# Chapter 2
# General Characteristics of the Country

## 2.1 Physical Features

The kingdom of Nepal is situated in the central part of the Himalayan Arc separating the Gangetic plains of India from the Tibetan plateau of China. The Himalayan belt extends over 2,400 km from the Punjab Himalayas in the west to the Bhutan and Assam Himalayas in the east. The Nepal Himalayas, situated between 26° 15' to 30° 30' N latitude and 80° 00' to 88° 15' E longitude, stretch from over 800 km northwest to southeast. Their total area of 147 181 sq.km spans the mountainous region with varying widths of between 90 and 230 km. Within an average width of only about 150 km the altitude range varies from less than 100 masl to 8,848 masl. About 83% of the national land is covered by the rugged terrain of the hills and mountains and the land above 4,500 masl is approximately 14.7% of the total land.

## 2.2 Climate

Nepal has a monsoon climate characterised by relatively wet summers and dry winters. Every summer, between June and July, the sun moves northwards and heats up the mountains creating a massive convection cell. The subsequent rising air produces a vacuum that draws the moisture-laden air off the Bay of Bengal. This air runs into the Himalayan barriers, cools as it rises and condenses in the form of rain. Thus begins the monsoon season, which brings three to four months of high humidity with overcast skies and gentle rain. About 70–80% of annual precipitation falls during this period.

The eastern Himalayas receive the brunt of the monsoon, which loses its effect as it moves west along the mountains. Consequently, there is a distinct moisture gradient from east to west.

In winter, western Nepal experiences a reverse monsoon caused by a shift in the jet stream. This phenomenon, which drags weather patterns from the west of the Arabian Sea, brings moisture to the region in the form of snow and is essential for agriculture. The oscillation of the jet stream lasts between November and March and is not only responsible for Everest's snow plume and black appearance but also renders mountaineering difficult.

## 2.3 River Systems

The country receives almost 80% of its annual rainfall within the short period of time of the monsoon season and as such produces a large number of small and big rivers in its mountains. The generation of big and small rivers fed by rainwater, snow melt water, and groundwater leads to the assumption that Nepal is one of the richest countries in the world in terms of hydropower potential. To date, a complete inventory of rivers in Nepal is not available. A study conducted in 1964–65 (Shrestha 1965) indicates that there are over 6,000 rivers in Nepal, of which 960 are more than 10 km long and about 24 of them exceed 100 km in length. The longest river flowing inside Nepal is the Karnali River. Measured along the Mugu branch, the Karnali has a length of 507 km. The average drainage density in Nepal is about 0.3 km $km^{-2}$.

Generally, the rivers in Nepal are classified into three groups on the basis of the source. The first group of rivers is fed by snow and ice melt water as their headwaters are in the snow covered and glaciated region of the High Himalayas. The Koshi, Gandaki, Karnali, and Mahakali rivers fall into this group (Figure 2.1). These rivers maintain a sustained flow during the dry season and therefore are very important for the development of the nation's water resources. In addition, these rivers contribute a major portion of the flow to the Ganges River during the lean flow period. The second group of rivers originates in the Mahabharat region. They are fed by groundwater during the dry season and therefore do not dry up. The Bagmati, Kamala, Rapti, Mechi, Kankai, and Babai rivers fall into this group. Rivers originating in the Siwalik range fall into the third group, and this includes the Tinau, Banganga, Tilawe, Sirsia, Manusmara, Hardinath, Sunsari and other smaller rivers of the south. The flow in these rivers is significantly low during the dry season, while some of the smaller rivers may dry up completely during the non-monsoon season.

