CHAPTER 2 STUDY SITES

A watershed is a natural hydrological entity, defined as the drainage basin or catchment area of a particular stream or river. Simply put, it refers to the area from where the water to a particular drainage system, like a river or stream, comes from. According to Integrated Mission for Sustainable development (IMSD 1995) guidelines, watershed is further classified into sub-watershed (± 30 - 50 km$^2$), mini-watershed (± 10 - 30 km$^2$) and micro watershed (± 5 - 10 km$^2$) (Vittal et al. 2004). Present study was carried in two sub-watershed areas of Shiwalik and middle Himalayas.

2.1: PHAKOT WATERSHED AREA

2.1.1: Topography

Phakot Watershed Area (PWA) is part of Phakot beat of Saklana range of Garhwal Himalayas. It lies between 78° 19' 53" to 78° 22' 16" East and 30° 14' 29" to 30° 13' 17" North in the lower and middle Himalayas. It is approximately 35 kilometers from Rishikesh town on either side of National Highway 94 in the Tehri district of Uttaranchal now Uttarakhand state. The study area is spread over 20 km$^2$. Mountain stream Hemal forms the eastern boundary of the study area. Watershed is the catchment area of this stream. The area is mountainous in nature and general elevation varies from 600 meters to 2000 meters.

2.1.2: Rainfall and temperature

There are three distinct seasons. Summer starts in mid march and lasts till June. The average temperature varies from 25 to 35° centigrade. Monsoon comes earlier than other north Indian towns. Starting from early June, there is heavy down pour. Monsoon lasts till the end of September. The days usually remain cool and foggy. Winter in Phakot is less
harsh than expected, mainly contributed by its geographic position. The nights are cold but days are comparatively warm. There is however, no snowfall in the area.

2.1.3: Agriculture

The people are primarily agriculturist. Ginger is the main crop grown and forms major cash crop of this watershed. Water is the limiting factor for the agricultural activities in the area. Villagers face a water deficit of up to 60% of their daily needs. Pea and pulses are also grown in the higher altitudes. Rice, wheat and Barley are grown in the lower areas were there is availability of water.

Apart from agriculture, people generally work as labors. Many young men are involved in service industry in the plains. All the villages are deficient in their food requirement, with villages like Agar and Bhaitan lead in deficiency more than 1000 quintals/annum.

2.1.4: Dependency on forest

Phakot Watershed is protected as a reserve forest however, part of it comes under civil land. The villages are deficient in their fodder requirements. This results into various human activities in the area and anthropogenic pressures on the natural resources. The local people depend on forests for fodder, fuel and minor forest products. Oak (Quercus spp) trees are usually lopped for fodder. This has led to the stunned growth of oak trees in and around the villages. During summer people also harvest berry of Myrica kaffal. The bark of Grewia oppositiflia (Bhimal) is used to make ropes. People also do mining and quarry for construction purposes.
2.1.5: Flora

Vegetation in Phakot is the characteristic of altitude. Five different forest types can be identified. In general, it is represented by dry deciduous forest with forest cover (40-70%) present in one-fifth of the watershed.

**Oak forest:** It is present above 1200m and dominated by *Quercus leucotrichophora* followed by *Rhododendron arboreum* and *Myrica sapida*. The trees around the villages are dwarf as a result of excessive lopping. However, beyond ‘kalban’, tree height and cover increases many fold and represents a healthy patch of oak forest. *Colebrookia oppositifolia* is the most dominating shrub.

**Sal forest:** On the lower elevations especially below Agar village is present sal forest. It is dominated by *Shorea robusta* and to an extant by *Anogeissus latifolia*. *Murraya koenigii* and *Lantana camara* and *Colebrookia oppositifolia* are the most widespread shrub species here.

**Anogeissus or mixed Bakli forest:** Below Phakot and Tachala is present forest dominated by *Anogeissus latifolia* and *Bauhinia semla*. It shows its significant presence upto 1000m. *Lantana camara* and *Murraya koenigii* is the dominant shrub in the forest.

**Mixed broadleaf or Miscellaneous forest:** Interspersed with different types of trees and shrubs, miscellaneous forest occupies the 1000 to 1500 m altitude. The forest is dominated by *Bauhinia semla* followed by *Quercus leucotrichophora*. *Eupatorium adenophorum* and *Rhus parviflora* are the dominant shrubs.
**Pine forest**: Though not part of the sub watershed but present in the vicinity and was included due to its significant impact on the fauna of sub watershed. It is dominated by *Pinus roxburghii* and followed by *Adina cordifolia*. *Indigofera heterantha* was the dominating shrubs.

**Fallow land**: Result of forest clearing in the past, these lands might have been used for agriculture. Traditionally, these lands are kept uncultivated to allow wild grass to grow for fodder. It has sparse tree population of *Quercus leucotrichophora* and *Mallotus philipinensis*. *Chyropogan fulvus* being the most widespread grass in the fallow lands.

### 2.1.6: Fauna

Despite being interspersed by human habitations, there are many species of mammals, birds and herpetofauna, Significant being muntjac, goral, black bear and leopard. There are also more than 100 species of birds.

