CHAPTER - 3
STUDY AREA

3.1 Brief Introduction

India is the seventh largest country in terms of area and is blessed with a large diversity of habitats. It is one of the 12 mega diverse countries of the world which harbours about 8% of the world's total biodiversity occupied by 2.4% of the world land (WMCC, 1992). It harbours about 91,000 species of animals which include 12.6% mammals, 4.5% birds, 45.8% reptiles, 55.8% amphibians. It also comprised of 45,500 species of plant that included algae - 7,411 species, bryophytes- 2,780 species, pteridophytes-1302 species, gymnosperms- 82 species and angiosperms- 18,666 species (BSI, 2019). It is divided into 12 biogeographic zones viz., Trans-Himalaya, Himalaya, West Himalaya, East Himalaya, North-East Himalaya, Indian desert, Semiarid, Western Ghats, Deccan peninsular, Gangetic plain, Indian coasts, Andaman and Nicobar Islands and Lakshadweep islands (Rodger and Panwar, 1988). India ranks 10th in the list of most forested nations in the world with 76.87 million ha. of forest and tree cover (FSI, 2019a). Total forest cover of India is 7,12,249 sq. km which includes 99,278 sq. km very dense forest, 3,08,472 sq. km moderately dense forest area and 3,04,499 sq. km open forest (FSI, 2019b). Large areas of these forests are protected areas either as national parks, sanctuaries and reserve forests. India hosts about total 550 sanctuaries and 104 national parks of which Gujarat holds 23 sanctuaries wherein the central Gujarat has about 3 important sanctuaries of the state (WII, 2019)

Gujarat is located on the west coast of India and is bordered by Pakistan on the north side, Rajasthan in the north east, Madhya Pradesh in the east, and Maharashtra and the Union territory of Dadra and Nagar Haveli in the south. The Arabian Sea borders the state both to the west and the south west. It is having India's longest sea coast of approximately 1600 km along the Arabian Sea (GEC, 2012). It is situated between 20°01'& 24°07' North Latitude and 68°04'to 74°04'East Longitude covering geographical area of 196244 sq. km, which accounts for about 6% of the country's land area. (FSI, 2019a)

Gujarat is divided into four biogeographic zones namely, the desert zone (3A- Kutch province), the semi-arid zone (4B-Gujarat- Rajwara province), the Western ghats (5B- Western Ghats) and the coastal zone (10A- West coast). The desert zone has a diversity of habitat types but has a dominance of scrubland while the coastal zone has a diversity of habitats like mangroves, coral reefs, sea grass meadows, rocky outcrops and beaches. Semi-arid region of Gujarat have dominance of scrub forest except the few protected area like Balaram Ambaji Wildlife Sanctaury that is inhabited by several mesophytes. The South Gujarat especially the Dangs district is the Northern part of Western ghats having rich diversity of lower to higher groups of plants. (Rodgers and Panwar, 1988). Gujarat is having a forest cover of about 21, 85914, 857.22 sq. km that includes 14,571.35 sq. km reserved area, 2,898.4 sq. km protected area and 4,389.47sq. km unclassed area (GFD, 2018). North Gujarat is mainly having dry deciduous scrub forest while South Gujarat has moist deciduous type forests. Central Gujarat is dominated by tropical dry mixed deciduous type of forest, while the Saurashtra peninsular dominated by dry deciduous scrub forests and also shows significant presence of mangrove forests and grasslands. Kutch also shows the the presence of mangrove forests and grasslands in addition to dry deciduous scrub forests. (GFD, 2018)

Gujarat is administratively, currently divided into 33 Districts which are broadly grouped into five zones namely North Gujarat, South Gujarat, Central Gujarat, Saurashtra and Kutch. 18,569 villages and 246 talukas are distributed within these different districts.

