Asst. Soil Conservation Officer - Channel Treatment (Forest/Agri. Service, Soil Conservation faculty, Ga. 2 Tech III)	-	-	1	-	-	1	-	-	1
4. Asst. Soil Conservation Officer - Extension Education & Research (Forest/Agri Service)	-	-	-	-	-	-	-	-	-
5. Overseers - Civil works (NG Tech I)	1	-	-	-	-	1	-	-	1
6. Soil Conservation Asst. (NG Tech I)	2	2	2	1	1	8	2	-	10
7. Adm. Asst. (NG Adm I)	1	-	-	-	-	1	-	-	1
8. Accountant (NG Acct. I)	1	-	-	-	-	1	-	-	1
9. Store Keeper (NG Adm I)	1	-	-	-	-	1	-	-	1
10. Driver cum Mechanics (NG Tech II)	-	-	-	-	-	-	-	2	2
11. Peons & Guards	2	-	2	-	-	4	-	-	4
GRAND TOTAL	38	17	18	14	6	93	18	4	115

Attachment IVI (a)

Inventory and Monitoring
(Operating Cost In Thousand Rupee)

Particulars	Unit	Unit Cost	Year 1	Year 2	Year 3	Year 4	Year 5	First Five Years		
								Total	L. C.	F. C.
1. Local Staff										
- Salaries & Benefits			157.3	212.9	246.2	273.1	279.8	1169.3	1169.3	
- Travel & Other Allowances			37.9	47.0	54.1	61.2	61.2	261.4	261.4	
- Project Allowances			51.9	71.3	78.8	85.3	85.3	372.6	372.6	
SUB TOTAL			247.1	331.2	379.1	419.6	426.3	1803.3	1803.3	
2. Operation of Vehicles and Equipments										
- Four Wheel Drive (4WD) Vehicles and Sedans			206.0	324.0	324.0	324.0	324.0	1502.0		1502.0
- Motor Cycles			5.0	10.0	10.0	10.0	10.0	45.0	5.0	40.0
- Duplicating Machines and other Equipments			5.0	5.0	5.0	5.0	5.0	25.0	25.0	
SUB TOTAL			216.0	339.0	339.0	339.0	339.0	1572.0	30.0	1542.0
3. Office Expenses										
- Office Running (electricity, phone, etc.)			50.0	50.0	50.0	50.0	50.0	250.0	200.0	50.0
- Office Rental			72.0	72.0	72.0	0.0	0.0	216.0	216.0	
SUB TOTAL			122.0	122.0	122.0	50.0	50.0	466.0	416.0	50.0
4. Miscellaneous Expenses and Office Supplies			100.0	100.0	100.0	100.0	100.0	500.0	400.0	100.0
5. Conservation Education			50.0	75.0	100.0	100.0	100.0	425.0	400.0	25.0
6. Local Consultancies			154.7	170.2	186.8	205.9	226.1	943.7	943.7	
TOTAL N Rs. '000			889.9	1137.4	1226.9	1214.5	1241.4	5710.0	3993.0	1717.0
TOTAL US $s '000			74.77	95.58	103.10	102.06	104.32	479.83	335.55	144.28

Attachment IVI(a) (Cont.)

Particulars	Second Five Year			Third Five Year			Fifteen Years Total		
	Total	L.C.	F.C.	Total	L.C.	F.C.	Total	L.C.	F.C.
1. Local Staff									
- Salaries & Benefits	1483.3	1483.3		1634.2	1634.2		4286.8	4286.8	
- Travel & Other Allowances	426.7	426.7		426.7	426.7		1226.1	1226.1	
- Project Allowances	312.1	312.1		312.1	312.1		885.5	885.5	
SUB TOTAL	2222.1	2222.1		2373.0	2373.0		6398.4	6398.4	
2. Operation of Vehicles and Equipments									
- 4WD Vehicles and Sedans	1200.0		1200.0	1200.0		1200.0	3902.0		3902.0
- Motor Cycles	50.0	10.0	40.0	50.0	10.0	40.0	145.0	25.0	120.0
- Duplicating Machines and Other Equipments	30.0	30.0		30.0	30.0		85.0	85.0	
SUB TOTAL	1280.0	40.0	1240.0	1280.0	40.0	1240.0	4132.0	110.0	120.0
3. Office Expenses									
- Office Running	250.0	200.0	50.0	250.0	200.0	50.0	750.0	600.0	150.0
- Office Rental							216.0	216.0	
SUB TOTAL	250.0	200.0	50.0	250.0	200.0	50.0	966.0	816.0	150.0
4. Miscellaneous Expenses and Office Supplies	500.0	400.0	100.0	500.0	400.0	100.0	1500.0	1200.0	300.0
5. Conservation Education	500.0	400.0	100.0	500.0	400.0	100.0	1425.0	1200.0	225.0
6. Local Consultancies									
TOTAL N Rs. '000	4752.1	3262.1	1490.0	4903.0	3413.0	1490.0	15365.1	10668.1	4697.0
TOTAL US $s '000	399.34	274.13	125.21	412.02	286.81	125.21	1291.18	896.48	394.70

Attachment IVi(b)

Inventory and Monitoring
(Capital Cost in Thousand Rupees)

Particulars	Unit	Unit Cost	Year 1	Year 2	Year 3	Year 4	Year 5	First Five Years Total	L.C.	F.C.
1. Printing & Photographic equipments (Offset printing machine, mimeographic machine, photocopying machine, typewriters, cameras, etc.)			100.0	200.0	150.0			450.0		450.0
2. Audiovisuals (Overhead projector, movie projector screen, tape recorders, etc.)										
3. Survey, drawing and cartographic equipments			50.0	100.0	100.0			250.0		250.0
4. Vehicles										
a) 4WD Jeeps	4	100.8	201.6	201.6				403.2		403.2
b) 4WD Pick Up	1	90.0	90.0					90.0		90.0
c) Compact Sedans	3	69.9	139.2	69.6				208.8		208.8
d) Environmental Education Van	1	330.0	330.0					330.0		330.0
e) Motor Bikes	4	10.0	20.0	20.0				40.0		40.0
f) Bicycles	4	1.0	2.0	2.0				74.0		74.0
SUB TOTAL			782.8	293.2				1076.0		1076.0
5. Field and Camping equipments (Tents, sleeping bags, utensils, etc.)			100.0	100.0	20.0	20.0		240.0		240.0
6. Furniture and other Office Equipments			100.0	100.0	50.0	20.0	20.0	290.0	150.0	140.0
7. Aerial photos, Satelite Imageries, Inventory, Mapping and Reporting			150.0	150.0	150.0	150.0		600.0	200.0	400.0
8. Project Monitoring Movies	1	300.0	300.0	300.0	300.0	300.0	300.0	1500.0	300.0	1200.0
TOTAL N Rs. '000			1582.8	1243.2	770.0	490.0	320.0	4406.0	650.0	3756.0
TOTAL US $s '000			133.01	104.47	64.71	41.18	26.88	370.25	54.62	315.63

Attachment IVI(b) (Cont.)

