Chapter 2. Study area: Nanda Devi Biosphere Reserve

SUMMARY
The study has been conducted in Nanda Devi Biosphere Reserve (NDBR). NDBR (30° 05’-31° 02’N Latitude, 79° 12’-80° 19’E Longitude), located in the state of Uttarakhand, India, falls in the biogeographically classified zone, 2B. The reserve is spread over Chamoli district in Garhwal region and Bageshwar and Pithoragarh districts in Kumaun region of the Uttarakhand State. The NDBR with an area of 6020.43 km² is comprised of two core zones i.e. Nanda Devi National Park, 630 km²; Valley of Flowers National Park, 87.5 km²; surrounded by a buffer and a transition zones. Both the core zones have been recognized as World Heritage Site by UNESCO. Being in the inner Himalayan region it has a microclimatic condition. Vast altitudinal variation (1800-7817m asl) has given rise to a variety of climates ranging from temperate, sub-alpine and alpine. The climate is temperate and monsoonal and can be divided into long winter, short summer and rainy seasons. Conditions are generally dry with low annual precipitation, but there is heavy rainfall from late June to August. Geologically, the area falls within the Greater Himalaya or Himadri System. A small part of Niti valley has characteristics of trans-Himalaya. Natural forested areas, alpine and temperate grasslands, water bodies (river, small streams and high altitude glacial lakes), snow and glacier area, natural landslide and rocky and barren areas fall under the categories of natural LULCs found in NDBR. Settlements (small townships and villages), agricultural land (terrace farms), orchards, plantation and developmental areas are human modified landscapes. Most of the flora and fauna in the NDBR is native and endemic. Forest types of NDBR can be divided into six categories: Subtropical pine, Himalayan moist temperate, Subalpine, Moist alpine scrub and Dry alpine scrub.

Human habitations are absent inside the core zones but there are 47 villages in the buffer zone and 33 villages in the transition zone with six villages in the immediate buffer of the core zones. Bhotia (Indo-Mongoloid) and Garhwali (Indo-Aryan) are the main communities in the area. Bhotia people are mainly dependent on handicraft and tourism while agriculture and cattle and goat rearing are the main occupation for the Garhwali communities. Communities of NDBR are culturally and economically dependent on natural resources. Human-wildlife conflict is a major
issue in management of the natural resources of the area. The area hosts a large number of religious and recreational tourists per year, which provide alternative livelihood to the people but also impact the quality of the natural ecosystem.

2.1. Introduction

The Himalayan ecosystems form the baseline for the overall well-being of human communities (Byers, 2005; Kaur et al., 2012) and provide regulating, provisioning, supporting and cultural services necessary for sustenance of life forms on earth (Negi and Agrawal, 2006). These services are very crucial for the survival of the local and downstream communities. 3.8% of India’s population inhabits the Indian Himalayas. The region is low in human density (mean=123.7 persons/km², as against 273.0 persons/km² for the rest of India), underdeveloped (mean Center for Monitoring of Indian Economy Index of development being 82.0 as against 100 for India), as compared to the rest of India (Government of India, 2010). Rain fed marginal agricultural is the most important occupation (Chauhan, 2010) hence dependence on natural resources is very high. The region is characterized by harsh, undulating terrain, small isolated villages, an agro-pastoral economy, small land holdings, dominance of dry farming and less area covered by irrigation. Himalayan glaciers are the origin of major rivers of North India, serving local and downstream communities. However, the capacity of Himalaya to provide many life supporting services has been degraded due to high resource use, rapid development and construction and uncontrolled higher visitations by tourists (Byers, 2005; Shrestha et al., 2012).