Central Gujarat

Central Gujarat comprises of the districts Ahmedabad, Anand, Bharuch, Chhota Udepur, Dahod, Nadiad (Kheda), Narmada, Panchmahal, and Vadodara, Ahmedabad, Anand, Bharuch and Nadiad which comprise of the western part of this region have a large agricultural area while the other districts viz. Chhota Udepur, Dahod, Narmada and Panchmahal which comprised of Eastern Central Gujarat has forested areas and were hence selected for the study (FSI, 2019b; DES, 2019). Vadodara and Chhota Udepur were one district till recently and were connected administratively and hence Vadodara district was also included in the study. The above areas were studied as they were not studied in the past by earlier researchers except Pavagadh in case of Panchmahal district that was earlier part of the Vadodara district. Fig. 3.1 depicts the location of the study area and gives details on the different Talukas found in the study area.

Fig 3.1: Outline Map of Study area

3.1.1 Geology

Gujarat is geologically very unique and on the basis of geology and geomorphology, it is divided into 3 broad regions

1. Mainland Gujarat
2. Saurashtra Peninsula
3. Kutch

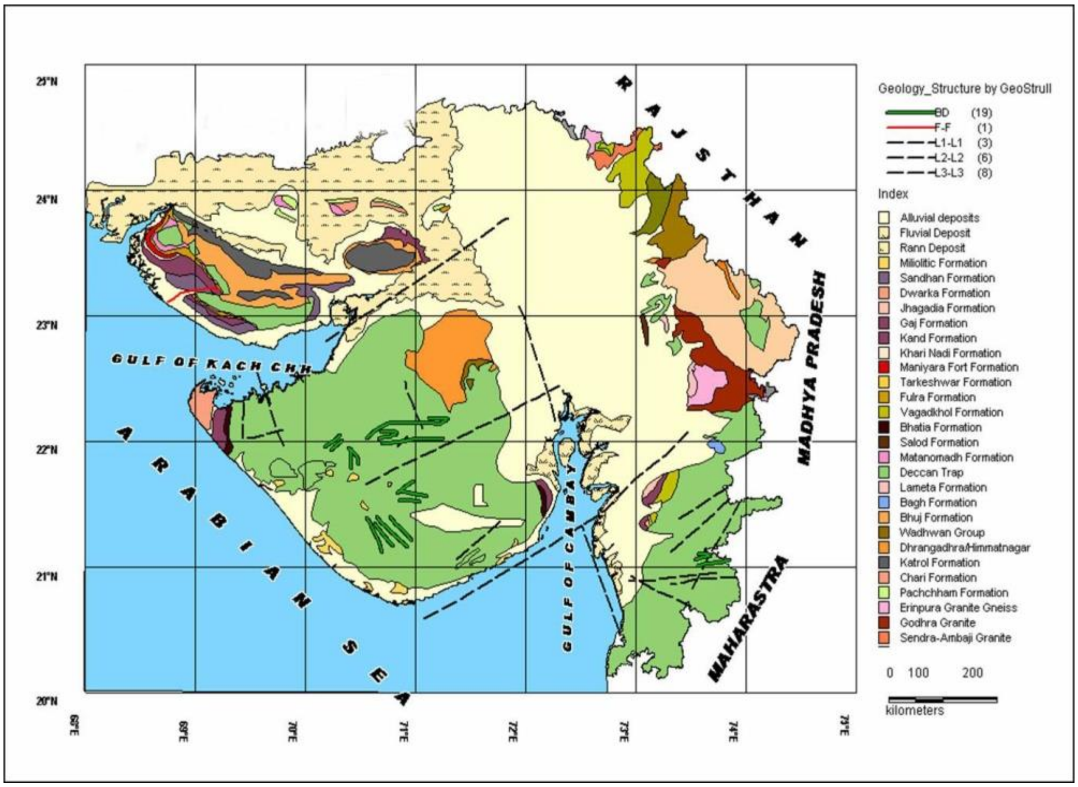

Fig 3.2: Geology Map of Gujarat (Source: NWRWS, 2019a)