Particulars	Second Five Year			Third Five Year			Fifteen Year Total		
	Total	L.C.	F.C.	Total	L.C.	F.C.	Total	L.C.	F.C.
1. Printing & Photographic equipments (offset printing machine, mimeographic machine, photocopying machine, typewriters, cameras, etc.)	400.0		400.0	400.0		400.0	1250.0		1250.0
2. Audiovisuals (Overhead projector, movie projectors, screen, tape recorders, etc.)	250.0		250.0	250.0		250.0	750.0		750.0
3. Survey, drawing and cartographic equipments									
4. Vehicles									
a) 4WD Jeeps	201.6		201.6	201.6		201.6	806.4		806.4
b) 4WD Pick Up	90.0		90.0	90.0		90.0	270.0		270.0
c) Compact Sedans							208.8		208.8
d) Environmental Education Van	330.0		330.0	330.0		330.0	990.0		990.0
e) Motor Bikes	40.0		40.0	40.0		40.0	120.0		120.0
f) Bicycles	4.0		4.0	4.0		4.0	12.0		12.0
SUB TOTAL	665.6		665.6	665.6		665.6	2407.2		2407.2
5. Field and Camping Equipments (Tents, sleeping bags, utensils, etc.)	200.0		200.0	200.0		200.0	640.0		640.0
6. Furniture and other Office Equipments	100.0	70.0	30.0	100.0	70.0	30.0	490.0	290.0	200.0
7. Aerial Photos, Satelite imageries, Inventory, Mapping and Reporting				200.0	100.0	100.0	800.0	300.0	500.0
8. Project Monitoring Movies	300.0	50.0	250.0	300.0	50.0	250.0	2100.0	400.0	1700.0
TOTAL N Rs. '000	1915.6	120.0	1795.6	2115.6	220.0	1895.6	8937.2	990.0	7447.2
TOTAL US $s '000	160.97	10.08	150.89	177.78	18.49	159.29	709.01	83.19	625.82

Attachment IV11(a)

Kulekhani Catchment - Watershed Management Project (Makawanpur)

(Capital Cost in Thousand Rupees)

Particulars	Unit	Unit Cost	Year 1	First Five Years				First Five Years		
				Year 2	Year 3	Year 4	Year 5	Total	L.C.	F.C.
1. Surveying Equipment (Levels, Theodolites, Drawing equipment, etc.)			100.0	100.0	10.0			210.0		210.0
2. Hydro-meteorological equipment (Precipitation guage, State recorders, Hydro-thermograph, etc.)			130.0	20.0				150.0		150.0
3. Vehicles										
4WD Pick Up	1	Rs.90000	90.0					90.0		90.0
4WD Jeep	1	Rs.100800		100.8				100.8		100.8
SUB TOTAL			90.0	100.8				190.8		190.8
4. Field and Camping Equipment			20.0	10.0	10.0	10.0	10.0	60.0	20.0	40.0
5. Furniture and other Office Equipment			20.0	15.0	15.0	15.0	10.0	75.0	60.0	15.0
6. Buildings										
i) Office building (1225 sq. ft.)	Sft.	Rs. 125/-		153.2				153.2	153.2	
ii) Quarter A Type (1037 sq. ft.)	Sft.	Rs. 125/-			129.6			129.6	129.6	
iii) Quarter B Type (900 sq. ft.)	Sft.	Rs. 110/-				99.0		99.0	99.0	
SUB TOTAL				153.2	129.6	99.0		381.8	381.8	
7. Construction of Hydrometeorological Stations				150.0				150.0	100.0	50.0
8. Terrace Improvement	Ha.	6.80	34.0	68.0	68.0	68.0	102.0	340.0	340.0	
9. Community Water Source Protection	Ha.	5.4	97.2	97.2	97.2	97.2	97.2	486.0	486.0	
10. Trail Improvement	Km.	16.6		16.6	16.6	16.6	33.2	83.0	83.0	
11. Major Gully Control on Range Land	$Km.^2$	261.6	261.6	261.6	261.6	261.6	261.6	1308.0	1308.0	
12. Landslide Control	Km.	225.0		225.0	337.5	337.5	225.0	1125.0	1125.0	
13. Stream Training										
i) Gabions	m	8.4	0.0	840.0	840.0	840.0		2520.0	2520.0	
ii) Riprap	Km.	12.0	2.4	2.4	2.4	2.4	2.4	12.0	12.0	
iii) Flood Plain Planting	Ha.	3.6	36.0	36.0	36.0	36.0	36.0	180.0	180.0	
iv) Channelization	100m.	18.0	0.0	0.0	0.0	45.0	45.0	90.0	90.0	
SUB TOTAL		42.0	38.4	878.4	878.4	923.4	83.4	2802.0	2802.0	
14. Roadside Slope Stabilization	100m.	37.0	148.0	148.0	148.0	148.0	148.0	740.0	740.0	
15. Catchment Pond (Hill Top)	1	6.5		6.5	13.0	13.0	19.5	52.0	50.0	2.0
TOTAL COST NC Rs.			939.2	2250.0	1984.3	1989.3	989.9	8153.6	7495.8	657.8
US $s			78.92	189.11	166.79	167.16	83.18	685.16	685.16	55.27

Attachment IVii (a)
(Cont.)