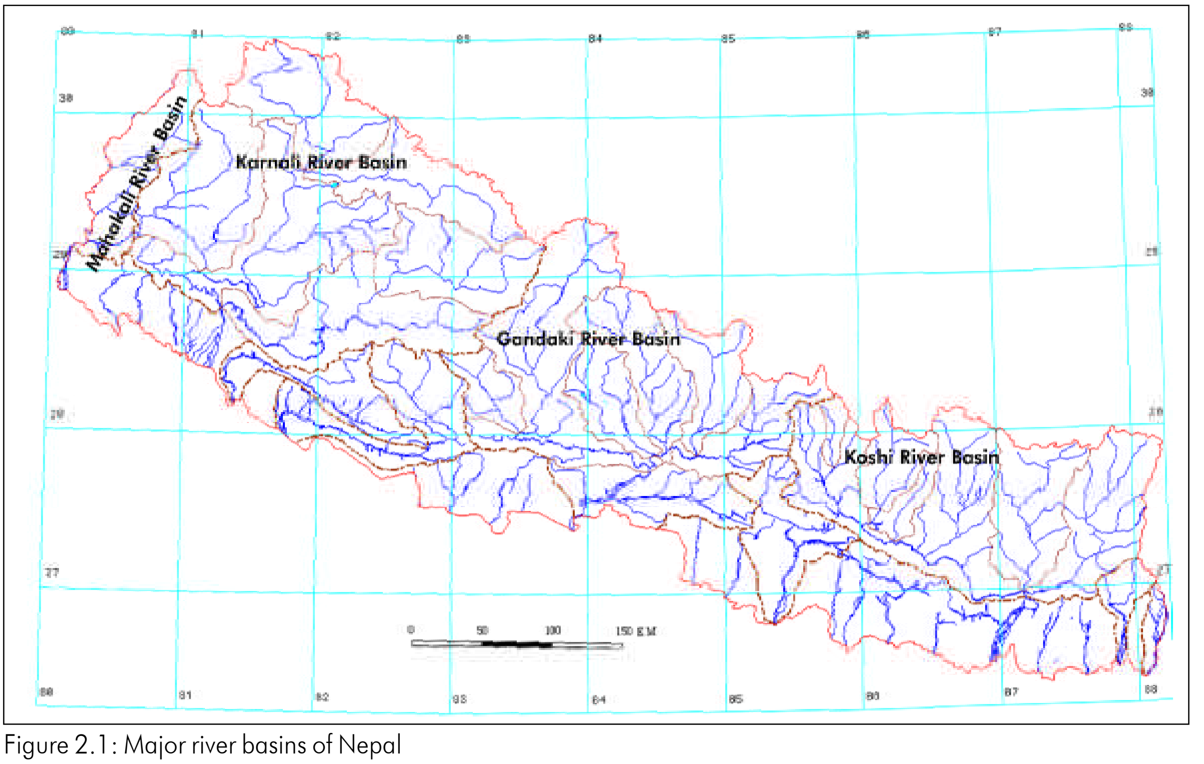

Figure 2.1: Major river basins of Nepal

## 2.4 Geology and Geomorphology

A simple geo-tectonic zonation, which is applicable to all of the Himalayan belt, is valid for Nepal too. It is also found that the geomorphic divisions are well correlated with the distribution of the geologic formations and structural arrangements along the Himalayan trend. The grouping of similar patterns of landforms has led to the recognition of five geomorphic divisions in the Himalayas: the Terai, Siwaliks, Middle Mountains, High Mountains, and High Himalayan regions (Figure 2.2). Bedrock and surface geology are the primary differentiating criteria for the geomorphic boundaries of land system mapping. The geomorphic cross section in the north–south direction is almost similar throughout the Himalayas.

The geological sub-divisions of the Nepal Himalayas arranged longitudinally from south to north are given in Table 2.1