Nanda Devi Biosphere Reserve (NDBR) is one of the great wilderness areas of the western Indian Himalaya. NDBR (30° 05’-31° 02’N Latitude, 79° 12’-80° 19’E Longitude), located in the state of Uttarakhand, India, falls in the biogeographically classified zone, 2B (Rodgers et al., 2000). The reserve is spread over Chamoli district in Garhwal region and Bageshwar and Pithoragarh districts in Kumaun region of the Uttarakhand State. The NDBR with an area of 6020.43 km² is comprised of two core zones i.e. Nanda Devi National Park (NDNP), 630 km²; Valley of Flowers National Park (VoF), 87.5 km²; surrounded by a buffer and a transition zones. Altitude varies within the range of 1800-7817 m asl. This wide geographical variation has added to the biological diversity of the Biosphere Reserve. The basin is dominated by Nanda Devi, a natural monument and India’s second highest peak (7817 m) (Maikhuri et al., 2001) (Figure 2.1). The diverse ecosystems of NDBR provide food, fuel, and fresh
water which are needed for human well-being (Silori and Badola, 2000; Bosak, 2008). However anthropogenic factors including unsustainable resource use (Silori, 2007), unplanned development activities such as over constructions of roads, residential buildings, hotels and hydroelectric power projects (Dangwal et al., 2011) and leakage in the tourism revenue have put natural resources under tremendous pressure. Transformation of local economy to market based economy has resulted in loss of forest and agricultural biodiversity (Plate 1).

2.2. Conservation status
The Nanda Devi basin was declared as Nanda Devi Sanctuary in 1939 (Green, 1993), later in 1982 the 630.33 km$^2$ area was declared as Nanda Devi National Park. In 1988, the area got the status of Biosphere Reserve (Bosak, 2008), with the Nanda Devi National Park as its core zone and an additional buffer zone of 1612 km$^2$. On February 7th, 2000 the Govt. of India extended the total area of NDBR from 2236.74 km$^2$ to present area 5881 km$^2$, by adding the Valley of Flower National park as the second core zone. Additionally these two cores areas, NDNP and VOF were declared as a World Heritage Sites, in 1998 and 2005, respectively (Bosak, 2008). NDBR comprises of 12 beats i.e. Benakuli, Bhyundar, Pandukeshwar, Aira, Urgam, Malari, Dunagiri, Reni, Tapovan, Barhgaon, Joshimath, Salur). These beats are further divided into 11 blocks (Kosa, Kurkuti, Malari, Joshimath, Dasholi-VI, Dasholi-VII, Dronagiri-I, Dronagiri-II, Talla painkhanda, Malla painkhanda and Urgam. These blocks are further divided into 60 compartments (Uttarakhand Forest Department Joshimath Records).

2.3. Administrative zones:
The different types of administrative areas identified within the boundary of the biosphere reserve are as under:
(a) Core zone: This area includes Nanda Devi National Park (630.33 km$^2$) and Valley of Flower National Park (87.50 km$^2$).
(b) Buffer zone: This area includes biosphere reserve excluding the area of the core zone. This also includes the areas of multiple use zones.
(c) Multiple use zone: The area of the Buffer zone extends on the south east (up to Nanda Ghunti), north- west (from Nanda Ghunti to village Peng), about five kilometer wide strip (including village Garpag) along Dhauliganga river from village Peng to
Malari, and east about four and a half kilometer wide strip along Goriganga from Samdu to Tota Shilling.

Figure 2.1. Map showing locations of National Parks within NDBR, transition zone and International boundary

2.4. Environmental attributes

2.4.1 Climate

Nanda Devi Basin enjoys the distinctive microclimate, being an inner Himalayan Valley. Vast altitudinal variation (1800-7817m asl) has given rise to a variety of climates ranging from temperate, sub-alpine and alpine. The climate is temperate and monsoonal and can be divided into long winter, short summer and rainy seasons (Purohit et al., 2001). Conditions are generally dry with low annual precipitation, but area receives and heavy rainfall from late June to August (Green, 1993). Most of the area remains snow bound for more than six months in a year. The higher reaches (4500 m asl) remain snow bound throughout the year (Khacher, 1978). Summers are very short starting from mid-May till late August. The temperature in the area vary between -2.3°C to 31.7°C, humidity ranges between 18-88% and average rainfall is 550 mm per year. The area experiences three main seasons i.e. (1) Winter - from
November to March, with heavy snowfall in the months of December, January and February, (2) Summer - from April to mid June and (3) Rainy season - from mid June to September (Gaur, 1999). The region has been divided into five climatic zones by Kaushik et al. (1962) (Table 2.1).