Kulekhani Catchment - Watershed Management Project (Makawanpur)

(Capital Cost in Thousand Rupees)

	Second Five Years			Third Five Years			Fifteen Years Total		
	Total	L.C.	F.C.	Total	L.C.	F.C.	Total	L.C.	F.C.
1. Surveying Equipment (Levels, Theodolites, Drawing equipment, etc.)	100.0		100.0	100.0		100.0	410.0		410.0
2. Hydro-meteorological equipment, (Precipitation guage, Stage recorders, Hydro-thermograph, etc.)							150.0		150.0
3. Vehicles									
4WD Pick Up	90.0		90.0	90.0		90.0	270.0		270.0
4WD Jeep	100.8		100.8	100.8		100.8	302.4		302.4
SUB TOTAL	190.8		190.8	190.8		190.8	572.4		572.4
4. Field and Camping Equipment	60.0	20.0	40.0	60.0	20.0	40.0	180.0	60.0	120.0
5. Furniture & Other Office Equipment	75.0	60.0	15.0	75.0	60.0	15.0	225.0	180.0	45.0
6. Buildings									
i) Office Building (1225 sq. ft.)							153.2	153.2	
ii) Quarter A type (1037 sq. ft.)							129.6	129.6	
iii) Quarter B type (900 sq. ft.)	99.0	99.0					198.0	198.0	
SUB TOTAL	99.0	99.0					480.8	480.8	
7. Construction of Hydrometeorological Stations							150.0	100.0	50.0
8. Terrace Improvement	340.0	340.0		340.0	340.0		1020.0	1020.0	
9. Community Water Source Protection	486.0	486.0		486.0	486.0		1458.0	1458.0	
10. Trail Improvement	83.0	83.0		83.0	83.0		249.0	249.0	
11. Major Gully Control on Range Land	1308.0	1308.0		1308.0	1308.0		3924.0	3924.0	
12. Landslide Control	1125.0	1125.0		1125.0	1125.0		3375.0	3375.0	
13. Stream Training									
i) Gabions	840.0	840.0		840.0	840.0		4200.0	4200.0	
ii) Riprap							12.0	12.0	
iii) Flood Plain Planting	90.0	90.0		90.0	90.0		360.0	360.0	
iv) Channelization							90.0	90.0	
SUB TOTAL	930.0	930.0		930.0	930.0		4662.0	4662.0	
14. Roadside Slope Stabilization	52.0	52.0		65.0	65.0		740.0	740.0	
15. Catchment Pond (Hill Top)							169.0	167.0	2.0
TOTAL COST NC Rs.	4848.8	4503.0	345.8	4762.8	4417.0	345.8	17365.2	16415.8	
US $	407.46	378.40	29.06	400.23	371.17	29.06	1492.87	1379.47	113.39

Attachment IVii(b)

Kulekhani Catchment - Watershed Management Project (Makawanpur)

(Operating Cost in Thousand Rupees)

Particulars	Year 1	Year 2	Year 3	Year 4	Year 5	First Five Year		
						Total	L.C.	F.C.
1. Local Staff								
- Salaries & Benefits	60.7	85.3	115.0	134.2	143.7	538.9	538.9	
- Project Allowances	23.7	31.7	43.3	48.7	51.3	198.7	198.7	
- T.A. & Other Allowances	18.3	23.7	32.1	36.6	37.5	148.2	148.2	
- Local Consultancies	20.0	40.0	40.0			100.0	100.0	
SUB TOTAL	122.7	180.7	230.4	219.5	232.5	985.8	985.8	
2. Operation of vehicles and other Equipments	36.0	72.0	72.0	72.0	72.0	324.0	74.0	250.0
SUB TOTAL	36.0	72.0	72.0	72.0	72.0	324.0	74.0	250.0
3. Office Expenses								
- Office Running	50.0	50.0	50.0	50.0	50.0	250.0	225.0	25.0
- Office Rental	20.0	20.0	20.0	20.0		80.0	80.0	
SUB TOTAL	70.0	70.0	70.0	70.0	50.0	330.0	305.0	25.0
4. Miscellaneous Expenses and Office Supplies	60.0	50.0	50.0	50.0	50.0	260.0	200.0	60.0
SUB TOTAL	60.0	50.0	50.0	50.0	50.0	260.0	200.0	60.0
5. Maintenance of Structures, Plantation & other Field Activities		20.0	20.0	20.0	20.0	80.0	80.0	
SUB TOTAL		20.0	20.0	20.0	20.0	80.0	80.0	
6. Conservation Education and Farmers' Training	50.0	100.0	100.0	100.0	100.0	450.0	450.0	
SUB TOTAL	50.0	100.0	100.0	100.0	100.0	450.0	450.0	
TOTAL COST IN NC Rs.	338.7	492.7	542.4	531.5	524.5	2429.8	2094.8	335.0
TOTAL COST IN US $	28.46	41.40	45.58	44.66	44.08	204.18	176.03	28.15

Attachment IVII(b) (Cont.)

Particulars	Second Five Year			Third Five Year			Fifteen Year Total		
	Total	L.C.	F.C.	Total	L.C.	F.C.	Total	L.C.	F.C.
1. Local Staff									
- Salaries & Benefits	764.0	764.0		840.3	840.3		2143.2	2143.2	
- Project Allowances	256.6	256.6		256.6	256.6		711.9	711.9	
- T.A. & Other Allowances	187.4	187.4		187.4	187.4		523.0	523.0	
- Local Consultancies	100.0	100.0		100.0	100.0		300.0	300.0	
SUB TOTAL	1308.0	1308.0		1384.3	1384.3		3678.1	3678.1	
2. Operation of Vehicles and other Equipments	360.0	110.0	250.0	360.0	110.0	250.0	1044.0	294.0	750.0
SUB TOTAL	360.0	110.0	250.0	360.0	110.0	250.0	1044.0	294.0	750.0
3. Office Expenses									
- Office Running	250.0	225.0	25.0	250.0	225.0	25.0	750.0	675.0	75.0
- Office Rental							80.0	80.0	
SUB TOTAL	250.0	225.0	25.0	250.0	225.0	25.0	830.0	755.0	75.0
4. Miscellaneous Expenses and Office Supplies	250.0	200.0	50.0	250.0	200.0	50.0	760.0	600.0	160.0
SUB TOTAL	250.0	200.0	50.0	250.0	200.0	50.0	760.0	600.0	160.0
5. Maintenance of Structures, Plantation & other Field Activities	80.0	80.0		60.0	60.0		220.0	220.0	
SUB TOTAL	80.0	80.0		60.0	60.0		220.0	220.0	
6. Conservation Education and Farmers' Training	500.0	500.0		500.0	500.0		1450.0	1450.0	
SUB TOTAL	500.0	500.0		500.0	500.0		1450.0	1450.0	
Total cost in NC Rs.	2748.0	2423.0	325.0	2804.3	2479.3	325.0	7982.1	6997.1	985.0
Total cost in US $	230.92	203.61	27.31	235.[illegible]	208.34	27.31	670.76	587.99	82.77