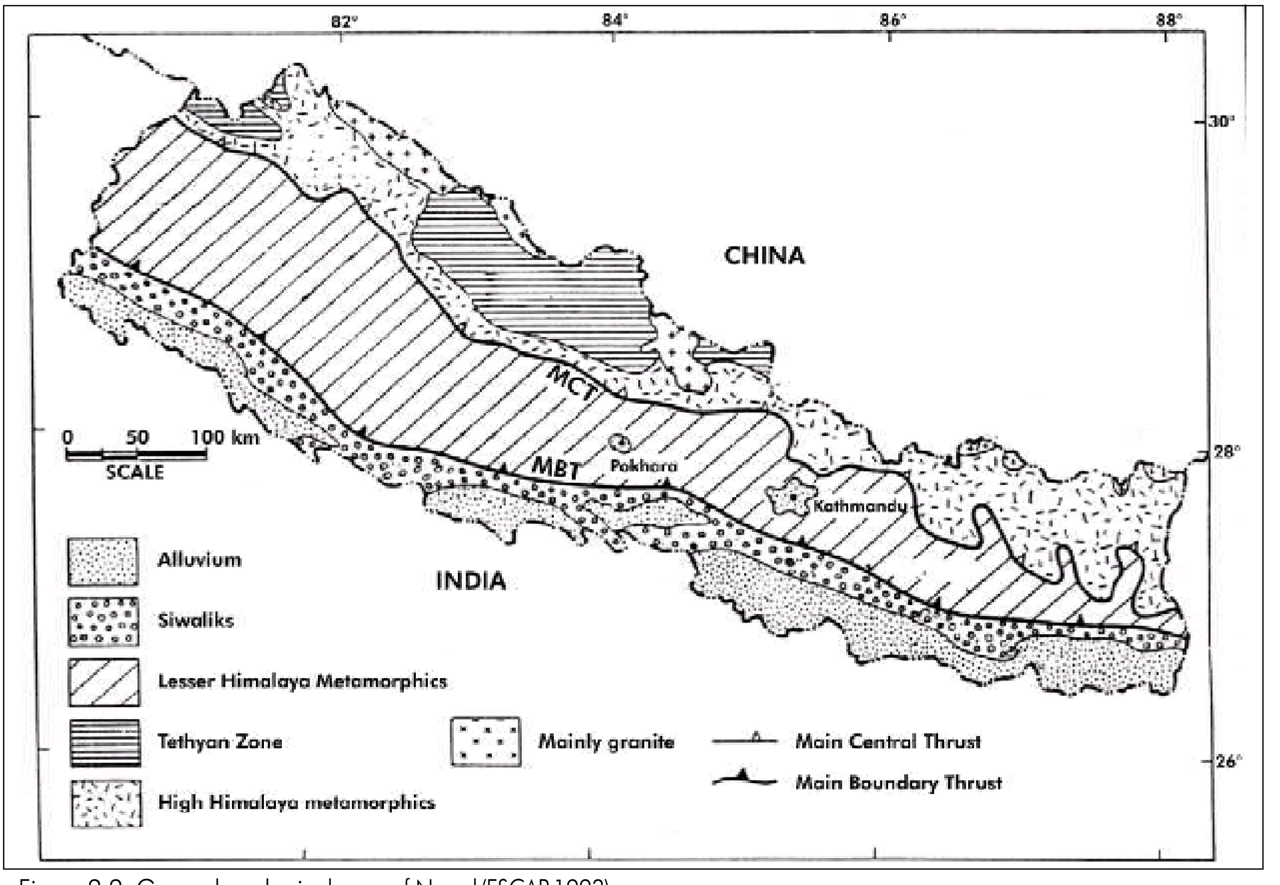


Figure 2.2: General geological map of Nepal (ESCAP 1993)

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## The Terai plain

Nepal, located in the central portion of the Himalayan Arc, occupies only 17% of the alluvial plain in the south of the mountainous terrain. The northern continuation of the Gangetic Plain in Nepal is called the Terai. The Terai Plain ranges in elevation from less than 100 to 200 masl. Its width varies between 10 and 50 km and forms a nearly continuous belt from east to west. It is an alluvial deposit of Gangetic sediments and composed mainly of sand, silt, and gravel. The main feature of the Terai Plain is the abrupt shifting of river channels. This zone is the extension of the fertile Gangetic Plain that comes to a sudden halt as it rises into mountainous relief in the north. The Terai Plain is divided into three parts: the Bhabar zone, the middle Terai, and the southern Terai.

This zone lies south of the Churia Range and is made up of alluvial fan deposits of boulder and pebble sloping to the south. The southern margin of the Bhabar zone is marked by a spring line, which generates many streams. The water table in the Bhabar zone lies at a greater depth, and hence the exposed stream valleys are dry except in the monsoon season.

*The Middle Terai*

This area lies south of the Bhabar zone immediately after the alluvial fan deposits. The area is composed of cobbles and a sand zone on undulating terrain with isolated pockets of waterlogged and marshy conditions.

*The Southern Terai*

This area lies south of the Middle Terai and stretches along the Nepal– India border. It is the lowest terrain of Nepal with an altitude of less than 100 masl. It contains clay and silt zones with sand layers.

## Churia range or Siwaliks

The Churia Range, known as the Siwalik Hills in India, comprises the foothills of the Himalayan ranges and it runs along the length of the Great Himalaya. The Churia has an average height of 900 masl, but the range is as high as 1,350 masl in many places. This range separates the Terai from the steep slopes of the Mahabharat Range. The soils of this region are immature and are unsuitable for agriculture and therefore large tracts of undisturbed tropical forest remain. The Churia Range consists of longitudinal basins formed by east–west flowing rivers and this area is called the Inner Terai or Dun Valley. The soils of these basins are fertile.

The Siwalik zone is limited by the main boundary thrust (MBT) to the north along the southern foot of the Mahabharat Range and the main frontal thrust (MFT) to the south at the southern edge of the Siwalik Group. The Lesser Himalayan rocks thrust over the sediments of the Siwalik. The Siwalik zone, a distinct foothill zone, is occupied by molasse deposits resulting from the rapid upheaval of the Higher Himalaya from the late Tertiary to the early Quaternary. Trellis, parallel, sub-parallel, and rectangular drainage patterns plus flash floods are characteristic of this region. Furthermore, the topography is rugged with numerous gullies and mounds of talus and scree. The streams are found to be dry most of the time but become hazardously active during the monsoon season, which causes intense erosion, flash floods, and debris flows. The Siwalik Group is divided into three major units, the Upper, Middle, and Lower Siwaliks.

*The Lower Siwaliks (LS)*

The Lower Siwaliks consist of irregularly alternating beds of fine-grained, grey sandstones, variegated mudstones, and pseudo-conglomerates. Sandstones are moderately indurate, and cemented mostly by calcite. The upper part of this unit is composed of sandstones and variegated mudstones in roughly equal amounts. The thickness of individual beds of sandstones and mudstones varies from 1 to 10m and 1 to 2m respectively.