Fig 3.2 given above depicts the Geological map of Gujarat. As seen in the map, the mainland Gujarat is formed by alluvial deposits of rivers like Sabarmati, Mahi, Narmada and Tapi. It extends from Ambaji in the North to Umbargaon in the South and comprises of rocks from pre-cambrian banded gneissic complex to recent deposits. The study areas fall in the mainland region of the state (Merh, 1995). Dahod and Panchmahal districts have a mountainous terrain which is made up of pre-cambian meta-sediments and similar other granites. Chhota Udepur and Vadodara districts are mainly comprised of quaternary rocks in addition to Mesozoic and tertiary rocks. Narmada district is mainly formed of detached masses of Deccan basalts. The Cambay basin is divded into four block from the north to south that includes ahmedabad-mehsana block, Cambay tarapur block, Jambusar-bharuch block and the Narmada block (Mathur *et al,* 1968). Later on the exposure the Cenozoic sediments led to the development of 5 different formations like Vagahkol formation, Dinod formation, Babaguru formation, Kand formation and Jhagadiya formation (Agrawal, 1986).

3.1.2 Topography

The North-eastern parts of the study are mainly hilly outcrops of the Aravalli, Vindhya, Satpura and Sahyadri ranges. The Vindhya ranges of Chhota Udepur are comparatively higher (min 123 m and max 356m) (Google earth, 2019). The Narmada river separates the Vindhya and Satpura ranges. The Rajpipla hills that form the western part of Satpura lies towards the south of Narmada. The southern part of study area has many hog-back (sharp ridge like structure formed by erosion and having steep slopes on both sides) features that makes the terrain unique (Merh,1995). Eastern central Gujarat is the combination of the both moist deciduous forest and semi-arid regions. The Northern region (i.e Dahod and Panchmahal) and the Southern region (Narmada) of the study area are composed of moist deciduous type of habitat while the central part of study (i.e Chhota Udepur and Vadodara to some extent) is semi-arid.

The average elevation of Gujarat is 197 m. Elevation in the different parts of Gujarat varies depending upon the topography of the regions. The elevation ranges from 0 to 820 m in mainland region, in Saurashtra peninsular it ranges from 0 to 1117 m while in Kutch it is in the range of 0 to 458 m. Girnar hills in the Saurashtra peninsular has the maximum (i.e. 1117 m) elevation in the state. Panchmahal district is having the highest elevation (820 m) while the Vadodara district is having lowest elevation (74 m) among the district of study area. Dahod and Narmada district have moderately elevated areas. Some of the forested areas of Chhota udepur have an elevation of about 350 m (Google earth, 2019).

3.1.3 Drainage

Drainage is one the main characteristics of the topography as it is controlled by factors like climate, physiography and geology (Merh, 1995). The rivers of Gujarat drain into either the Arabian Sea or the Gulf of Khambhat. The major rivers of Gujarat are Dhadhar, Mahi Narmada, Tapi and Sabarmati while the minor rivers include Anas, Bhadar Kim, Orsang, Vishwamitri etc (Fig 3.3). Table 3.1 below shows the characteristics of the major rivers of the state.