Attachment IVIII(a)

Barandi Watershed Management Project (Gorkha)

(Capital Cost In Thousand Rupees)

	Second Five Year			Third Five Year			Fifteen Year Total		
	Total	L.C.	F.C.	Total	L.C.	F.C.	Total	L.C.	F.C.
1. Surveying Equipments, Levels, Theodolites, Drawing Equipments.	100.0		100.0	200.0		200.0	520.0		520.0
2. Hydro-meteorological Equipments, Precipitation guage, Stage recorder, Hydro-thermography, etc.	50.0		50.0	50.0		50.0	450.0		450.0
3. Vehicles									
4WD Pick Up	90.0		90.0	90.0		90.0	270.0		270.0
4WD Jeep	100.8		100.8	100.8		100.8	302.4		302.4
SUB TOTAL	190.8		190.8	190.8		190.8	572.4		572.4
4. Field & Camping Equipments	110.0	50.0	60.0	110.0	50.0	60.0	330.0	150.0	180.0
5. Furniture & Other Office Equipments.	100.0	90.0	10.0	100.0	90.0	10.0	320.0	280.0	40.0
6. Buildings									
i) Office building (1225 sft.)							192.2	192.2	
ii) Quarter 'A' Type (1037 sft.)							162.8	162.8	
iii) Quarter 'B' Type (900 sft.)							124.2	124.2	
SUB TOTAL							479.2	479.2	
7. Construction of Hydrometeorological Stations							150.0	150.0	
8. Terrace Improvement (Tread regarding, Bund construction, River base drainage)	1836.0	1836.0		1836.0	1836.0		4080.0	4080.0	
9. Community Watershed Protection	648.0	648.0		648.0	648.0		1944.0	1944.0	
10. Trail Improvement	99.6	99.6		99.6	99.6		298.8	298.8	
11. Major gully control on range land	1569.5	1569.5		1569.5	1569.5		4708.5	4708.5	
12. Road slope stabilization							888.0	888.0	
13. Stream Training									
i) Gabions	1008.0	1008.0		1008.0	1008.0		6048.0	6048.0	
ii) Riprap	7.2	7.2		7.2	7.2		40.4	40.4	
iii) Flood plain planting	648.0	648.0		648.0	648.0		2160.0	2160.0	
iv) Diversion	0.72	0.72		0.48	0.48		2.4	2.4	
SUB TOTAL	1663.9	1663.9		1663.9	1663.9		8250.8	8250.8	
14. Catchment Pond (Hill Top)	117.0	117.0		156.0	156.0		382.2	382.2	
TOTAL COST IN NC Rs.	6484.8	6074.0	410.8	6623.6	6112.8	510.8	23373.9	21611.5	1762.4
TOTAL COST IN US $	544.94	510.42	34.52	556.60	513.69	42.92	1964.17	1816.07	148.10

Attachment IVIII(a) (Cont.)

Particulars	Unit	Unit Cost	Year 1	Year 2	Year 3	Year 4	Year 5	First Five Year Total	L.C.	F.C.
1. Surveying Equipments, Levels, Theodolites, Drawing Equipments.			100.0	100.0	20.0			220.0		220.0
2. Hydro-metorological Equipments, Precipitation guage, Stage recorder, Hydro thermography etc.			150.0	150.0	50.0			350.0		350.0
3. Vehicles										
4WD Pick Up		90.0		90.0				90.0		90.0
4WD Jeep		100.8	100.8					100.8		100.8
SUB TOTAL			100.8	90.0				190.8		190.8
4. Field & Camping Equipments			30.0	20.0	20.0	20.0	20.0	110.0	50.0	60.0
5. Furniture & Other Office Equipments			30.0	30.0	20.0	20.0	20.0	120.0	100.0	20.0
6. Buildings										
i) Office building (1225 sft.)	Sft.	Rs. 157		192.2				192.2	192.2	
ii) Quarter 'A' Type (1037 sft.)	Sft.	Rs. 197			162.8			162.8	162.8	
iii) Quarter 'B' Type (900 sft.)	Sft.	Rs. 138				124.2		124.2	124.2	
SUB TOTAL				192.2	162.8	124.2		479.2	479.2	
7. Construction of Hydrometeorological Stations			75.0	75.0				150.0	150.0	
8. Terrace Improvement (Tread regarding, Bund construction, River base drainage)	Ha.	8.16	40.8	81.6	81.6	81.6	122.4	408.0	408.0	
9. Community Watershed Protection	Ha.	6.48	129.6	129.6	129.6	129.6	129.6	648.0	648.0	
10. Trail Improvement	Km.	19.92		19.92	19.92	19.92	39.84	99.6	99.6	
11. Major gully control on range land	Km^2	313.9		313.9	313.9	313.9	627.8	1569.5	1569.5	
12. Road slope stabilization	100m	44.4	177.6	177.6	177.6	177.6	177.6	888.0	888.0	
13. Stream Training										
i) Gabions	Im	10.1		1008.0	1008.0	1008.0	1008.0	4032.0	4032.0	
ii) Riprap	Km.	14.4	14.4	2.9	2.9	2.9	2.9	26.0	26.0	
iii) Flood Plain planting	Ha.	4.3	172.8	172.8	172.8	172.8	172.8	864.0	864.0	
iv) Diversion		0.24				0.48	0.72	1.2	1.2	
SUB TOTAL			187.2	1183.7	1183.7	1184.2	1184.42	4923.2	4923.2	
Catchment Pond (Hill Top)	1	7.8	7.8	7.8	15.6	39.0	39.0	109.2	109.2	
TOTAL COST IN NC Rs.			1028.8	2571.3	2194.7	2110.0	2360.7	10265.5	9424.7	840.8
TOTAL COST IN US $			86.45	216.07	184.43	177.31	198.38	862.64	791.99	70.65

Attachment IVIII(b)

Daraundi Watershed Management Project (Gorkha)

(Operating Cost in Thousand Rupees)