*The Middle Siwaliks (MS)*

This Middle Siwaliks are further sub-divided into two subunits, the Lower Member ($MS_1$) and the Upper Member ($MS_2$). The $MS_1$ is represented by fine- to medium-grained, thick-bedded, compact, fairly hard, greenish grey to light brownish grey, micaceous sandstones interbedded with greenish grey or brownish yellow to purplish gray mudstones and shales. In some places, especially in the upper horizons, thin lenses of pseudo-conglomerates are recorded. The size of the pebbles varies from 5 to 20 cm. Plant and animal fossils are preserved in mudstones as well as in sandstones. The $MS_2$ is composed of medium- to coarse-grained, pebbly sandstones with rare grey to dark grey mudstones and occasionally silty sandstones and conglomerates. The thickness of individual beds varies from 1 to 15m.

*The Upper Siwaliks (US)*

These are composed predominantly of gravel and conglomerate beds. Individual conglomerate beds of from 2–8m thick lie in between the medium- to coarse-grained, brownish grey sandstones and, occasionally, siltstones. The size of the pebbles varies from several millimetres to ten centimetres. The rock is loosely packed and consists of pebbles of quartzite, dolomite, marble, limestone, granite, and Lower Siwalik sandstone and shale. The matrix is calcareous or clayey.

## The Lesser Himalaya

The Lesser Himalayan zone lies to the south of the Higher Himalayan zone. It is bordered by the main central thrust (MCT) in the north and in the south by the MBT. This zone is characterised by medium to low-grade metamorphic rocks, igneous rocks, and sedimentary rocks. It can be further sub-divided physiographically into the Midland and Mahabharat Range from north to south.

*The Mahabharat range*

The outstanding steep sloping mountains to the north of the Churia hills are often referred to as the Mahabharat Range or Middle Hills. Their altitude varies between 1,500 and 2,700 masl. Quite steep sloping mountains are characterised by water-retentive soils allowing for terrace cultivation. On the lower slopes remnants of sub-tropical forests can be found, whereas on the upper reaches, above cultivation, temperate forest begins. The rock type consists mainly of quartzite, granite, schist marble, and limestone. Most of the high peaks are found either on granite or limestone. The range is characterised by dendritic, radial, and rectangular drainage patterns.

*The Midland*

This zone lies north of the Mahabharat Range and forms no sharp boundary with the Mahabharat Range. The landforms of this zone are the reflection of the rock and comparatively low lying hills between the Mahabharat and the Himalayan ranges. The Midland is represented by a rather dissected topography with predominantly dendritic, centripetal, and sub-parallel drainage patterns. Additionally, residual soils are observed on the ridges while colluvial soil and talus deposits are present along the slopes. It consists mainly of metamorphic and igneous rocks. Due to the presence of soft rock, such as phyllite, the Midland is found to be amenable to terrace cultivation. Furthermore, this zone is characterised by a temperate climate. Therefore, this zone is favourable for cultivation and shelter and includes fertile valleys like Kathmandu, Banepa, and Pokhara. This area, which has been inhabited for centuries, supports nearly half of Nepal's population. As a result, the central and eastern parts of this zone have been cultivated extensively. Due to altitudinal ranges of between 1,000 and 2,000m, sub-tropical and lower temperate forests are found here.

## The Higher Himalaya

The Higher Himalayan zone ranges from 3,000m to more than 8,000m and is mostly covered with snow and glaciers. Out of the 14 peaks in the world higher than 8,000m, The Nepal Himalaya host the eight highest peaks, i.e., Mount Everest, Kanchanjunga, Lhotse, Makalu, Dhaulagiri, Manaslu, Cho-Oyu, and Annapurna I. There are many more higher peaks in the eastern part of Nepal than in the western part. The upper parts of these mountains are formed by Tethys sediments, which are underlain by the central crystalline rocks. The whole range consists mainly of high grade metamorphic rocks like schist and gneiss. Sharp peaks and vertical walled valleys characterise the landforms of this zone.

Both the crystalline basement rock of the Higher Himalaya and the Tibetan Tethys sediments thrust on the Lesser Himalayan rocks along the MCT.

## The Tibetan Tethys Himalaya

The north of the Himalayas is comprised of a generally arid region similar to the Tibetan Plateau. This area encompasses the arid valleys of Mustang, Manang, and Dolpa. The Trans-Himalaya is in the rainshadow area and receives significantly less precipitation than the southern region. Some of the glaciers and glacial lakes studied lie within this zone.

The Tibetan Tethys Himalaya rise up to an altitude of 5,000 masl. In this zone, the Tethys sediments of the Paleozoic to the early Cenozoic age are found spread over the area, which is underlain by a vast amount of granite bodies. The sedimentary rocks are highly fossiliferous. The Tibetan Tethys zone is bordered on the north by the Indus-Tsangpo Suture, which stretches along the Indus and Tsangpo rivers. This fault zone, about 40 km wide, signifies the collision trace of the Indian sub-continent with Eurasia. The Thak Khola area in Mustang is considered as the type area in Nepal.