Table 2.1. Climatic zones of Nanda Devi Biosphere Reserve

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Climatic Zones (Altitude in m asl)</th>
<th>Temperature in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rainy</td>
</tr>
<tr>
<td>1</td>
<td>Sub tropical</td>
<td>18.9-21.1</td>
</tr>
<tr>
<td>2</td>
<td>Warm temperate (1800-2400)</td>
<td>13.9-18.9</td>
</tr>
<tr>
<td>3</td>
<td>Cool temperate (1800-2400)</td>
<td>10.3-13.9</td>
</tr>
<tr>
<td>4</td>
<td>Cold zone (2400-3000)</td>
<td>4.4-10.3</td>
</tr>
<tr>
<td>5</td>
<td>Alpine zone (3000-4200)</td>
<td>3.9-4.5</td>
</tr>
<tr>
<td>6</td>
<td>Glacial zone (above 4200)</td>
<td>-</td>
</tr>
</tbody>
</table>

2.4.2. Geology and edaphic characteristics

Geologically, the area falls within the Greater Himalaya or Himadri System. A small part of Niti valley has characteristics of trans-Himalaya. The crystalline rocks found in the Rishi Ganga basin are sub-divided into four formations i.e., Lata, Ramni, Kharapatal and Martoli. The rock type includes Mica Schist, Mica Quartzite and Schist etc. The soil is mainly black, gray and brown in color. In the higher elevation it is skeleton type. The pH of the soil varies from 4.2 to 6.4 and moisture content oscillates between 21-65% (NDBR, 2002). Region is the head water of several rivers and streams such as Gori Ganga, Rishi Ganga, Dhauli Ganga and Girthi Ganga which are the tributaries of Alaknanda River which later meets Bhagirathi at Devprayag. Pindari and Milam are the most important glaciers of the region.

2.4.3. Land use and land class categories

Area of NDBR can be divided into natural and human modified land use land cover classes (LU/LC). Natural forested areas, alpine and temperate grasslands, water bodies (river, small streams and high altitude glacial lakes), snow and glacier area, natural landslide and rocky and barren areas fall under the categories of natural
LULCs found in NDBR. Settlements (small townships and villages), agricultural land (terrace farms), orchards, plantation and developmental areas are human modified landscapes. About 85% area of the Biosphere Reserve falls under snow and glacier and barren rocky categories. In vegetation classes alpine grasslands occupy the largest area. To support a large volume of tourist every year many governmental and privately owned hotels, inns and guest houses have been built up. In last few years many developmental activities have taken place in the area e.g. hydroelectric dams, new roads to remote villages of area. Conversion between LULCs has also been reported in the Reserve. Agricultural land is being abandoned as new non-farm opportunities are available to the people. Alpine grasslands were converted to summer settlements and agricultural land long back but no such conversion is taking place at present. Land holding division or fragmentation is taking place due to increase in population. People are now growing more cash crops (potato and cabbage) than the traditional grains and millets (Ragi, Fafar, Ogal, Foxtail millet etc.), which has changed locally self sufficient economy to market dependent economy. For the present study a land use land cover map of NDBR was generated using LISS IV imagery National Remote Sensing Centre (Fig. 2.2) (Plate 2).

2.4.4. Forest types

The wide altitudinal range, soil, climatic and microclimatic conditions found in the area has naturally produced highly diverse floral and faunal classes. Most of the flora and fauna in the NDBR is native and endemic (Tak and Kumar, 1983). According to classification given by Champion and Seth (1968) forest types of NDBR can be divided into six categories: Subtropical pine, Himalayan moist temperate, Subalpine, Moist alpine scrub and Dry alpine scrub (Fig. 2.2).
Flora

The biosphere enjoys a very distinctive climate, which helps in harboring a rich floral and faunal diversity. The reserve supports over 1,000 species of plants including bryophytes, fungi and lichens (Uniyal, 2004). The vegetation mainly comprises of temperate, sub alpine and alpine types. The alpine meadow of NDBR supports a wide variety of flowering plants such as Potentilla spp, Geranium spp, Androsace spp, Primula spp, Cyananthus spp, Gentiana spp, and Morina spp etc. (Samant, 1993; Samant and Joshi, 2005). The NDNP has about fifteen rare and endangered plant species viz. Aconitum spp, Circeaster agrestis, Epipogium aphyllum, Listera spp, Meconopsis aculeata, Nardostachys grandiflora, Orchis latifolia, Podophyllum hexandrum, Saussurea obvallata and Taxus baccata (Hazra and Jain, 1983; Samant et al., 1996).

