CHAPTER II
PHYSICAL LANDSCAPE

1. Physiography of Himalaya:
The Himalaya forms an orographic feature that is located on the southern edge of the Tibetan plateau. It contains the highest mountain peaks on the earth’s surface, including all the 14 peaks over 8 km above the sea level. The Himalayan peaks are arranged in a series of several more or less parallel ranges. These ranges are separated by deep gorges. Based on the general physiographic characters, the Himalaya has been divided into three main divisions which can be longitudinally traced from east to west. These geomorphic divisions are demarcated by major tectonic lines. The three geomorphic divisions are the Higher Himalaya, Lesser Himalaya and the Outer Himalaya (Burrard and Hayden, 1908).

1.1. Higher Himalaya: The Higher Himalaya which is the northernmost division represents the greatest uplift and consists primarily of metamorphic rocks with granite bodies. It comprises of the highest peaks which are arranged as continuous ranges. Its average altitude is over 6000m. The Higher Himalayan ranges are tectonically underlain by the Lesser Himalayan ranges along the Main Central Thrust (MCT). The Higher Himalayan ranges are snowbound all through the year and therefore lack any vegetation. Many glaciers descend from these ranges.

1.2. Lesser Himalaya: The Lesser Himalaya lies to the south of the Higher Himalaya. It is bound by the MCT in the north and the Main Boundary Thrust (MBT) in the south. It consists of a number of more or less parallel belts of mostly unfossiliferous sediments becoming increasingly older towards the north. The Lesser Himalayan ranges form the most rugged and intricate mountain system which is 60-80km wide and 1000-4500m high. The topography is dissected by many rivers which originate either within the Lesser Himalaya or in the Higher Himalaya and beyond. The northern slopes are
usually gentle and covered with dense forest while the southern slopes are steep and less thickly vegetated.

1.3. **Outer Himalaya:** The Outer Himalaya is the southernmost division of the Himalaya. It is comprised of low lying hills, commonly referred to as ‘Foothill Belt’. It forms a more or less continuous belt traceable from the Potwar plateau in Pakistan to Arunachal Pradesh in India. It is bound in the north by the MBT and in the south by the Indo-Gangetic alluvial plains along the Himalayan Frontal Fault (HFF). The Foothills run almost parallel to the Lesser Himalayan ranges. The width of these hills varies from 50 km in Himachal Pradesh to 15 km in Arunachal Pradesh. The altitude varies from 600 to 1500m. A characteristic feature of the Outer Himalaya is the flat floored structural valleys called ‘Duns’. These intermontane basins are tectonic depressions, the southern slopes of which lie steeply against the Indo-Gangetic plains, whereas the northern slopes are comparatively gentler. There are a number of such ‘Duns’, the most prominent being the Dehradun. Dehradun is a crescent shaped intermontane depression over 100 km long and 25 km wide at its maximum. The Ganga in the east and the Yamuna in the west cut through this valley along major transverse faults, i.e. the Ganga tear and the Yamuna tear respectively. The Himalaya has risen as orogenic wedges through three (Wadia, 1964) or five (Krishnan, 1968) orogenic stages punctuated by intervals of quiescence.

The youngest one that has taken place since the Middle Pleistocene decided the final outline of the Himalayan mountain ranges, raising the Siwalik Hills to their present altitudes. The Himalayan orogenic wedges or ranges are arranged parallel to each other. The distribution of these wedges is controlled by the orogenic wedge dynamics which determines the primary distribution of the topographic ridges and valleys within the orogen (Fielding, 2000). During the Pleistocene Period, the Himalaya has also experienced the glaciation in the northwestern part (De Terra, 1939). These glaciers receded in the Higher Himalayan region since the final upheaval took place. The climatic changes that followed the last glacial maxima have indirectly resulted in the formation of a number of geomorphic surfaces along the Himalayan foothills. Thus both, tectonic movements and climatic changes seem to be responsible for the evolution
of landforms in the Himalaya as a whole and the Sub-Himalaya in particular. The uplift of the Himalaya has had several dramatic effects on the topography. Antecedent rivers cut across the ranges, bring about voluminous load of sediments. The major rivers of the Himalaya are antecedent i.e. they predate the rise of the Himalaya. Some of these rivers such as Indus now flow through deep gorges. Another effect of the uplift has been the initiation of monsoon weather system in South Asia that leads to erosion and discharge of tremendous volume of sediment much of which is deposited as fans and fluvial terraces along the foothills.