### 2.2: PATHRI RAO WATERSHED AREA

#### 2.2.1: Location

Pathri Rao watershed (PRWA) is located between 77° 57' 7" to 78° 23' 36" East and 29° 51' 7" to 30° 15' 50" North in the district of Haridwar, covering an area of 51.00 ha. The Watershed is named after Pathri Rao, a seasonal river, originating from Shiwalik foothills and flowing towards south-west direction. The area is hilly towards north-east and almost plain in the south-western part.

Half of the study area falls on the south-east of Rajaji National Park. The area lies between Ranipur and Beri Bara ranges and is comprised of three beats i.e. Chirak East (1069 ha),
Chirak West (526 ha) and Hamul (706 ha). Two hill streams or ‘Rao’ namely Chirak Rao and Hamul Rao which receive the water from many small mountain streams pass respectively through the Chirak West and Hamul beats. These two streams meet at the boundary of the protected area forming a larger stream called Pathri Rao. The rest of the area is mosaic of agricultural land under different crops, plantations, villages and wasteland.

2.2.2: Topography

The topography of the study area, mainly consisted of the shivalik hills and alluvial deposits. The slopes of the shivalik hills are largely steep forming ‘V’ shaped valleys (Khan 2004). The area is subjected to heavy erosion because the hills and plains are mainly composed of the sandstone and sandrocks, due to which there is a rapid and fast runoff during heavy rains. During heavy rains, landslides are very common in this area. The bottom of the streams, rivulets and valleys consist mainly of large and small-sized rounded stones and pebbles which is used as shelter by many wild animals such as reptiles and amphibians. Pathri Rao (stream) that passes through this area is full of sand but completely devoid of any type of stones and pebbles. The formation occurring to the south of Shiwalik hills are alluvial fan deposits of recent age. Pathri Rao is also comprised of two hydrogeo-morphological units i.e. shivalik and upper piedmont or bhabbar zone.

2.2.3: Soil and water table

The hills and sub-montane areas have sandy loam and dry soil, in the moist areas the soil is covered by humus and is loamy. The soil of the outside part is completely sandy and dry. The water table in the area is deep and varies from 9 – 30 mbgl in pre-monsoon period to 8.68 - 28.50 mbgl during post monsoon. In general, water table depth increases
as we move towards shivaliks. The deficiency in water has influenced the agricultural and social life of people on the area.

2.2.4: Rainfall and temperature

There is an extreme variation in climate of the study area, giving rise to three different seasons namely winter, summer and monsoon. Winter commences from mid November and lasts till March. Nights are cold and mornings are foggy reducing the visibility. Summers are very hot with temperature going above 40 degrees. It starts by mid of March and lasts till the onset of monsoon in July. During summer there is occasional short duration sand and dust storms accompanied by rain or sometimes hail. Onset of monsoon varies but usually July witnesses the first shower and rains last till October. People do many activities for living. Most of them are labourers, working in the nearby factors and newly established industrial estate in the Roshanabad area. About 25 to 30% of the population is cultivator.

2.2.5: Agriculture

Farmers grow varied crops including maize, sorghum, pear millet, foxtail millet, rice, ground nut and dhaincha. Sugar cane and tomato are also grown. These crops are grown either as sole crops or intercropped in different combinations.

All the villages are deficit in food requirements and this deficiency varies from 1000 to 15000 quintals per annum, similarly villagers are also deficit in fodder requirements measuring upto 500 -700 quintals per annum. About 20 – 40% of the population is dependent on the forests especially Rajaji National Park for daily fuel wood needs.
Villages like Aneki and Hitampur are almost 50% dependent on the forest for their requirements, putting pressure on the natural forest.

2.2.6: Flora

The watershed represents mixed dry deciduous vegetation which shows variation with altitude and topography.

**Dry deciduous forest (L):** With forest cover up to 40%, this forest type is most diverse and rich both with respect to trees and shrubs. *Anogeissus latifolia* is the dominant tree species followed by *Acacia catechu* and *Shorea robusta*. It also has few patches of dry *Dalbergia sisso* Among shrubs *Lantana camara*, *Leea* spp are most dominant. Restricted to the plain and low hills within National Park, it covers approximately an area of 700 ha. *Cassia tora*, *Parthenium sp* and *Cynodon dactylon* are some of the dominant herbs and grass in the habitat.

**Dry deciduous forest (M):** This forest type covers one-fourth of total areas. It is present throughout the National Park area of watershed. With forest cover density of 40 to 70%, it is represented with *Terminalia tomentosa*, *Adina cordifolia*. Suwali is the most dominant shrub followed by *Lantana camara*.

**Dry deciduous forest (D):** Present in hills and higher elevations, it is dense and has forest cover density of more than 70%. Present in patches, it is dominated by *Anogeissus latifolia*. *Iscoemum angustofolium* is the most dominant grass.
Plantation: In the private lands people have grown different plantation including *Mangifera indica*, *Populus sp.*, *Eucalyptus sp.* and *Bombax cieba*. These plantations are grown for certain period of time and then cut. *Lantana camara* and Datura is the most dominant shrubs in these plantations.

2.2.7: Fauna

Being part of the Rajaji National Park, this watershed holds quite a good diversity of mammals, birds and other herpetofauna. It includes tiger, elephant and many ungulates. The area holds about 100 bird species and reptiles like king cobra, python and common Krait.
Chapter 2 Study Area

Pathri Rao Watershed Area (PRWA)  Phakot Watershed Area (PWA)