From NDNP a total of 490 species belonging to 281 genera and 89 families of Angiosperms (480 species, 274 genera and 85 families) and Gymnosperms (10 species, 7 genera and 4 families) have been recorded. Of these, 357 species were
herbs, 103 shrubs and 30 trees (Samant and Joshi, 2005). From VoF, 520 species of vascular plants belong to 72 families and 248 genera were recorded. Of 520 species, 498 belong to angiosperms or flowering plants (61 families and 234 genera), 18 Pteridophytes and 4 Gymnosperms. The VoF harbours 472 species of herbs, 41 species of shrubs and 8 species of trees (Kala, 2005).

2.4.6. Fauna
About 520 species of fauna including mammals, birds, reptiles, amphibians, fishes, insects, molluses and annelids have been recorded from the area (Arora et al., 1995). Nearly 200 avifaunal species have been reported for the reserve (Sankaran, 1994). The important mammals are Snow leopard (*Panthera uncia*), Asiatic black bear (*Ursus thibetanus*), Himalayan brown bear (*Ursus arctos*), Himalayan musk deer (*Moschus chrysogaster*), Bharal (*Pseudois nayaur*), Himalayan tahr (*Hemitragus jemlahicus*) (Kandari, 1981). The area of the reserve lies within the Western Himalayas Endemic Bird Area. Many of the birds species found in the area move down to lower altitudes in the lower Himalayas and foothill while a few migrate down even to the northern plains and peninsular India in the winters. Abundant species recorded include Crested black tit (*Parus melanolophus*), Yellow-bellied fantail flycatcher (*Rhipidura hypoxantha*), Orange flanked bush robin (*Erithacus cyanurus*), Blue-fronted redstart (*Phoenicurus frontalis*), Indian tree pipit (*Anthus hodgsoni*), Rosy pipit (*A. roseatus*), Common rosefinch (*Carpodacus erythrinus*) and Nutcracker (*Nucifraga caryocatactes*) (Sankaran, 1994).

2.5. Socio-economic attributes
2.5.1 Communities of NDBR
NDBR is named after the bliss giving goddess Nanda Devi worshipped by the communities of the region. Human habitations are absent inside the core zones but there are 47 villages in the buffer zone and 33 villages in the transition zone with six villages in the immediate buffer of the core zones. These villages are distributed in Chamoli, Bageshwar and Pithoragarh districts of Uttarakhand state. Along the Dhauli Ganga lies the famed Niti Valley that draws its name from the last village before the Indo-Tibetan frontier. Besides Lata and Reni villages that remain among the best known settlements in this region due to their involvement in the *Chipko* movement, other villages include Jamgavar, Juma, Garpag, Kaga, Peng, Phagti, Surai, Tolma and
Malari. However, these villages are further divided into summer and winter encampments situated at different elevations to cope with the climatic conditions throughout the year (Badola and Silori, 1999; Nautiyal et al., 2003).

_Bhotia_ (Indo-Mongoloid) and Garhwali (Indo-Aryan) are the main communities in the area. _Bhotias_ are semi-nomads and have summer settlements in the higher altitudes while their winter houses are in lower regions inside and outside of the biosphere reserve. Most of the Garhwali people have permanent settlements while some of the inhabitants seasonally migrate from summer house (higher altitude or upper ridge of the same mountain) to winter settlements (lower altitude or lower part of the village generally near river) within the same village. Migration from higher altitude to lower altitude takes place because of the harsh winter and unavailability of basic resources. Villagers migrate within same village or locality as the lower settlement (winter) is nearer to collect the riverain outcrop as the flow and volume of the river is less in the winter and it is easy to cross it. Villagers make a temporary bridge of logs to cross the river and participation from every family is mandatory. Families which are not willing or unable to provide any physical input have to pay a small amount to use the bridge.