2. Topography of the study area:

The topography of the Yamuna valley represents mature, rugged, hazardous and moderate to thinly forested slopes. The area is surrounded by high peaks and is endowed with fluvial and fluvio-glacial landforms, deep gorges and perennial streams with turbulent flow. Landslides are one of the major characteristic features within the study area.

The altitude in the study area ranges from minimum of 400m to maximum of 2920m. The highest peak in the study area is at Bahak near Muralto Dhar. Yamuna valley flows from north east to south west and divides the study area in two parts. From north to south the upper reaches of Yamuna valley flows through Lesser Himalaya while lower reaches incorporates Outer Himalaya composed of Lower, Middle and Upper Siwalik group of rocks. Different geomorphological features are observed and classified along the Yamuna Valley. The water divides in the Lesser Himalaya is running almost parallel to one another.

The slopes in the upper reaches of Yamuna River are either very steep or vertical and gentle in lower reaches. Slopes are often landslide prone involving small to large rock volume. The probable reasons of landslides are undercutting of slopes, fragile rocks, frequent shaking of lands due to earthquake or tectonic movements. Frequency of landslides is distinctly more around fault zones.

Yamuna River is draining the terrain with its emerald water and snowy droplets. Numerous large and small tributaries join themselves at right angle to Yamuna. Right angle junction points out the structural control. Notable powerful tributaries enriching
the water wealth of Yamuna are Kamola Nadi, Rikhnar Gad, Sarna Gad, Seli Gad, Bin Gad, Amlawa Nadi, Tons River, Giri River, Asan River, Naro & Bin Nadi, Aglar River, Bhadri Gad, Sari Gad, Barni Gad, Bada Gad etc. These tributaries sustain the perennial turbulent flow of Yamuna. These rivers draw their water from melting of snow, rain, springs and seepages.

3. Major rivers and tributaries:

The 1380 km long broadly NE-SW flowing Yamuna river originates from Saptarishi kund (lake) near Yamunotri situated at a height of 2400 m in the Central Himalaya of Uttarakhand. From Barkot to Paonta the Yamuna river flows 105 km through Uttarkashi Tehri, Dehradun district of Uttarakhand and Sirmaur district of Himachal Pradesh. It traverses through the Lesser Himalaya (71 km) and Outer Himalaya (34 km). The study area can be divided in to two parts, streams north east to Yamuna and north west to Yamuna.

3.1 Giri river: The river Giri is an important tributary of the Yamuna river. It drains a part of South-Eastern Himachal Pradesh. The Giri or Giriganga as it is famous in the Jubbal, Rohru hills that rises from Kupar peak just above Jubbal town after flowing through the heart of Shimla hills, flows down in the South-Eastern direction and divides the Sirmaur district into equal parts that are known as Cis-Giri and Trans-Giri region and joins Yamuna upstream of Paonta below Mokkampur. The river Ashni joins Giri near Sadhupul (Chail) while river Jalal which originates from Dharthi ranges adjoining Pachhad joins it at Dadahu from the right side

3.2 Tons river: This river is an important tributary of the Yamuna river and joins it at Kalsi in the North-Western part of Dehradun valley (approximately 48 km. away from Dehradun). It rises as the following two feeder streams - the Supin river rises from in the Northern part of the Tons catchment near the Himachal Pradesh and Uttarakhand border and the Rupin river rises from a glacier at the head of the famous Har-Ki-Dun valley in the North-North Eastern part of the Tons catchment. These two feeder streams merge near the mountain hamlet of Naitwar and the channel downstream of Naitwar is
known as Tons river. The river flows along a V shaped valley. A number of settlements have come up along the Tons river such as Tuni, Naitwar and Menus.

