Study Area

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Gujarat State

CHAPTER - III

Gujarat is located between 20°01'-24°07'N latitudes and 68°04'-74°04'E longitude and covers an area of 195,984 km^2. Administratively, the state is divided into 33 districts (Anonymous 2020) whereas topographically it is divided into 3 major regions, namely the Mainland, Saurashtra region and Kachchh (Kulkarni 1985). Based on geology, climatic variation, forest types, soil, and drainage patterns of the state, it is further sub-divided into five regions *viz*., Saurashtra (Jamnagar, Morbi, Surendranagar, Rajkot, Porbandar, Junagadh, Amreli, Devbhoomi Dwarka, Gir Somnath, Bhavnagar and Botad), Kachchh (Kachchh), North (Mehsana, Arvalli, Sabarkantha, Banaskantha and Patan), Central (Gandhinagar, Ahmedabad, Kheda, Anand, Vadodara, Panchmahal, Chhota Udaipur, Dahod, Mahisagar, Bharuch and Narmada) and South Gujarat (Valsad, Dang, Navsari, Tapi and Surat) by Patel & Vyas (2019). Further, bio-geographically, the state is divided into six zones *viz*., 1) Desert; 2) Semi-Arid; 3) the Western Ghats (Malabar Plains); 4) the Western Ghats (Western Mountains); 5) Deccan Peninsula and 6) Coasts [Anonymous 2021c] (fig. 2).

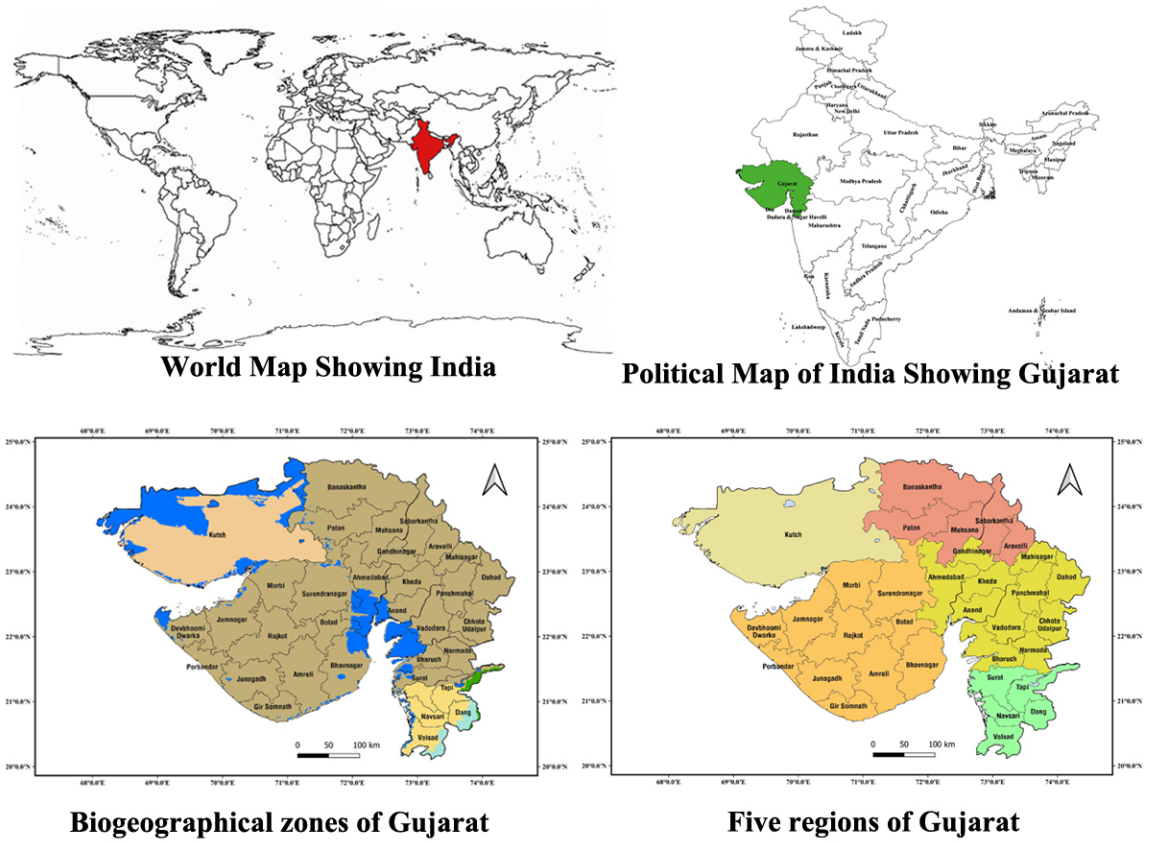

Figure 2: Showing study area - Gujarat state.