_Bhotia_ people are mainly dependent on handicraft and tourism while agriculture and cattle and goat rearing are the main occupation for the Garhwali communities. _Bhotia_ is transhumant community and has divided into different subgroups. Garhwal region is inhabited by _Marcha, Tolcha_ and few families of _Johar_ while in Kumaun _Shaukya_ and _Johar_ are the main subgroups of _Bhotias_. _Bhotia_ people have similarities with Hindu and Buddhist cultures while Garhwali people are the follower of Hindu beliefs. _Bhotia_ have traditionally gained a livelihood as transhumant shepherds and traders. _Bhotia_ used to trade with Tibet, which has been closed due to Indo-China conflict in 1962. In the entire region farming remains subsistence oriented, but food grain output is no longer adequate for subsistence. Added to these are the multiple environmental hazards that have further jeopardized the economic condition the people (Badola and Hussain, 2003). Thus the economy lacks resilience and is highly vulnerable to shocks and stresses. This leads to migration of people in search of employment phenomenon that was reflected in the human population trends, registering 15% decline between 1981 and 1991 and another 13% between 1991 and 1996 (Silori, 2004).
High and low elevation villages differed more in terms of the rate of increase in number of households and migration of families than total population growth during 1981-2001 period and population in low elevation zone villages increased by 22% compared to 18% in high elevation zone. Outmigration occurred at higher rates in high elevation-buffer zone villages compared to low elevation-outside reserve villages. Immigrant Nepalese people settled only in low elevation-outside reserve villages (Saxena et al., 2011).

2.5.2 Livestock holdings
Cow, bullocks, goat, sheep, mules and horses are the main livestock reared by the local people of the area. Mules and horses are used in transportation of goods by the local villagers while during peak seasons of tourism they are used as medium of transportation by the tourist and are one of the important sources of income for the local communities (Saxena et al., 2011). Goats are mainly reared for meat and manure, sheep are kept for wool, cows are reared for dairy products and manure and bullocks are mainly used for agricultural work. People now have started keeping hybrid cows for better production of milk. Population of goats and sheep has declined drastically after the area was declared as national park. Closure of business with Tibet has also made people less willing to keep sheep and goats as these species were used for transportation of goods across the snow covered areas. This has also affected the traditional livelihood – handloom, of Bhotia community. The population of livestock reared by the inhabitants of the NDBR buffer zone villages showed a drastic decline in the periods 1970–1975 and 1990–1995. This was due to sharp reductions in the sheep and goat populations and near extinction of yak breeds in the area (Nautiyal et al., 2003).

2.5.3. Dependence on natural resources
Communities of NDBR are completely dependent on natural resources for their survival. Culture of the area also shows a significant influence of the nature on it. Economy of the area is completely dependent on the services of the natural resources of NDBR. Livestock production of the area is completely dependent on the availability of the forest and grasslands of the area. Most of the basic necessities are met by using natural resources. Forests are the only source for fuelwood, fodder, leaf litter and support for leguminous crops. Although hydroelectric projects on rivers
have negative impacts on environment of the area but also are main source of revenue for state and have provided alternative livelihoods to the locals, in terms of daily wages received as labour work. The natural resources of the biosphere reserve are facing threats because of high dependence of local and downstream communities. Human communities have also become vulnerable to the degradation in the environment.

Second highest peak of the country, rich natural and cultural diversity make NDBR one of the hotspots of cultural, adventure and nature tourism (Silori, 2004). Nanda Devi peak is located inside the NDNP, once was the most popular for mountaineering and expedition till the ban on tourism in 1982. Ban on tourism has affected the local economy and has raised conflict among management and communities in the nearby area (Silori, 2004). Sustainable nature-based tourism is being developed as a tool to manage the conflict, provide alternative livelihood and conservation of natural resources.

2.5.4. Human-wildlife conflict and attitude of people towards forest and wildlife
Human-wildlife conflict is a major issue in management of the natural resources of the area. Declaration of the two national parks in the area and ban on tourism has reduced the tolerance level of people towards wildlife. Incidences of crop raiding, attack on human and livestock has played a major role in shaping up the negative attitude of people. Cases of poaching and illegal felling of trees have been reported from the area. Some studies, conducted in the past revealed that incidences of livestock lifting have increased (Rao et al., 2002). Attack on human especially on women folk during agricultural work and fodder and fuel wood collection is not so uncommon. Crop raiding is a main threat to economically marginal communities. Uttarakhand Forest Department does provide cash compensation for any loss due to wildlife but the amount is very less in comparison to the real loss.
STUDY AREA

View of Nanda Devi peak from Auli

Valley of flowers National Park  Hemkunt Sahib

Adventure tourism at Auli  Cultural dependence on nature

PLATE 1
LAND USE LAND COVER CLASSES OF NDBR

Deodar forest

Kharsu Oak forest

Alpine meadows

Mixed forest with retained fresh water

Blue pine forest

Agriculture land

Multiple use area