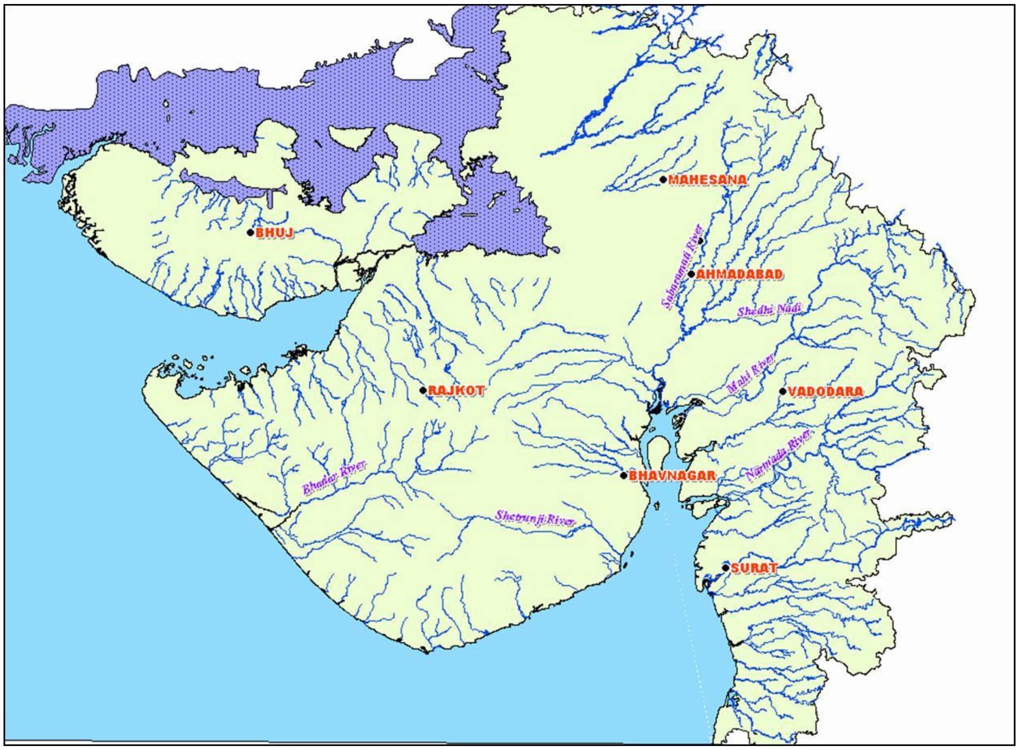

Fig 3.3: River Map of Gujarat (Source: NWRWS, 2019b)

Table 3.1: Major Rivers of Gujarat and their Characteristics.

Major River	Origin	Catchment area	Tributaries	Drainage area (sq. km)
Dhadhar	Pavagadh hills, Gujarat	Gujarat	Dev, Jambau, Vishwamitri and Surya	3423
Tapi	Maikal hill, Madhyapradesh	Maharashtra, MP, Gujarat	Madhya Pradesh, Gujarat	
Mahi	Vindhaychal range, Madhya pradesh	Gujarat, Madhya Pradesh, Rajasthan	Anas, Bhadar, Chap Eru, Gomti, Jhakham, Moran, Nori, , Som,	34842
Narmada	Amarkanthak, Madhya pradesh	Chattisgarh, Gujarat,	Barna, Chohota tawa, Ganjal,	98796

Major River	Origin	Catchment area	Tributaries	Drainage area (sq. km)
		Mahasrahtra, Madhya pradesh	Hiran,Kolar, Jamtara, Orsang, Sher	
Sabarmati	Aravalli ranges, Rajasthan	Gujarat		21674

(Source: Anon, 1961, Anon 2006)

3.1.4 Soil

The soil of Gujarat is divided into five main types that includes Ardisols, Mollisols, Entisols, Vertisols, and Inceptisols (Bhattacharya *et al*, 2013). The study area has mainly vertisol type of soil (Merh, 1995). Vertisols are clay soils that show significant expansion and contraction due to wetting and drying. They are black- brown to dark greyish in colour. They are found in semi-arid to humid area having annual precipitation ranging from 500-2000 mm. The soil is neutral with a depth of about 50 cm (Merh, 1995).

