CHAPTER 2

Study Area
2 Study Area

2.1 Location and Extent

Southern Aravalli Hills in North Gujarat (SAHNG), the main study area, is located in the northern part of Gujarat state. The study area is located between 23° 35' 13.0" to 24° 30' 57.0" N and 72° 10' 28.0" to 73° 24' 47.0" E. However, the forest of SAHNG covers a larger extent of area spreading over c.2550 km², though not contiguous, the forests of the main study area extends to c.1650 km². This includes two Protected Areas and adjoining Reserved Forests interspersed with patches of agriculture ecosystem forming a mosaic. The entire study area falls in Banaskantha, Mehsana and Sabarkantha districts of Gujarat State (Map 2.1).

2.2 Boundaries of the Study Area

The study area is bound on the north by the Gujarat Rajasthan State boundary, while on the south it followed the roads and boundaries of forests. The Hatmathi River demarcates the eastern limit of the study area, while the western boundary of the Jessore Wildlife Sanctuary formed the western limit of the study area (Map 2.1).

2.3 Site Description

Southern Aravalli hills of North Gujarat, where this study was carried out, harbours 15.68% of the forest cover i.e. 2955.87 km², of the total forest cover of 18,868.28 km² of Gujarat State, which comprises 1500.25 km² forest of Banaskantha 178.16 km² of Mehsana and 1277.46 km² of Sabarkantha districts (FSI 1997).

The SAHNG mainly constitute the southwestern extremity of the Aravalli’s mountains. These hills do not show any well-defined direction, but regionally they show a NE-SW trend with a greater part of these hills occurring both as ridges as well as rounded hills (Merh 1995). The study area is bounded in the north western side by the Thar Desert (3 Desert & 3A: Desert- Thar - Rodgers et al. 2000), which probably has very minimal influence on the biodiversity of the study area, mainly due to the Aravalli hill range that form as a barrier curbing the expansion of the desert. On the western side lies the Greater and Little Rann of Kachchh, a very unique ecosystem characterized by salt and sand with
high salinity (3 Desert & 3B Desert – Kachchh - Rodgers et al. 2000), while on the south Tropical Thorn Forest and the agro-ecosystem (4 Semi-Arid & 4B Semi-Arid – Gujarat Rajputana - Rodgers et al. 2000) are prime ecosystems. These could probably have its influence on the biodiversity of the study area. Southern Aravalli Hills of North Gujarat Region, in terms of agro-climatic zones, falls under the hot arid to semi-arid type overlain with gray brown deltaic coastal alluvium (Anon 1991).

2.4 Geography

2.4.1 Terrain

The study area is undulating in nature with the hills lying in a series and the altitudinal range varying between 150m and 1050m, with the mean altitude of 327 m MSL. The contour density and altitudinal variation is highest in northern, northeastern and central part of the study area. As a consequence, the terrain in the northern portion of Jessore Wildlife Sanctuary and predominant part of Balaram-Ambaji Wildlife Sanctuary and some sections of the reserved forest in the north eastern side are more rugged and undulating broken by numerous great rounded or pointed hill masses with occasional steep falls or by smaller hillocks compared to other parts of the study area. The areas lying in the southern boundary are flat to very gentle undulation.

2.4.2 Slope and Aspect

The slope in the study area varied between 0° and 45° with a mean slope of 6.9°. The slope in percent varied from 0 to 100 with an average percent slope of 12.3% (Joshua et al. 2007a). Further in the study area West, Northwest and Southwest aspects or facing slopes are comparatively predominant, which extends to a total of 1113km² area, with Northwest aspect covering the maximum extent of 444.1km². The East, Northeast, and Southeast aspects together covered an area of 949.6km² with maximum area of 412.9km² covered by Southeast aspect (Joshua et al. 2007a).