## 2.5 Seismicity

The Himalayan Arc was formed due to the convergence of the Indian plate northwards into the Eurasian plate. Initial convergence between India and Eurasia involved the closing of an ancient sea located between the two land masses. During this stage in the evolution of the Himalayas, the Indus-Tsangpo suture acted as the primary locale of plate interaction and convergence. The sea between the Indian and Eurasian continent had been completely closed between 40 and 50 million years ago. At or shortly following this line, the Indus-Tsangpo suture ceased to be the active plate boundary. Most investigators propose that since the closing of the Indus-Tsangpo suture, the active plate boundary has 'jumped' progressively southward, first to the MCT, and more recently to the MBT.

Rocks between the Indus-Tsangpo suture and the MCT, and the rocks between the MCT and the MBT, represent successive 'slices' of the Indian plate that have been accreted on to the Eurasian plate. During the last 100 years, five great earthquakes have occurred along the Himalayan Arc (Figure 2.3). Inferred rupture length for four of these great events extends 300 km along the strike of the Himalayan Arc. In the case of the 1897 Assam earthquake, the rupture is somewhat longer. Between the 1934 Bihar rupture and the 1905 Kangra rupture, there is a gap where no great earthquake has been reported during the last 100 years.

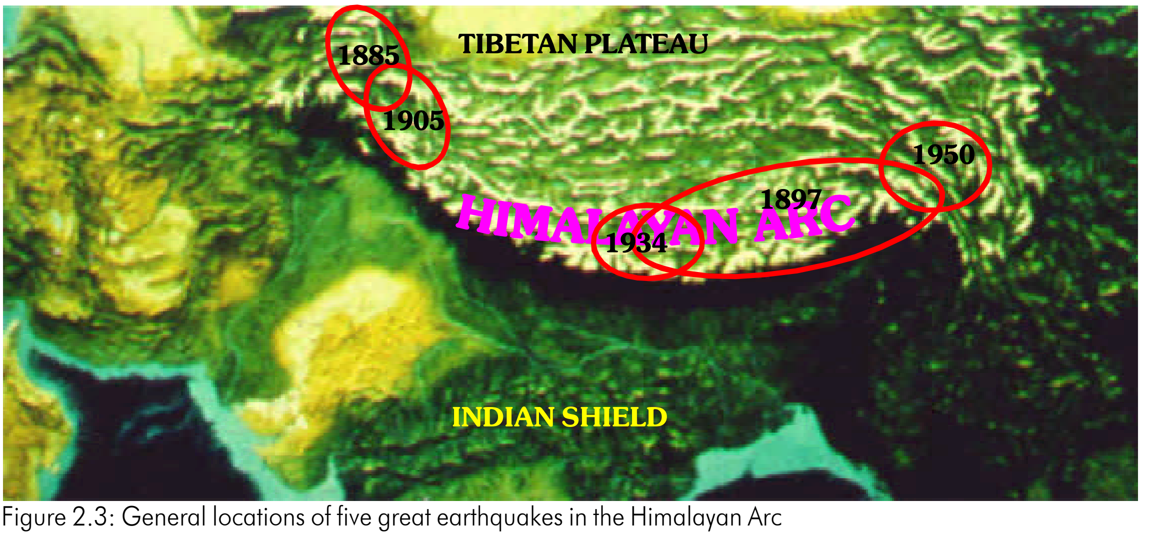


Figure 2.3: General locations of five great earthquakes in the Himalayan Arc

## 2.6 Land Use/Land Cover

The geomorphic divisions are well correlated with the distribution of the geologic formations and structural arrangements along the Himalayan trend. The grouping of similar patterns of landforms has led to the recognition of five land use/land cover divisions in the Himalayas which include the Terai, Siwaliks, Middle Mountains, High Mountains, and High Himalayan regions. The geomorphic cross section in the north–south direction is almost similar throughout the Himalayas.

In general, the land use/land cover category includes cultivated land, non-cultivated land, grassland, forest, shrubland, and other land covering 21, 7, 12, 37, 5, and 18% respectively (Table 2.2). Ice cover occupies 3.6% of the present study area, which is a part of the 'other land' category in Table 2.2.