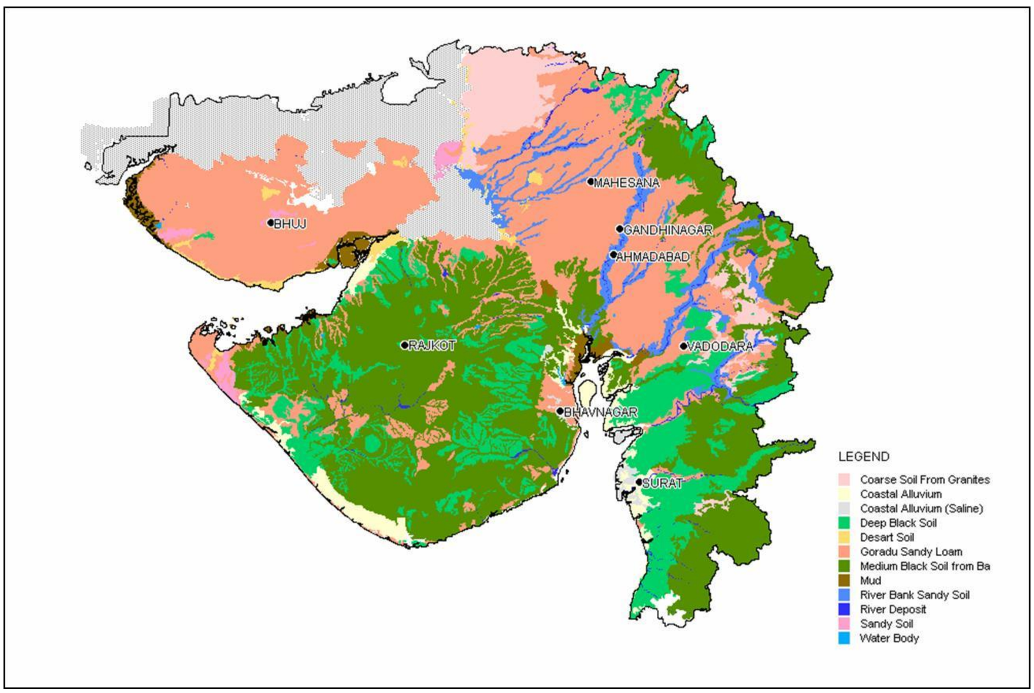

Fig 3.4: Soil Map of Gujarat (Source: NWRWS, 2019c)

According to Merh (1995), Central Gujarat has shallow to deep soil depth class. They are fine to coarser in texture. In case of Panchmahal and Dahod, it is sandy coarse while in Vadodara and Chhota Udepur it is more of clayey coarse. The soil in Vadodara and Chhota Udepur is less saline compared to the other parts of eastern Central Gujarat. In case of Narmada District, the soil is deep, well drained and fine to medium textured. Fig. 3.4 below shows the distribution of soils in Gujarat and also depicts the presence of Vertisols in major part of the study area.

3.1.5 Minerals

Central Gujarat has a deposition of many major and minor minerals. The important minerals of the region include manganese, quartz, trap, quartzite, limestone, dolomite, fluorite etc. (DES, 2019). The Shivrajpur region of the Panchmahal is rich in manganese. The region is formed by rocks that range from acidic to basic. It is the largest producer of quartz, trap and quartzite in the state of Gujarat (MSME, 2016d). Quartz is the major mineral of Dahod (MSME, 2016b). The Narmada valley has deposition of sandstone, impure limestone, shale and quartzite while the Vadodara district is the largest producer of dolomite (MSME, 2016c). The Chhota Udepur has large deposits of minable dolomite (DES, 2019). Kawant taluka of Chhota udepur produces Fluorspar (MSME, 2016a). Dolomite and Fluorspar are the major minerals of Vadodara district (MSME, 2016e)

Climate

The whole state experiences all the three seasons prominently. The climate is broadly hot and dry in the north while it is warm and humid in the south. The humidity increases as we move from north to south while the temperature decreases. In case of central Gujarat, the climate is mostly semi-arid especially in district like Chhota Udepur. Some parts of the sanctuaries and reserved forests within the study area have humid climate.

3.1.6 Temperature

The temperature varies in central Gujarat in different seasons. In all district, April and May are the hottest months while December and January are the coldest months. The temperature is moderately low with high humidity during the months July to September. While the average temperature varies in different districts, it ranges from 10°C (min) to 49°C (max) (DES, 2019). Within the cities of the district also mild variation in temperature were recorded.

3.1.7 Rainfall

The average rainfall in north-eastern central Gujarat (i.e. Panchamahal and Dahod) is about 731.53 mm. The central region of the study (i.e. Vadodara and Chhota Udepur) area receives an average rainfall of about 785.13 mm while the southern region receives an average rainfall of about 942.08 mm. Thus, in case of southern part of the study area (i.e. Narmada) the precipitation is comparatively higher than other parts. It sometimes varies from 1000-1500 mm per annum (DES, 2019).

3.1.8 Transport

All the districts of the study area are well connected with road and rail network each other. Vadodara district is one of the main Railway junction of the state. Moreover, the district also has an International and National Airport. The talukas of the districts had connection of National or State highways. Even the villages within the talukas have good road connectivity.