2.4.3 Rivers and Streams

The majority of the rivers and streams in the study area are seasonal and mostly flowing from north to south. All minor rivers and streams like Sipu, Balaram and Gomti drains into River Banas that flows outside the confines of the study area. River Sabarmati, which raises from Aravalli hills in Rajasthan state, flows almost through the center, dividing the
study area into western and eastern parts, extending to a mean distance of c.60 km. This river is one of the largest in the study area, flows through both Palanpur and Sabarkantha districts. River Saraswati, also one of the major river systems starts from the forests of the study area. Harnav River, which originates from the forest in Rajasthan State, flows through some parts in the eastern portion of the study area and empties into River Sabarmati close to Taranga hills. River Hatmathi, which demarcates the eastern boundary of the study area, also flows north to south. The stream system of the study area remains dry for nearly eight to nine months in a year, but for few puddles in most of its length, which also dries up in summer. Usually water starts flowing in them only during rainy season (July – October). The rivers flow from the northeast direction to southeast and southwest direction (Map 2.1).

2.5 Geology

Geologically majority of the Southern Aravalli Hills of North Gujarat is formed by Calcareous and Argillaceous meta-sediments. It is also composed of igneous rocks, quartzite granites, gneiss and base metal deposits along with Holocene, Miocene, Eocene, Cretaceous, Jurassic, Mesozoic and Tertiary formations (Merh 1995). Basically the rock types found in the study area were of the Aravalli system of formations, Delhi system, Alwar series, Ajabgarh series, Manchar series, Kirthar series, Ultramafic Intrusives, Himatnagar series, Deccan Traps and Laterite.

The soil, in general is sandy with varying proportion of loam. The origin of the soil, its situation and the state of disintegration contribute to the variation in the colour, structure, texture and composition of the soil. Eastern and southern parts of the study area are gentle to flat and rich in soil while western and northern parts that are hilly contain poor soil. Generally the plains and valleys have deep and fertile soil, while in the hilly areas it is very shallow and poor. In the extreme case the parent rocks are also exposed.

2.6 Climate

The climate in the study area is subtropical with three main seasons: monsoon (mid June to October), winter (November to February) and summer (March to June).
2.6.1 Temperature

The entire SAHNG experiences a high variation in temperature with a minimum going down to 5°C in winter and maximum to 46°C in summer. Temperatures increase rapidly after mid March, with May being the hottest month. The heat is intense in summer and before the onset of monsoon, while decreases in the month of October after the withdrawal of monsoon. The summer usually starts from February end and extends till mid June, while winter begins in October after the showers and chillness increases from November and extends till February.

2.6.2 Rainfall

Monsoon is irregular and erratic, and accompanied with gusty winds. It starts from about mid June and continues till September sometimes even till October. Rainfall is not evenly distributed in the area. Usually the Monsoon season experiences average rainfall of 765 mm, with the north and northeastern parts receiving comparative more rain than the south and southwestern parts. More than 96% of the annual rainfall in the study area is received from southwest monsoon (IMD 1995). The number of rainy days varies from west to east. On an average, there are about 25 and 40 rainy days in a year in the western and eastern parts respectively. The general trend in rainfall of the area shows a decline between 1993 and 2004 with the maximum of 1225 mm in 1994 and minimum of 341 mm in 1999 (Figure 2.1).

Figure 2.1: Rainfall of the Study Area between 1993 and 2004
2.6.3 **Humidity**

The climate being generally drier, the humidity in the air is reported to be very less in most part of the year ranging from 20% to 25%. It is generally high ranging between 60% and 85% during the southwest monsoon and remains very low throughout the year with the lowest in summer. Winter is quite pleasant; however, extreme cold and frost are experienced in some eastern parts of the study area.

Dew is heavy in the months of December and January, following the monsoon and persists up to February. It plays an important role in growth of vegetation when the rainfall is scanty.

2.6.4 **Wind**

Easterly winds prevail in winter and westerly winds through rest of the year. Though there are no heavy cyclonic winds, gusty winds blow during May and beginning of monsoon, bringing along with them local dust storms. April to September the winds are from south to west with SW winds being more common. Usually between November and March morning winds are mostly from North and East, while the afternoon winds are west to North (IMD 1995).