3.3 Asan river: The Asan river originates from Nalota nala at Robert’s Cave in Dehradun and flows in western direction to meet Yamuna at right angle. The river Asan is fed by seasonal Lesser Himalayan rivers in the north and Siwalik rivers in the south.

4. Soil:
In mountaneous regions one of the most precious natural resources, basic essential to life support system, is the soil. The soil, if skillfully managed and utilized, will provide food, fuel, timber, etc. indefinitely. The surface of the soil varies considerably from place to place because of the changes in the parent rocks, altitude, slope, aspect and vegetation (Ghildiyal, 1981). In the area under investigation the geomorphic processes are conspicuously responsible for the varied type of weathering of rocks under humid conditions resulting in the formation of diversified soils.

Soil is the natural body of mineral ad organic constituents, differentiated into horizons, which differ among themselves as well as from the underlying material in morphology, physical makeup, chemical composition and biological characteristics. Soil is the result of soil forming processes, representing an intricate exchange of radiant energy and matter, a complex of prolonged interactions between lithosphere, biosphere and the environment including topography, parental material, climatic and geographical situation (space and time). The soil functions are (1) to act as physical support to vegetation, (2) serve as a medium for sorting water to be used by roots of plants and (3) to supply a small but an essential percentage of the materials which are converted into plant food by photosynthesis.

Sporadic information and account of soils of the lower and accessible areas have been invogue till early eighties. Kaushik (1961) drawing samples from the altitude between 1000 and 2500 m has studied the acidic soils of Garhwal hills in his attempt to form pedo-ecological zones of Garhwal.
Tectonically soil formation processes like sericitization and chloritization are stimulated by thrusting, faulting and crumpling movements under humid conditions of the valley (Saxena, 1987).

In the soil formation, parent material usually plays a significant role. Regolith is converted in to soil by weathering and other associated processes (Anantharaman, Saxena and Pandey, 1982). In the region due to steep slopes and plenty of rainfall correlation between soil and parent rock is very difficult. Majority of the soils are diluvial in nature. Most of agricultural soils usually lose their top horizon ‘A’ mainly due to erosion and construction of terraces.
4.1. Geological Structure of Soils:

Geologically, the soils of the area are composed of heterogeneous and unconsolidated alluvial deposits in various geological belts (Fig 2.1) as given below:

4.1.1. Valley belt soil: This zone comprises of soils occurring in the area, which is along the Yamuna, Giri, Tons, Aglar and Kamola valleys. All along the valleys slope is very gentle and is characterised by the occurrence of a large number of river terraces.

Soil is very deep and fairly rich in organic matter content. Along river beds, the soil tends to be sandy and poor in clay. Due to fluvial action, soils from the Himalayan as well as Siwalik belt have been brought out to lie over the valley belt soils in the form of piedmont plains. Soils of the Himalayan belt have been very strongly leached and produce piedmont plains which are rich in acidic soils. On the other hand, soil cover over the piedmont plains brought down from the Siwalik belt, are relatively less acidic in nature.

This zone is very widely cultivated, which further testifies to the richness of the soil cover.

4.1.2. The boulder belt: This belt included the Dun gravels of great thickness belonging to Pleistocene and Holocene periods and is generally a sandy loam and poor with varying proportion of clay.

4.1.3. The Siwalik belt: The belt is made up of Tertiary conglomerates, sandstones, shales and clay which are often very soft and friable.

Petrologically the parent rocks of the soil in the area consist of quartzites, shales, slates, conglomerates, thick purple semi-nodular clay and sandstones.