Particulars	Year 1	Year 2	Year 3	Year 4	Year 5	First Five Year		
1. Local Staff								
Salaries & Benefits	85.8	129.2	187.7	241.2	274.1	918.0	918.0	
Project Allowances	24.6	35.2	50.2	63.4	71.2	244.6	244.6	
Travel & Other Allowances	23.2	30.4	42.3	50.4	53.1	199.4	199.4	
Local Consultancies	30.0	40.0	40.0	50.0	50.0	210.0	210.0	
SUB TOTAL	163.6	234.8	320.2	405.0	448.4	1572.0	1572.0	
2. Operation of Vehicles and Equipments	36.0	72.0	72.0	72.0	72.0	324.0	74.0	250.0
3. Office Expenses								
Office Running	50.0	50.0	50.0	50.0	50.0	250.0	225.0	25.0
Office Rental	20.0	20.0	20.0	20.0		80.0	80.0	
SUB TOTAL	70.0	70.0	70.0	70.0	50.0	330.0	305.0	25.0
4. Miscellaneous Expenses and Office Supplies	60.0	60.0	75.0	75.0	75.0	345.0	300.0	45.0
5. Maintenance of building structures and other field activities	5.0	15.0	20.0	20.0	20.0	80.0	80.0	
6. Conservation Education and Farmers' training	50.0	100.0	100.0	100.0	110.0	460.0	460.0	
TOTAL COST IN NC Rs.	384.6	551.8	657.2	742.0	775.4	3111.0	2791.0	320.0
TOTAL COST IN US $	32.32	46.37	55.23	62.35	65.16	261.43	234.54	26.89

Appendix IVIII(b) (Cont.)

	Second Five Year			Third Five Year			Fifteen Year Total		
	Total	L.C.	F.C.	Total	L.C.	F.C.	Total	L.C.	F.C.
1. Local Staff									
Salaries & Benefits	1811.0	1811.0		2117.7	2117.7		4846.7	4846.7	
Project Allowances	450.0	450.0		473.5	473.5		1168.1	1168.1	
Travel & Other Allowances	298.7	298.7		306.9	306.9		805.0	805.0	
Local Consultancies	150.0	150.0		150.0	150.0		510.0	510.0	
SUB TOTAL	2709.7	2709.7		3048.1	3048.1		7329.8	7329.8	
2. Operation of Vehicles and Equipments	360.0	110.0	250.0	360.0	110.0	250.0	1044.0	294.0	750.0
3. Office Expenses									
Office Running	375.0	300.0	75.0	375.0	300.0	75.0	1000.0	825.0	175.0
Office Rental							80.0	80.0	
SUB TOTAL	375.0	300.0	75.0	375.0	300.0	75.0	1080.0	905.0	175.0
4. Miscellaneous Expenses and Office Supplies	350.0	300.0	50.0	350.0	300.0	50.0	1045.0	900.0	145.0
5. Maintenance of building structures and other field activities	100.0	100.0		100.0	100.0		280.0	280.0	
6. Conservation Education and farmers training	460.0	460.0		460.0	460.0		1380.0	1380.0	
TOTAL COST IN NC Rs.	4354.7	3979.7	375.0	4693.1	4318.1	375.0	12158.8	11088.8	1070.0
TOTAL COST IN US $	365.94	334.40	31.51	394.38	362.87	31.51	1021.75	931.83	89.91

Attachment IVIv(a)

Upper Kali-Gandaki Watershed Management Project (Myagdi)

(Capital Cost In Thousand Rupees)

Particulars	Unit	Unit Cost	Year 1	Year 2	Year 3	Year 4	Year 5	First Five Year		
1. Surveying Equipments, Levels, Theodolites, Drawing Equipment			100.0	100.0	10.0			210.0		210.0
2. Hydrometeorological Equipment, Precipitation guage, Stage recorder, Hydro thermograph etc. (For detail see Watershed Management Report)			100.0	50.0				150.0		150.0
3. Vehicles										
4WD Pick Up	1	Rs 90000								
4WD Jeep	1	Rs 100800								
SUB TOTAL										
4. Field & Camping Equipments			10.0	20.0	10.0	10.0	10.0	60.0	20.0	40.0
5. Furniture & Other Office Equipments			30.0	20.0	20.0	20.0	20.0	110.0	80.0	30.0
6. Buildings										
Office building (1225 sq. ft.)	Sft.	Rs 187.5		230.0				230.0	230.0	
Quarter A Type (1037 sq. ft.)	Sft.	Rs 187.5			195.0			195.0	195.0	
Quarter B Type (900 sq. ft.)	Sft.	Rs 165.0				148.0		148.0	148.0	
SUB TOTAL				230.0	195.0	148.0		573.0	573.0	
7. Hydrometeorological Stations				150.0				150.0	100.0	50.0
8. Terrace Improvement (Tread regarding, Bund Construction, River base drainage)	Ha.	12.24	122.4	122.4	122.4	122.4	122.4	612.0	612.0	
9. Watershed Protection	Ha.	9.72	97.2	97.2	97.2	97.2	97.2	486.0	486.0	
10. Trail Improvement	Km.	29.9	59.8	89.7	119.6	119.6	59.8	448.5	448.5	
11. Range Denudation	Km^2	471.0			471.0	471.0	471.0	1413.0	1413.0	
12. Catchment Pond	1	6.5		6.5	6.5	6.5	26.0	45.5	45.5	
TOTAL COST IN NC Rs.			519.4	885.8	1051.7	994.7	806.4	4258.0	3778.0	480.0
TOTAL COST IN US $			43.65	74.44	88.38	83.59	67.76	357.82	317.48	40.34

Attachment IVIv(a) (Cont.)

Particulars	Second Five Year			Third Five Year			Fifteen Year Total		
	Total	L.C.	F.C.	Total	L.C.	F.C.	Total	L.C.	F.C.
1. Surveying Equipments, Levels, Theodolites, Drawing Equipment	100.0		100.0	100.0		100.0	410.0		410.0
2. Hydrometeorological Equipment, Precipitation guage, Stage recorder, Hydro thermograph etc. (For detail see Watershed Management Report)							150.0		150.0
3. Vehicles									
4WD Pick Up				90.0		90.0	90.0		90.0
4WD Jeep				100.8		100.8	100.8		100.8
SUB TOTAL				190.8		190.8	190.8		190.8
4. Field & Camping Equipments	60.0	20.0	40.0	60.0	20.0	40.0	180.0	60.0	120.0
5. Furniture & Other Equipments	110.0	80.0	30.0	110.0	80.0	30.0	330.0	240.0	90.0
6. Buildings									
Office Building (1225 sq. ft.)							230.0	230.0	
Quarter A Type (1037 sq. ft.)							195.0	195.0	
Quarter B Type (900 sq. ft.)							148.0	148.0	
SUB TOTAL							573.0	573.0	
7. Hydrometeorological Stations							150.0	100.0	50.0
8. Terrace Improvement (Tread regarding, Bund Construction, River base drainage)	918.0	918.0		918.0	918.0		2448.0	2448.0	
9. Watershed Protection	486.0	486.0		486.0	486.0		1458.0	1458.0	
10. Trail Improvement	149.5	149.5		149.5	149.5		747.5	747.5	
11. Range Denudation	1176.0	1176.0		1176.0	1176.0		3765.0	3765.0	
12. Catchment Pond	26.0	26.0	65.0	65.0	65.0		136.5	136.5	
TOTAL COST IN NC Rs.	3025.5	2855.5	170.0	3254.5	2894.5	360.0	10538.0	9527.2	1010.8
TOTAL COST IN US $	254.24	239.96	14.28	273.49	243.24	30.25	885.55	800.61	84.94