## 2.7 Economy

Nepal's economy is dominated by agriculture. The majority of the population (81%) depends on agriculture for their livelihood. In the fiscal year 1996/97 (i.e., by the end of the eighth five-year plan) the contribution to the gross domestic product (GDP) from agriculture was 41.7%. The trade and commercial sector contributed 11.2%, the construction sector 10%, and the industrial and social services' sectors 9.7 and 9.1% respectively. The other sectors that contributed significantly are the financial and real estate sector and the transport and communication sector. Their contributions to GDP were 10.1

| Table 2.2: Land-use pattern ('000 ha) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Land use | Cultivated land | Non-cultivated land inclusions | Grass-land | Forested land/forest plantation | Shrubland/degraded forest | Other land | Total |
| High Himalaya | 8 | 1 | 885 | 155 | 67 | 2,234 | 3,350 |
| High Mountains | 244 | 148 | 508 | 1,639 | 176 | 245 | 2,960 |
| Middle Mountains | 1,223 | 667 | 278 | 1,811 | 404 | 59 | 4,442 |
| Siwaliks | 269 | 59 | 16 | 1,438 | 29 | 75 | 1,886 |
| Terai | 1,308 | 123 | 58 | 475 | 30 | 116 | 2,110 |
| | | | | | | | |

and 6.8% respectively. The energy and water sector made a contribution of only 1.5%. The expected GDP growth rate in factor cost during the ninth five-year plan period is 6% from NRs 267 billion to 357 billion with an increase in non-agricultural GDP from 58.3 to 62.1% (see Table 2.3).

Table 2.3: The expected change in sector-wise share of GDP in the plan period from 1996/97 to 2001/02

(in billion NRs)

| Sector | 1996/97 | | Estimated for 2001/02 | | Annual growth rate (%) |
|---|---|---|---|---|---|
| | Product | % | Product | % | |
| Agriculture, irrigation, and forest | 111.2 | 41.7 | 135.2 | 37.9 | 4.0 |
| Industry | 25.9 | 9.7 | 40.1 | 11.2 | 9.1 |
| Electricity, gas, and water | 4.0 | 1.5 | 6.5 | 1.8 | 10.4 |
| Construction | 26.6 | 10.0 | 35.4 | 9.9 | 5.9 |
| Trade, hotel, and restaurant | 30.0 | 11.2 | 42.8 | 12.0 | 7.4 |
| Transport and communication | 18.0 | 6.8 | 27.3 | 7.7 | 8.7 |
| Financial and real estate | 26.9 | 10.1 | 35.6 | 10.0 | 5.8 |
| Social services | 24.4 | 9.1 | 24.2 | 9.6 | 7.0 |
| Total GDP | 267.0 | 100 | 357.0 | 100 | 6.0 |

Source: Ninth five-year plan (NPC 1998)

## 2.8 Natural Resources

### Forest resources

Forests form one of the major natural resources of Nepal. About 37% of the country's area is covered by forest (Forest Development Master Plan 1988), of which 277.28 sq.km comprises national parks, wildlife reserves, conservation areas, hunting reserves, and buffer zones. The forests supply fuelwood to meet about 79% of the energy consumption of the country. Similarly, they provide more than 50% of the fodder for livestock. The raw materials for several industries in the country are based on forest products. Revenue from forest products has been estimated to be NRs 242.8 million for the year 1997/98 (Central Bureau of Statistics [CBS] 1999).

### Mineral resources

The endowment of Nepal in metallic minerals is poor, though both base and precious metal deposits are known. However, Nepal possesses commercially viable non-metallic mineral resources like limestone, dolomite, marble, magnesite, and talc. Exploration activities have also revealed the existence of ruby, sapphire, aquamarine, tourmaline, and quartz. Impure limestone and dolomites of chemically inferior quality but of high strength constitute construction materials. Such construction minerals, including slate, boulder, gravel, sand, and clay, occur extensively. They are produced on different scales to fulfil mainly domestic demand and for export to India. The existence of fuel minerals is also being explored and peat, lignite, and coal are known to occur in different parts of the country. Among the various occurrences, the coal seams identified in Dang Valley and the surrounding area seem to be the most significant, though the reserve is very small. Natural gas associated with groundwater exists in the lake sediment of Kathmandu Valley—exploration proved the presence of 300 million $m^3$ over an area of 26 sq.km. For petroleum, one drill hole was made in eastern Nepal up to a depth of 3,520m and the borehole was recorded dry. At present, activities have been initiated to carry out seismic and geological studies for petroleum exploration in the central part (Chitwan) and western part (Nepalgunj) of the country. The cumulative revenue from various minerals was NRs 909.3 million in the fiscal year 1997/98.

### Hydropower potential

Most of the major rivers of Nepal are fed by glaciers and glacial lakes located at the sources of these rivers. The altitude difference provides huge scope for hydropower development. The theoretical potential estimated for Nepal based on average flow is as follows (Shrestha 1985).

- Overall basin potential surface of flow = 126.4 GW
- Potential concentrated on river courses having a catchment of more than 300 sq.km = 83.3 GW

Altogether 122 sites have been identified so far for development. Of these, 23 projects have been covered by studies at least to the pre-feasibility level. These projects alone are capable of producing about 43,000 GWh of average energy per annum with a total installation of 14.742 GW. Inclusive of all the identified sites, the total generating capacity would be 43.442 GW with an annual energy generation potential of more than 177,000 GWh (Shrestha 1995). However, present installed hydropower capacity is only about 0.370 GW. By the end of the ninth plan period the developed capacity is expected to reach 0.534 GW. This shows the enormous scope for future development.