2.7 **Land Use**

The most predominant land use type was forest extending to 1638 km$^2$ forming 59.18% of the total study area (2768 km$^2$) followed by agriculture land with 622 km$^2$ (22.5%) and was very common in the valleys, which also include encroachments. Rocky barren extended to about 485 km$^2$ (17.5%). Since this area is locked with minerals and marbles being predominant, mining of different minerals are not uncommon. This has led to different land use of mining areas and spread over 15 km$^2$. The area under the influence of water bodies in the study area had the minimum spread of 8 km$^2$ (**Table 2.1 & Map 2.2**).

<table>
<thead>
<tr>
<th>Land Use Types</th>
<th>Total Area (Km$^2$)</th>
<th>Relative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>1638</td>
<td>59.18</td>
</tr>
<tr>
<td>Agriculture</td>
<td>622</td>
<td>22.47</td>
</tr>
<tr>
<td>Rocky Barren</td>
<td>485</td>
<td>17.52</td>
</tr>
<tr>
<td>Mining</td>
<td>15</td>
<td>0.54</td>
</tr>
<tr>
<td>Water Body</td>
<td>8</td>
<td>0.29</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2768</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

*Source: Joshua et al. (2007a)*
2.7.1 Forest types

Dry deciduous and thorn forests are predominant in Sabarkantha and Banaskantha, which is due to the study area being a part of Western Aravalis that have moderating effect on the climate of North Gujarat (Singh, J. 2001). Further the study area being located in the southern part of Aravallis, which receives comparative more rain than the areas adjoining to the deserts, the forest is denser.

2.7.1.1 Vegetation Types

Various forest types found in the study area are under two major and 16 sub-groups viz. 5A - Southern Tropical Dry Deciduous Forest (STDDF) and 6B - Northern Tropical Thorn Forest (NTTF) (Champion and Seth 1968). The 5A zone (STDDF) is further subdivided into various sub zones with different forest types distributed in these districts. The Sabarkantha district alone holds conspicuous forest cover like Very Dry Teak Forest (C1a), Dry Teak Forest (C1b) and Dry Bamboo Brakes (E9). While Banaskantha district owns two forest covers e.g. *Aegle marmelos* forest (E6) and *Acacia catechu* forest (1S2). These two districts together comprise many forest types such as Southern Dry Mixed Deciduous Forest (C3), Dry Deciduous Scrub (DS1), *Anogeissus pendula* Forest (E1), *Boswellia* Forest (E2), *Butea* Forest (E5) and Secondary Dry Deciduous Scrub Forest (2S1) (Joshua et al. 2007a).

Some of the dominant plant species found are: Top canopy – *Anogeissus latifolia, Diospyros melanoxylon, Lannea coromandelica, Miliusa tomentosa, Boswellia serrata, sterculia urens, Emblica officinalis, Bridelia retusa, Mitragyna parviflora, Adina cordifolia, Pterocarpus marsupium, Madhuca indica, Terminalia crenulata, Terminalia bellirica, Holoptelea integrifolia, Albizia odoratissima, A. lebbeck and A. procera; Middle canopy – Wrigtia tinctoria, W. tomentosa, Bauhinia racemosa, *Dendrocalamus strictus, Balanites aegyptica, Cassia fictula, Butea monosperma, and Aegle marmelos; Lower canopy – *Holarrhina antidysentrica, Xanthium strumarium, Helicterus isora, Nyctanthes arbor-tristis, Capparis sepiaria, Cassia auriculata, Annona squamosa, Vitex negundo, Adhatoda vasica and Zizyphus nummularia.* The predominant grass species reported are *Aristida funiculate, Dichanthium annulatum* and *Cymbopogon martini* (Joshua et al. 2007a).
While under 6B zone (NTTF), northern part of Banaskantha district is formed by Desert Thorn Forest (C1) and Desert Dune Scrub (IS1) and Ravine Thorn Forest (C2) adjacent to Sabarmati River, scattered scrubs of *Cassia auriculata* (DS1), and *Zizyphus* Scrub (DS1) and Rann Saline Desert Thorn Forest of *Prosopis* Scrublands (E3) occurs in Sabarkantha, Banaskantha (Singh, H.S. 1998) and Mehsana districts. The common species encountered are *Acacia senegal*, *A. catechu*, *A. leucophloea*, *Anogeissus pendula*, *Zizyphus nummularia*, *Xeromphis spinosa* and *Maytenus emarginata*.