4.1.4. The Lesser Himalayan belt: This belt consists of pebbles, sandstones, silts, micaceous clay derived from quartzites, phyllites, limestones etc.

5. Climate:

There is great diversification in the climatic conditions of the study area due to variation in elevation (400-2920mtrs). It varies from hot and sub-humid tropical (450-900mtrs) in
the southern Low tracts, warm and temperate (900-1800mtrs), cool and temperate (1900-2400mtrs) and cold alpine and glacial (>2400mtrs) in the northern and eastern high mountain ranges. The Siwalik zone is very warm during the summer days and relatively cooler during night. By October, nights and mornings are very cold. The main season is the spring from mid-Feb to March-April. Most of the precipitation is received in the form of monsoon rains. Rains in the winter season are received during December – January and sometimes even February, but these are erratic and uncertain. Monsoon generally sets in during the last week of June or early July and may continue up to September. The heavy rains in July and August cause damage to erosion, floods and landslides. Pre-monsoon showers are received in April or early May. May and June are the driest and warmest months. The average rainfall in Paonta area is 2093 (In 2005). Frost is a common feature in the valley. It is particularly severe during the long and cold winters, causing extensive damage to forests and agriculture.

6. Vegetation:

The Forests of Uttarakhand and Himachal Pradesh known for their grandeur and majesty are like a green pearl in the Himalayan crown. The diversity of altitude and climate has given a rich variety of flora covering nearly two third of the area of the state. Forests form an important source of income, providing raw material for industries, fodder and nutritious grasses for livestock and resource to meet the needs of agriculturalists and other people. The life supporting systems are presently under great stress due to impact of modern civilization, economic development and growth in human and cattle population. According to national Forest Policy, 1988, at least two third i.e. 66% of the geographical area should be under forest in the hilly states. The forests have been classified on an ecological basis can be broadly classified into Coniferous Forests and Broad-leaved Forests. Distribution of various species follows fairly regular altitudinal stratification. The vegetation varies from Dry Scrub Forests at lower altitudes to Alpine Pastures at higher altitudes. In between these two extremes, distinct vegetational zones of Mixed Deciduous Forests, Bamboo, Banj, Chir, Oaks, Deodar, Kail, Fir and Spruce, are found. The factors governing the type, distribution
and extent of vegetation in the area are relief, soils, climate and underground water conditions.

6.1. Forest types in the study area

i. Moist Tropical Forests:

ii. Dry Tropical Forests:

iii. Montane Sub-Tropical Forests.


v. Sub-Alpine Forests.

Apart from the above climatic division, the forest covers are generally divided into Protected Forest (P.F.) reserved Forest (R.F.), Unclassified Forests (U.F.) and Others (Cantonments and municipal forests). The P.F.’s were further classified into two classes i.e. Un-demarcated Protected Forests (U.P.F) and Demarcated Protected Forests (D.P.F).

The important plants of the study area are: Pinus wallichiana (Kail), Pinus roxburghii, Shorea robusta (Sal), Q. d/ata (Mohra), Euphorbia roy/Dana, Casia fistula, Ficus sp. (Gular), lramia nudif/ora (Guntal), Acacia catchu (Khair), Delonex regia, Eula/ispsia binata (Bhaber), Sprengchisy (Gorla), Dendrocalamus spp. (Eucalyptus), Erianthus sp. (Munj), Sacharum apontanum Linn. (Kans), Indigifera, Agava sislena, Carissa, Lantana camera” Frogaria indica (strawberry), Stremisia vul/garia (Kunj), Hadera nepa/ensia, (Eucalyptus), Cedrus deodara (Deodar), Quercus sp. (Oak), Abies pindrow (Fir), Picea smithiana (Spruce). The alpine region is mainly covered with grass.

Another little known fact about the Yamuna is that it is the frontier of the Indian elephant. West of the Yamuna, there is no elephant in 900 Km of the western Himalaya or its foothills. The forests of the lower Yamuna offered ideal corridors for elephant movement.