## 2.9 Population

From figures published in 1999, Nepal's population is estimated to be 22,367,048. The population is growing at 2.3% annually. Over 85% of the population live in rural areas (CBS 1999).

The literacy rate for six years and above is 48%. There are five universities and over 26,000 schools of various levels. Tribhuvan University (the oldest one) has 166 campuses inclusive of private campuses affiliated to it. The total number of students enrolled in education was 4,753,803 in 1996/97.

Public health services are provided by 74 hospitals, 17 health centres, 200 ayurvedic dispensaries and 754 health posts. Sixty-one per cent of the total population has drinking water supply facilities. The infant mortality rate was 7.9% in 1996/97. Average life expectancy is 55.9 years for men and 53.4 years for women.

There are 3,836 post offices. The density of telephone services is one line per 100 people on average. Various parts of the country are connected by 13,223 km of roads including 4,080 km of black-topped. Ropeway and railway facilities are limited to 42 and 51 km respectively. International airways' route coverage is 36,044 km (CBS 1999).

## 2.10 Glaciers

A glacier is a huge flowing ice mass. The flow is an essential property in defining a glacier. Usually a glacier develops under conditions of low temperature caused by the cold climate, which in itself is not sufficient to create a glacier. There are regions in which the amount of the total depositing mass of snow exceeds the total mass of snow melting during a year in both the polar and high mountain regions. A stretch of such an area is defined as an accumulation area. Thus, snow layers are piled up year after year in the accumulation area because of the fact that the annual net mass balance is positive. As a result of the overburden pressure due to their own weight, compression occurs in the deeper snow layers. As a consequence, the density of the snow layers increases whereby snow finally changes to ice below a certain depth. At the critical density of approximately 0.83g $cm^{-3}$, snow becomes impermeable to air. The impermeable snow is called ice. Its density ranges from 0.83 to a pure ice density of 0.917g $cm^{-3}$. Snow has a density range from 0.01g $cm^{-3}$ for fresh snow layers just after snowfall to ice at a density of 0.83g cm$^{-3}$. Perennial snow with high density is called firn. When the thickness of ice exceeds a certain critical depth, the ice mass starts to flow down along the slope by a plastic deformation and slides along the ground driven by its own weight. The lower the altitude, the warmer the climate. Below a critical altitude, the annual mass of deposited snow melts completely. Snow disappears during the hot season and may not accumulate year after year. Such an area in terms of negative annual mass balance is defined as an ablation area. A glacier is divided into two such areas, the accumulation area in the upper apart of the glacier and the ablation area in the lower part. The boundary line between them is defined as the **equilibrium line** where the deposited snow mass is equal to the melting mass in a year. Ice mass in the accumulation area flows down into the ablation area and melts away. Such a dynamic mass circulation system is defined as a glacier.

A glacier sometimes changes in size and shape due to the influence of climatic change. A glacier advances when the climate changes to a cool summer and a heavy snowfall in winter and the monsoon season. As the glacier advances, it expands and the terminus shifts down to a lower altitude. On the contrary, a glacier retreats when the climate changes to a warm summer and less snowfall. As the glacier retreats, it shrinks and the terminus climbs up to a higher altitude. Thus, climatic change results in a glacier shifting to another equilibrium size and shape.

The present study on the glaciers of the Nepal Himalayas divided the area into four major river basins from east to west and revealed 3,252 glaciers with a coverage of 5,323 sq.km in area (Figure 2.4) and an estimated ice reserve of 481 km$^3$. The Koshi River Basin comprises 779 glaciers with an area of 1,409.84 sq.km and has an estimated ice reserve of 152.06 km$^3$. There are altogether 1,025 glaciers in the The Gandaki River Basin which covers an area of 2,030.15 sq.km and has an estimated ice reserve of 191.39 km$^3$. The Karnali River Basin consists of 1,361 glaciers with an area of 1,740.22 sq.km and an estimated ice reserve of 127.72 km$^3$. Only 35% of the Mahakali River Basin, comprising 87 glaciers, lies within the territory of Nepal. The area covered by these glaciers is 143.23 sq.km, and the estimated ice reserve is 10.06 km$^3$.

## 2.11 Glacial Lakes

The study of glacial lakes is very important for the planning and implementation of any water resources development project. Past records show that glacial lakes have produced devastating floods and damage to major constructions and infrastructure.

Prior to the present study, there was hardly any inventory of lakes in the country. All the lakes at elevations higher than 3,500 masl are considered to be glacial lakes by the present study. Some of the lakes are isolated and far behind the ice mass, which may or may not be the glacial origin. The inventory of glacial lakes revealed 2,323 lakes with a coverage of 75 sq.km in Nepal (Figure 2.4). The Koshi River Basin contains 1,062 lakes, the Gandaki River Basin 338 lakes, the Karnali River Basin 907 lakes, and the Mahakali River Basin in Nepalese territory contains 16 lakes.