However the above mentioned forest types are existing in the study area, these have been grouped into only four broad vegetation or forest types in a biodiversity study carried out in the same area (Joshua *et al.* 2007a), which was dominated by Dry Deciduous Forest (DDF) that included also the teak mixed forests and other sub types of deciduous forests. The second major type was Open Scrub Forest (OSF), which included the highly degraded and very sparse DDF, fallow lands with shrubs and some agriculture lands, followed by Tropical Thorn Forest (TTF) mostly found in the areas with sandy substrate and Moist Deciduous Forest (MDF) found along the rivers, streams and moist rich nullahs (Map 2.2 & Plate 2.1).

The DDF in the study area extends over majority of the area with an extent of 802 km\(^2\) forming 48.96% of the total forest area. Open Scrub Forest is the second largest in the study area extending to 586 km\(^2\) with a relative percent of 35.78%. Tropical Thorn Forest formed the third largest forest type spreading over an area of 213 km\(^2\) (13%), which also included the *Prosopis juliflora*, presently found in low abundance in the study area. The MDF extends to only 37 km\(^2\) (2.26%) (Table 2.2) (Joshua *et al.* 2007a).

<table>
<thead>
<tr>
<th>Forest Types</th>
<th>Total Area (km(^2))</th>
<th>Relative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Deciduous Forest (DDF)</td>
<td>802</td>
<td>48.96</td>
</tr>
<tr>
<td>Moist Deciduous Forest (MDF)</td>
<td>37</td>
<td>2.26</td>
</tr>
<tr>
<td>Tropical Thorn Forest (TTF)</td>
<td>213</td>
<td>13.00</td>
</tr>
<tr>
<td>Open Scrub Forest (OSF)</td>
<td>586</td>
<td>35.78</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1638</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: Joshua *et al.* (2007a)

2.7.1.2 **Protected Forests**

These forested ecosystems in the SAHNG, includes a considerable extent of forest area of some of the Protected Area (PAs) in Banaskantha district viz. Jessore Sloth Bear Sanctuary (JSBS - 180.66 km\(^2\)), Balaram – Ambaji Wildlife Sanctuary (BAWS) (542.08
Plate 2.1: Major Forest Types

Before Monsoon

After Monsoon

Dry Deciduous Forest (DDF)

Moist Deciduous Forest (MDF)

Tropical Thorn Forest (TTF)

Open Scrub Forest (OSF)
2.7.2 **Wetlands**

There are three major irrigation dams in the study area, which harbour a good number of migratory birds, but the water bodies or the total wetland site also includes small shallow ponds to man-made check-dam and natural ponds. Of the three dams in the study area, Dharoi dam in Mehsana district, the largest, constructed across the River Sabarmati, forms the main source of drinking water in north Gujarat. Other two dams are Mukteshwar dam in Mehsana district and Vanaj Dam in Vijaynagar in Sabarkantha district constructed on the River Harnav and mainly used for irrigation. Small wetland includes Jessore Sloth Bear Sanctuary wetland in Banaskantha, Idar and Navanagar pond at Vijaynagar in Sabarkantha district.

2.8 **Floral and Faunal Richness**

The status of floral richness of the area is 743 species of plants with 604 dicotyledons and 139 monocotyledons and grouped under 19 life forms. Among the invertebrate fauna only butterflies and spiders have been inventorized and are represented by 86 and 50 species respectively. In the vertebrate group eight species of amphibians, 33 species of reptiles, 292 species of birds and 30 species of mammals have been reported to exist in the area (Joshua et al. 2007a).

2.9 **Threats**

The study area faces both natural and man-made threats to which the different forms of disturbances that exert negative pressure to the forest ecosystem and associated biodiversity. The natural causes include floods, and landslides. The man-made threats included deliberate loss of habitat for developments and habitat destruction due to overexploitation of NTFP.