Attachment IVIv(b)

Upper Kali-Gandaki Watershed Management Project (Myagdi)

(Operating Cost in Thousand Rupees)

Particulars	Unit	Unit Cost	Year 1	Year 2	Year 3	Year 4	Year 5	First Five Year		
								Total	L.C.	F.C.
1. Local Staff										
Salaries & Benefits			80.2	118.9	158.1	205.1	225.3	787.6	787.6	
Project Allowances			20.0	28.0	36.0	45.8	51.0	180.8	180.8	
Travel & Other Allowances			23.4	31.1	38.3	50.0	51.8	194.6	194.6	
Local Consultancies			30.0	30.0	30.0	30.0	30.0	150.0	150.0	
SUB TOTAL			153.6	208.0	262.4	330.9	358.1	1313.0	1313.0	
2. Operation of Equipments and Vehicles			6.0	6.0	6.0	6.0	6.0	30.0	25.0	5.0
3. Office Expenses										
Office Running			50.0	50.0	50.0	50.0	50.0	250.0	225.0	25.0
Office Rental			20.0	20.0	20.0	20.0		80.0	80.0	
SUB TOTAL			70.0	70.0	70.0	70.0	50.0	330.0	305.0	25.0
4. Miscellaneous Expenses and Supplies			60.0	60.0	75.0	75.0	75.0	345.0	300.0	45.0
5. Maintenance of buildings, structures and other field activities			5.0	20.0	20.0	20.0	20.0	85.0	85.0	
TOTAL COST IN NC Rs.			294.6	364.0	433.4	501.9	509.1	2103.0	2028.0	75.0
TOTAL COST IN US $			24.76	30.58	36.42	42.18	42.78	176.72	170.42	6.3

Attachment IViv(b) (Cont.)

Particulars	Second Five Year			Third Five Year			Fifteen Year Total		
	Total	L.C.	F.C.	Total	L.C.	F.C.	Total	L.C.	F.C.
1. Local Staff									
Salaries & Benefits	1390.4	1390.4		1509.1	1509.1		3687.1	3687.1	
Project Allowances	302.1	302.1		307.4	307.4		790.3	790.3	
Travel & other Allowances	275.5	275.5		277.4	277.4		747.5	747.5	
Local Consultancies	150.0	150.0		150.0	150.0		450.0	450.0	
SUB TOTAL	2118.0	2118.0		2243.9	2243.9		5674.9	5674.9	
2. Operation of Equipment and Vehicles	40.0	30.0	10.0	360.0	110.0	250.0	430.0	165.0	265.0
3. Office Expenses									
Office Running	375.0	300.0	75.0	375.0	300.0	75.0	1000.0	825.0	175.0
Office Rental							80.0	80.0	
SUB TOTAL	375.0	300.0	75.0	375.0	300.0	75.0	1080.0	905.0	175.0
4. Miscellaneous Expenses and Supplies	350.0	300.0	50.0	350.0	300.0	50.0	1045.0	900.0	145.0
5. Maintenance of buildings, structures and other Field activities	100.0	100.0		100.0	100.0		285.0	285.0	
TOTAL COST IN NC Rs.	2983.0	2848.0	135.0	3428.9	3053.9	375.0	8514.9	7929.9	585.0
TOTAL COST IN US $	250.67	239.33	11.34	288.14	256.63	31.51	715.53	666.38	49.15

Attachment IVv(a)

Upper Kali-Gandaki Watershed Management Project (Mustang)

(Capital Cost In Thousand Rupees)

Particulars	Unit	Unit Cost	Year 1	Year 2	Year 3	Year 4	Year 5	First Five Years Total	L.C.	F.C.
1. Surveying Equipments (Levels, Theodolites, Drawing equipments.)			100.0	100.0	10.0			210.0		210.0
2. Hydro-meteorological equipments (Precipitation guage, Stage recorders, Hydro-thermograph, etc.) For detail see Watershed Management Report.			100.0					100.0		100.0
3. Vehicles										
4WD Pick Up	1	Rs 90000								
4WD Jeeps	1	Rs 100800								
SUB TOTAL										
4. Field & Camping Equipments			10.0	20.0	10.0	10.0	10.0	60.0	40.0	20.0
5. Furniture & Other Office Equipment			30.0	20.0	20.0	20.0	20.0	110.0	80.0	30.0
6. Buildings										
Office Buildings (1225 sq. ft.)	Sq. ft.	220		269.5				269.5	269.5	
Quarter A Type (1037 sq. ft.)	Sq. ft.	220			228.1			228.1	228.1	
Quarter B Type (900 sq. ft.)	Sq. ft.	192.5				174.0		174.0	174.0	
				269.5	228.1	174.0		671.6	671.6	
7. Construction of Hydro-meteorological Station				150.0				150.0	100.0	50.0
8. Terrace Expansion	Ha.	12.24			122.4	122.4	122.4	367.2	367.2	
9. Test Drilling	1	24.0		144.0	144.0	144.0	144.0	576.0	276.0	300.0
10. Water Conservation Impoundments	1	45.40			45.4		45.4	90.8	90.8	
11. Wind Mills	1	24.00			24.0	48.0	48.0	120.0	60.0	60.0
12. Community Watershed Protection	Ha.	9.72		97.2	97.2	97.2	97.2	388.8	388.8	
13. Catchment Pond	1	11.7			11.7	23.4	35.1	70.2	70.2	
TOTAL COST IN NC Rs.			240.0	800.7	712.8	639.0	522.1	2914.6	2144.6	770.0
TOTAL COST IN US $			20.17	67.29	59.90	53.70	43.87	244.93	180.22	64.71

Attachment IV#(a) (Cont.)