## 2.12 Glacial Lake Outburst Flood Events

In Nepal, several GLOF events have occurred over the past few decades incurring extensive damage to roads, bridges, trekking trials, villages, as well as incurring loss of human life and other infrastructures (Fushimi et al. 1985; Galey 1985; Vuichard and Zimmerman 1986, 1987; Ives 1986; Water and Energy Commission Secretariat [WECS] 1996).

In Nepal at least 12 GLOF events have been reported to date. The GLOFs have caused extensive damage to major infrastructures. The government has undertaken some mitigation steps to minimise the risk by establishing a telemetric early warning system in Tsho Rolpa and the lower areas that could probably be affected. The open canal constructed to lower the lake level of Tsho Rolpa Glacial Lake has been operating since June 2000.

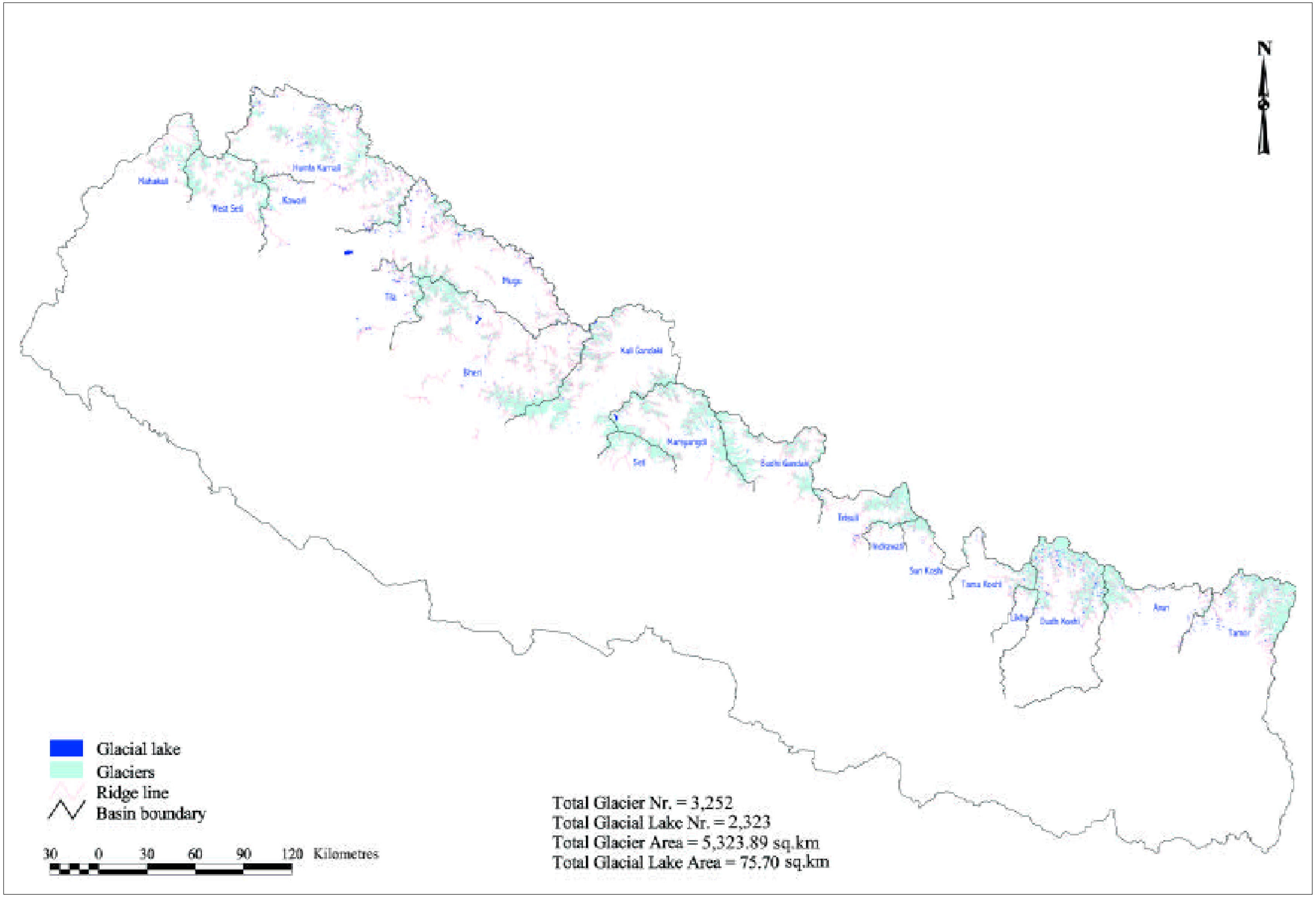


Figure 2.4: Glaciers and glacial lakes of Nepal