2.9.1 **Habitat Loss and Degradation**

The main causes of habitat loss include extraction of minerals and marbles, industrial developments, construction of dams and encroachment for agriculture. The locals living inside and along the boundaries of these forests involve in collection of non timber forest
produce (NTFP) like *Madhuca latifolia* flowers, *Diospyros melanoxylon* leaves, gums and other produce. Some people in the vicinity of bigger towns and villages live on sale of firewood carried on head loads. The requirement of the people like; timber, bamboos, firewood, wood based charcoal, leaf and grass fodder are met from these forests, that exerts lot of pressure on the forests of the study area in the form of habitat degradation and loss of productivity.

2.9.2 **Invasive species**

*Prosopis juliflora* and *Lantana camera* are the two main species that are main sources of competitors for the local and native flora the main source of habitat for the biodiversity in the study area.

2.9.3 **Human Habitation and Communities**

There are in total 278 villages inside the study area with 23 villages in and bordering JSBWS and nearly 100 in and bordering BAWS and rest (155) spread in the other parts. The total human population of the study area is c. 5.5 lakhs (Census 2001) at a density of 199 people/km². Tribal communities predominantly occupy these forest villages. Though grouped together as tribal, there is clear categorization. There are Rajput Garasia and the Bhil Garasia. There appears to be a clear distinction in the areas that the two tribal communities inhabit in this study area. The Bhil garasia seem to be more dominant in the eastern part of Danta block whereas the Garasia Rajput predominate in the northern and northwestern part of Danta and most of the Amirgadh taluka (FES unpublished data). Other than the tribal communities, there are mixed caste villages, which are few in number and found mainly on the periphery that follow the pattern of mainstream villages. This includes Rajputs, the Rabari, the Brahiman, the Prajapati, the Thakardas, the Damors and the Dalit. Muslims are the Memon and the Bohra, both of which are mainly business communities (Joshua et al. 2007a). The global disturbance map (Hannah and Lohse 1993) clearly depicts this area as human dominated.

2.9.4 **Livestock**

The density of livestock in the study area based on 2003 census was 180 livestock/km² of which cattle were represented at a density of 55.08/km², buffaloes 83.23/km² goats and sheep 42.35/km² (Livestock Census 2003) in addition to camels and others. The animals
in the upland are small in build but are sturdy and suited to the hilly terrain. Milk production is very low and the livestock both big and small are mainly kept for manure and women and children collect dung intensively. Goats are kept for self-consumption but increasingly used as a critical source of income in times of stress, most notably in drought. However for the Rabari the livestock is of utmost importance. The community has large holdings of buffaloes, cows, sheep and goat. The main source of their livelihood is through the sale of milk and milk products (FES Unpublished Data). These livestock of the villages is fully dependent on these forests for their grass and leaf fodder.

Another major problem is pressure from migratory livestock as the study area lies on the main route. This has resulted in severe grazing and fodder lopping pressure, while thousands of sheep, goats, cattle and buffaloes pass through this area from the adjacent Rajasthan State to other parts of Gujarat.

2.9.5 Tourism and Pilgrimage

The tourism is nowhere more destructive than other threats, because habitat once seriously damaged their recovery capability become too low. The Southern Aravalli Hills in North Gujarat is very famous from religious point of view and harbours many pilgrimage spots, and draws thousands of pilgrims from Gujarat as well as the other states of the country. Shamlaji, Khedbrahma, Ambaji temple, Balaram temple and Mahadev temple in Jessore forest (Singh, H.S. 2001), in addition to the other temples like Kumbharia, Koteswar, Mokeshwar, Taranga, Vireshwar, Idar are religious sites in the study area that are visited regularly by people. The major ones like Ambaji, Gabbar Taranga, Khedbrahma, Chota Kedarnath, Balaram, in addition to attracting thousands of pilgrims on regular basis, receive several thousands of pilgrims and tourists during festive seasons every year, which is between July and September. All these exert enormous pressure on the forests of the study area and this region either directly (pollution – dust and smoke due to heavy vehicle traffic, garbage in the form of plastics, and noise) or indirectly (hotels using fire and fuel wood in large quantities and, increase in NTFP collection) (Joshua et al. 2007a).