Particulars	Second Five Year			Third Five Year			Fifteen Year Total		
	Total	L.C.	F.C.	Total	L.C.	F.C.	Total	L.C.	F.C.
1. Surveying Equipments (Levels, Theodolites, Drawing equipments)	100.0		100.0	100.0		100.0	410.0		410.0
2. Hydro-meteorological equipments (Precipitation guage, Stage recorder, Hydro-thermograph, etc.) For detail see Watershed Management Report.							100.0		100.0
3. Vehicles									
4WD Pick Up				90.0		90.0	90.0		90.0
4WD Jeep				100.8		100.8	100.8		100.8
SUB TOTAL				190.8		190.8	190.8		190.8
4. Field & Camping Equipments	60.0	40.0	20.0	60.0	40.0	20.0	180.0	120.0	60.0
5. Furniture & other Office Equipment	110.0	80.0	30.0	110.0	80.0	30.0	330.0	240.0	90.0
6. Buildings									
Office Buildings (1225 sq. ft.)							269.5	269.5	
Quarter A Type (1037 sq. ft.)							228.1	228.1	
Quarter B Type (900 sq. ft.)							174.0	174.0	
SUB TOTAL							671.6	671.6	
7. Construction of Hydro-meteorological Station							150.0	100.0	50.0
8. Terrace Expansion	2448.0	2448.0		2448.0	2448.0		5263.2	5263.2	
9. Test Drilling							576.0	276.0	300.0
10. Water Conservation Impoundments	45.4	45.4		45.4	45.4		181.6	181.6	
11. Wind Mills							120.0	60.0	60.0
12. Community Watershed Protection	972.0	972.0		972.0	972.0		2332.8	2332.8	
13. Catchment Pond	35.1	35.1		117.0	117.0		222.3	222.3	
TOTAL COST IN NC Rs.	3770.5	3620.5	150.0	4043.2	3702.4	340.8	10728.3	9467.5	1260.8
TOTAL COST IN US $	316.85	304.24	12.61	339.76	311.13	28.63	901.54	795.59	105.95

Attachment IVv(b)

Upper Kali-Gandaki Watershed Management Project (Mustang)

(Operating Cost in Thousand Rupees)

Particulars	Year 1	Year 2	Year 3	Year 4	Year 5	First Five Year		
1. Local Staff								
- Salaries & Benefits	96.1	139.4	188.2	227.7	254.7	906.1	906.1	
- Project Allowances	19.1	27.1	35.1	40.5	43.1	164.9	164.9	
- Travel & Other Allowances	23.7	30.9	38.0	44.3	45.2	182.1	182.1	
- Consultancies	30.0	30.0	30.0	30.0	30.0	150.0	150.0	
SUB TOTAL	168.9	227.4	291.3	342.5	373.0	1402.1	1402.1	
2. Operation of Equipments and Vehicles	6.0	6.0	6.0	6.0	6.0	30.0	25.0	5.0
3. Office Expenses								
- Office Running	50.0	50.0	50.0	50.0	50.0	250.0	225.0	25.0
- Office Rental	20.0	20.0	20.0	20.0		80.0	80.0	
SUB TOTAL	70.0	70.0	70.0	70.0	50.0	330.0	305.0	25.0
4. Miscellaneous Expenses and Supplies	60.0	60.0	75.0	75.0	75.0	345.0	300.0	45.0
5. Maintenance of Building structure and other Field activities	5.0	20.0	20.0	20.0	20.0	85.0	85.0	
TOTAL COST IN NC Rs.	309.9	383.4	462.3	513.5	524.0	2193.1	2118.1	75.0
TOTAL COST IN US $	26.04	32.22	38.85	43.15	44.03	184.29	177.99	6.30

Attachment IVv(b) (Cont.)

PARTICULARS	Second Five Year			Third Five Year			Fifteen Year Total		
	Total	L.C.	F.C.	Total	L.C.	F.C.	Total	L.C.	F.C.
1. Local Staff									
- Salaries & Benefits	1534.0	1534.0		1650.5	1650.5		4090.6	4090.6	
- Project Allowances	239.0	239.0		241.7	241.7		645.6	645.6	
- Travel & Other Allowances	234.4	234.4		235.3	235.3		651.8	651.8	
- Consultancies	150.0	150.0		150.0	150.0		450.0	450.0	
SUB TOTAL	2157.4	2157.4		2277.5	2277.5		5838.0	5838.0	
2. Operation of Equipments and Vehicles	40.0	30.0	10.0	360.0	110.0	250.0	430.0	165.0	265.0
3. Office Expenses									
- Office Running	375.0	300.0	75.0	375.0	300.0	75.0	1000.0	825.0	175.0
- Office Rental							80.0	80.0	
SUB TOTAL	375.0	300.0	75.0	375.0	300.0	75.0	1080.0	905.0	175.0
4. Miscellaneous Expenses and Supplies	350.0	300.0	50.0	350.0	300.0	50.0	1045.0	900.0	145.0
5. Maintenance of Building structures and other field activities	100.0	100.0		100.0	100.0		285.0	285.0	
TOTAL COST IN NC Rs.	3022.4	2887.4	135.0	3462.5	3087.5	375.0	8678.0	8093.0	585.0
TOTAL COST IN US $	253.98	242.64	11.34	290.97	259.45	31.5	729.24	680.08	49.16

Attachment V

Watershed Management Project (Four Districts and Central Office

Summary of Cost (NRs '000)