3.2 Introduction disticts of Study area

3.2.1 Chhota Udepur

Chhota Udepur district came into existence in 15 august 2013. It got separated from the Vadodara district. It is located between 22 °11'& 22 °30'N latitude and 73 °52'&74 0 15'E longitude. It is 28th district of Gujarat. It is surrounded by Baria taluka of Panchmahals district on North, Maharashtra on south, Madhya Pradesh in east and its Pavijetpur taluka on west. It has 8 talukas namely: Chhota Udepur, Dolariya, Rangpur, Panvad, Kawant, Jetpur-Pavi, Boriyad and Naswadi. The total area of the district is about 757 sq. km. The district is having a population of about 25,787 individuals. (GFD, 2018). It is mainly dominated by the Rathva tribal community. There are two main rivers viz., Narmada and Orsang that passes through the district (MSME, 2016a, Tyagi *et al*, 2007).

The forest area of the district is 753.48 sq km. administratively; Chhota Udepur taluka covers three forest ranges, which are Chhotaudepur, Dolariya and Rangpur. The forest area of Chhota Udepur Division is 75,349 ha which is 9.98 % of geographical area of the district. It is mostly teak dominated forest. North east of the division falls into 5A/Clb Dry Teak forest type while the South east of the division falls under type 5A/C3 southern dry mixed deciduous forests (Tyagi *et al*, 2007). The district has an reserved forest area of about 676.47 sq km (DES, 2019).The forest cover assessment carried out by Forest survey of

India had not considered the newly formed 7 districts that also included the Chhoa udepur. It has only considered the old 26 districts i.e. districts before 2013 partition Moreover, the Districts does not hold any protected areas like sanctuary or National Park hence the it is not categorised into very dense forest (VDF), 118sq km Moderate dense forest (MDF) and 419 sq km Open forest area (OFA).

3.2.2 Dahod

Dahod district is located towards the eastern side of Gujarat. Dahod is made up of two words "Do" means two and "Hadh" means border, as it lies near the border of two states namely Rajasthan and Madhya Pradesh (MSME, 2016b). The district lies between 20°30'& 23°30'N Latitude and 73°15' & 74°30' E longitude. The district is surrounded by Madhya Pradesh on east and southeast, Rajasthan on North and Northeast, Mahisagar on northwest, Panchmahal on the west and Southwest, Chhota udepur on South, . Dahod district is divided into 7 talukas namely Dahod, Garbada, Dhanpur, Devgadh Baria, Limkheda, Zalod and Fatehpur. The total area of the district is about 3,642 sq. km The population of the district is about 21, 26,558 individuals. (DCO, 2011a). The District is mainly occupied by tribals of Bhil community. The rivers Anas, Panam, Macchan and Kali flow through the district (Sunani and Mishra, 2019).

Total forest cover of the district was about 538 sq. km that included 1 sq. km very dense forest (VDF), 115.64sq km Moderate dense forest (MDF) and 413.18 sq km Open forest area (OFA) (FSI, 2019b). The Ratanmahal wildlife sanctuary lies in this district. Ratanmahal WLS is triangular in outline and was declared as WLS under Section 18 of wildlife (Protection act), 1972 on 19 March 1982. It included several villages like Pipargota, Kubero, Bhuvero, Bhindol, Panam, Kanjeta, Udhalmahuda, Limdi medari, Morai and Ghumli. It occurs in the Kanjeta range of the district. It is known in the state for its sloth bears. The area of the sanctuary is 55.65 sq. km. and is mostly a dry deciduous forest. It occurs between the two rivers Panam and Orsang. It is located at the union of Malwa plateau and Vindhya mountain ranges. It is inhabited by tribals like Barias, Damors, Naikas, Waghers etc. It has plateaus in the central region and hilly areas towards south, east and west. The plateau like flat region is locally called as "Mal" (GFD, 2015a).