Particulars		Year 1	Year 2	Year 3	Year 4	Year 5	First Five Year Total		F.C.
CAPITAL COST									
KULEKHANI (MAKWANPUR)	NC Rs.	939.2	2250.3	1984.9	1989.3	989.9	8153.6	7495.8	657.8
	US $	78.92	189.11	166.79	167.16	83.18	658.16	629.89	55.27
DARAUNDI (GORKHA)	NC Rs.	1028.8	2571.3	2194.7	2110.0	2360.7	10265.5	9424.7	840.8
	US $	86.45	216.07	184.43	177.31	198.38	862.64	791.99	70.65
UPPER KALI-GANDAKI (MYAGDI)	NC Rs.	519.4	885.8	1051.7	994.7	806.4	4258.0	3778.0	480.0
	US $	43.65	74.44	88.38	83.59	67.76	357.82	317.48	40.34
UPPER KALI-GANDAKI (MUSTANG)	NC Rs.	240.0	800.7	712.8	639.0	522.1	2914.6	2144.6	770.0
	US $	20.17	67.29	59.90	53.70	43.87	244.93	180.22	64.71
TOTAL CAPITAL	NC Rs.	2727.4	6508.1	5944.1	5733.0	4679.1	25591.7	22843.1	2748.6
	US $	229.19	546.89	499.50	481.76	393.20	2150.56	1919.59	230.97
OPERATING COST									
KULEKHANI (MAKWANPUR)	NC Rs.	338.7	492.7	542.4	531.[illegible]	524.5	2429.8	2094.8	335.0
	US $	28.46	41.40	45.58	44.66	44.08	204.18	176.03	28.15
DARAUNDI (GORKHA)	NC Rs.	384.6	5[illegible]1.8	657.2	742.0	775.4	3111.0	2791.0	320.0
	US $	32.32	46.37	55.23	62.3[illegible]	65.16	261.43	234.54	26.89
UPPER KALI-GANDAKI (MYAGDI)	NC Rs.	294.6	364.0	433.4	501.9	509.1	2103.0	2028.0	75.0
	US $	24.76	30.58	26.42	42.18	42.78	176.72	170.42	6.30
UPPER KALI-GANDAKI (MUSTANG)	NC Rs.	309.9	383.4	462.3	513.5	524.0	2193.1	2118.1	75.0
	US $	26.04	32.22	38.85	43.15	44.03	184.29	177.99	6.30
TOTAL OPERATING	NC Rs.	1327.8	1791.9	2095.3	2288.9	2333.0	9836.9	9031.9	805.0
	US $	111.58	150.57	176.08	192.34	196.05	826.62	758.98	67.64
GRAND TOTAL (CAPITAL & OPERATING)	NC Rs.	4055.2	8300.0	8039.4	8021.9	7012.1	35428.6	31875.0	3553.6
	US $	340.77	697.48	675.58	674.11	589.25	2977.19	2678.57	298.62
INVENTORY AND MONITORING									
OPERATING COST	NC Rs.	898.8	1137.4	1226.9	1214.5	1241.4	5710.0	3993.0	1717.0
	US $	74.77	95.58	103.10	102.06	104.32	479.83	335.55	144.28
CAPITAL COST	NC Rs.	1582.8	1243.2	770.0	490.0	320.0	4406.0	650.0	3756.0
	US $	133.01	104.47	64.71	41.18	26.88	370.25	54.62	315.63
TOTAL	NC Rs.	2472.6	2380.6	1996.9	1704.5	1561.4	10116.0	4643.0	5473.0
	US $	207.78	200.05	167.81	143.24	131.20	850.08	390.17	459.97

Attachment V (Cont.)

Particulars		Second Five Year			Third Five Year			Fifteen Year Total		
		Total	L.C.	F.C.	Total	L.C.	F.C.	Total	L.C.	F.C.
CAPITAL COST										
KULEKHANI (MAKWANPUR)	NC Rs.	4848.8	4503.0	345.8	4762.8	4417.0	345.8	17765.2	16415.8	1349.4
	US $	407.46	378.40	29.06	400.23	371.17	29.06	1492.87	1379.47	113.40
DARAUNDI (GORKHA)	NC Rs.	6484.8	6074.0	410.8	6623.6	6112.8	510.8	23373.9	21611.5	1762.4
	US $	544.94	510.42	34.52	556.60	513.69	42.91	1964.19	1816.09	148.10
UPPER KALI-GANDAKI (MYAGDI)	NC Rs.	3025.5	2855.5	170.0	3254.5	2994.5	360.0	10538.0	9527.2	1010.8
	US $	254.24	239.96	14.28	273.49	243.24	30.25	885.55	800.61	84.94
UPPER KALI-GANDAKI (MUSTANG)	NC Rs.	3770.5	3620.5	150.0	4043.2	3707.4	340.8	10728.3	9467.5	1260.8
	US $									
TOTAL CAPITAL	NC Rs.	18129.6	17053.0	1076.6	18684.1	17126.7	1557.4	62405.4	57022.0	5383.4
	US $	1523.50	1433.01	90.47	1570.09	1439.22	130.87	5244.15	4791.76	452.39
OPERATING COST										
KULEKHANI (MAKWANPUR)	NC Rs.	2748.3	2423.0	325.0	2804.3	2479.3	325.0	7982.1	6997.1	985.0
	US $	230.92	203.61	27.31	235.65	208.34	27.31	670.76	587.99	82.77
DARAUNDI (GORKHA)	NC Rs.	4354.7	3979.7	375.0	4693.1	4318.1	375.0	12158.8	11088.8	1070.0
	US $	365.94	334.43	31.51	394.38	362.87	31.51	1021.74	931.83	89.91
UPPER KALI-GANDAKI (MYAGDI)	NC Rs.	2983.0	2848.0	135.0	3428.9	3053.0	375.0	8514.9	7929.9	585.0
	US $	250.67	239.33	11.34	288.14	256.63	31.51	715.53	66.38	49.15
UPPER KALI-GANDAKI (MUSTANG)	NC Rs.	3022.4	2887.4	135.0	3462.5	3087.5	375.0	8678.0	8093.0	585.0
	US $	253.98	242.64	11.34	290.97	259.45	31.52	729.24	680.08	49.16
TOTAL OPERATING	NC Rs.	13108.1	12138.1	970.0	14388.8	12938.8	1450.0	37333.8	34108.8	3225.0
	US $	1101.51	1020.01	81.50	1209.14	1087.29	121.85	3137.27	2866.27	271.0
GRAND TOTAL (CAPITAL & OPERATING)	NC Rs.	31237.7	29191.1	2046.6	33072.9	30065.5	3007.4	99739.2	91130.8	8607.6
	US $	2625.01	2453.03	171.98	2779.23	2526.51	252.72	8381.44	7658.05	723.39
INVENTORY AND MONITORING										
OPERATING COST	NC Rs.	4752.1	3262.1	1490.0	4903.0	3413.0	1490.0	15365.1	10668.1	4697.0
	US $	399.34	274.13	125.21	412.02	286.82	125.21	1291.18	896.48	394.70
CAPITAL COST	NC Rs.	1915.6	120.0	1795.6	2115.6	220.0	1895.6	8437.2	990.0	744.72
	US $	160.97	10.08	150.89	177.78	18.49	159.29	709.01	8 .19	625.82
TOTAL	NC Rs.	6666.7	3382.1	3285.6	7018.6	3633.0	3385.6	23802.3	11658.1	12144.2
	US $	560.31	284.21	276.10	589.80	305.31	284.50	2000.19	979.67	1020.52