3.2.3 Narmada

Narmada district forms a part of South Gujarat, yet in this study it is considered as the South eastern part of central Gujarat The district lies between 21°23’ and 22°05’ N latitude and 73°17’ and 73°59’E longitudes. The geographical area of the district is 2755 sq.km. Narmada district is surrounded by Maharashtra on east, Bharuch district on west, Vadodara district on north and Surat on South. The district is divided into 4 talukas i.e. Tilakwada, Nandod, Dediapada and Sagbara. The total area of the district is about 2,817 sq. km. The population of the district is about 590,297 individuals (DCO, 2011b). The main river of the district is Narmada (DCO, 2011b).

Total forest cover of the district was about 963 sq. km that included 20 sq. km VDF, 464 sq. km MDF and 479 sq. km OFA (FSI, 2019b). It is mainly composed of moist and dry deciduous type of forest. It forms the catchment of two dams viz Karjan and Sardar Sarovar dams. The Sanctuary has derived its name from the mythological temple “Shoolpaneshwar”. The area of the sanctuary is about 607.708 sq. km and surrounded by 565.9 sq km of reserved area. It falls in two talukas namely Nandod and Dediapada and 5 ranges namely Piplod, Sagai, Fulsar, Gora and Dediapada. It is part of the South west and Penisular provinces of Indian sub-continent (Rodgers and Panwar, 1988). The terrain is undulating with cultivated lands in the valley. The hills represent the western part of the Saputara hills and its surrounding areas are inhabited by many tribals. (GFD, 2015b).

3.2.4 Panchmahal

After the independence the district was comprised of five talukas namely Godhra, Halol, Kalol, Jhalod and Dohad. Hence, the district Panchmahal has got its name Panchmahal from two ords “Panch” which means five and “Mahal” which means Palace (DCO, 2011a). The district lies to the eastern region of the Gujarat. It lies parallel to the 20°31’ and 23°30’ N latitude and 73°15’ and 74°30’ longitudes. Towards its east lies Dahod district, Mahisagar on the North, Kheda and Vadodara on the West while Chota udepur on the South. It is divided into 7 number of talukas viz Ghoghamba, Halol, Jambhughoda, Godhra Kalol, Morava and Sahera.The total area of the district is about 5,231 sq. km. The district is having a population of 2,025,277 individuals (DCO, 2011c). The major river of the district is Mahi while other small rivers include Kun, Meshri, Karad, Kun Kali etc. (DCO, 2011c).

Total forest cover of the district was about 737 sq. km that included 219 sq. km MDF and 518 sq. km OFA (FSI, 2019b). Jambughoda wildlife sanctuary lies in this district. Jambughoda wild life sanctuary is rectangular in shape and falls under the Jambhughoda and Halol taluka of Panchmahal district. The Sanctuary has area of about 130.38 sq. km falling under two forest range namely Shivrapur and Jambhughoda. The sanctuary has undulating terrain surrounded by small hills. The hills are mainly the extension of southern region of the Aravallis. The Jambhughoda taluka of Panchamhal districts hold 67.87 sq. km area of sanctuary while Halol taluka holds 45.76 sq. km of the sanctuary (DCO, 2011c).

3.2.5 Vadodara

The district of Vadodara got its name from its city Vadodara formerly called as Baroda. Vadodara has derived this name due to large number of trees of *Ficus bengalensis* called '*Vad'* in Gujarati that are spread in the district**.** It is also known as '*Sayaji Nagari'* (in the honour ruler sayajirao Gaekward) and '*Sanskari Nagri'* (City of Culture) (DCO, 2011b). It is 3rd most populated city after Ahmedabad and Surat (DES, 2019). It is situated between 21°50' and 22°50' latitudes and 72° 50' and 74°10' longitudes. It is surrounded by Panchmahal on north, Kheda and Anand on the north-west, Bharuch on West Narmada on South and Chhota Udepur on east. The total area of the district is about 7,512 sq. km (Anon, 2011c). In terms of area, it ranks 9th in the state. The population of the district is about 4,165,626 individuals (GFD, 2018). The major rivers of the district are Narmada, Vishwamitri and Mahi while the minor rivers include Surya, Jambuva and Dhadhar (DCO, 2011b).

The forest area of the district is 20.83 sq. km (FSI, 2019b). This indicates that the district has little forest area.