3.1 Topography of Gujarat:

Physically, the state shows a wide range of geographical features ranging from forest covers, drainage, desert, soil to the coastal and marine environment. In terms of topography, Gujarat shows wide range of variations. Physiographically, the state may be divided into three distinct regions *viz*., Peninsular Gujarat (southeastern land which is traditionally known as Saurashtra, comprises mainly low land to hilly regions), Kachchh (on the north-west) is a barren area including Rann of Kachchh and the mainland extending from the Rann of Kachchh and the Arvalli hills to the river Damanganga and consists of plains with alluvial soil.

3.1.1 The mainland of Gujarat (includes North, Central and South Gujarat) extends from Mount Abu (Rajasthan) in the north to Umbergaon (Maharashtra) in the south. This comprises chains of hilly ranges *viz*., Arvalli, Vindhya, Satpura and Sahyadri (the Western Ghats). The Arvalli mountain range stretches from north Gujarat in the southwest to the north in the capital city of the nation, Delhi in flexures of the fold. They are mainly composed of Quartzite, Phyllite, calc-silicate rock and granites (Kulkarni 1985). The Vindhya Mountain range starts in the east of Chhota Udaipur near Amba Dungar. The natural occurrence of fluorite, the Vindhya mountain ranges are economically important for the state whereas the Satpura Mountain ranges lie between the south of the Narmada River and Tapi basins. It is administer parallels to the Vindhya Range in the north. These ranges divide the Indian subcontinent in northern India by Indo-Gangetic plain and in the south by the Deccan Plateau (Kulkarni 1985). These hilly ranges mainly composed of quartzite. The Sahyadri ranges are also known as the Western Ghats. It is one of the world's imperative biodiversity hotspots along with Sri Lanka. Biogeographically, it is an important formation of the Gondwana land and includes a series of mountains ranges, which are almost parallel to west coast of India originating at north from Tapti (Tapi) river in Gujarat and run downwards through the states *i.e.* Maharashtra, Karnataka, Kerala, and reaches Kanyakumari in Tamil Nadu with several natural breaks (gaps) and passes. The Western Ghats covers a total of five districts of Gujarat state *viz*., Bharuch, Surat, Navsari, Valsad and Dangs (Nayar *et al*. 2014).

3.1.2 Saurashtra region is popularly known as Saurashtra or Kathiawar or Kathiawad province. This region is well-bounded by Arabian seawater on three sides *viz*., Gulf of Kachchh at the north and Little Rann side, the Arabian Sea at south and west side and Gulf of Khambhat (also known as Gulf of Cambay) in the south-east side. The soil is

alluvial type, similar to the Mainland of Gujarat. The Shatrunjaya and Girnar are the famous hills of this region while Gir and Barda are the famous protected forest areas of Saurashtra. Among these protected areas, Gir National Park is famous throughout the globe for Asiatic Lions. Rivers in this region flows from the central part toward the Rann of Kachchh, Arabian Sea, Gulf of Khambhat and the mainland of Gujarat.

3.1.3 The Kachchh region lies in the north-western part of the Gujarat state, which is an isolated and detached crescent-shaped landmass. It shares an international border with Pakistan. The region is bounded in the north by the Great Rann of Kachchh, south-east of the little Rann of Kachchh and in the south and south-west by the Arabian Sea. This region comprises small hills and undulating rocky areas. Soil is rich in minerals *viz*., Bauxite, Gypsum, Agate and Limestone (Kulkarni 1985).

3.2 Climate of Gujarat:

India including Gujarat state is deceptions in the north-eastern hemisphere of the globe, which lies in the tropical and sub-tropical zones. The climatic conditions are pretty diverse in the state of Gujarat. Mostly, the state has tropical climate *viz*., sub-humid, semi-arid to arid that spread over different regions of the state. North and north-west part of Gujarat receives arid climate (North Gujarat and Kachchh Region) Saurashtra and northern part of mainland region has a semi-arid climate, while the central and southern part of mainland falls under sub-humid climate region. The climate of the state is moderate with mean temperature ranging from 25^{o}C-28^{o}C and average rainfall from 800 mm to 1,000 mm. These features have bestowed the state with rich in floral and faunal diversity. The state has 33 districts out of which eight districts are tribal.

The unique geographical position of the state shows three different seasons' *viz*., monsoon, winter and summer. The winter season (November to February) is mild and dry, temperature fluctuating between 25-28ºC during day time and 10-12ºC at night. The summer season (March to June) is hot and dry, temperatures range between 44-47ºC during day time and 29-32ºC at night. The monsoon season (July to October) is mild and humid with average temperature ranging between 36-38ºC during daytime and 25-27ºC at night.

3.3 Rainfall in Gujarat State:

Rainfall in Gujarat is greatly variable over time and space leading to flooding situation while sometimes faces drought too. The average annual rainfall for the year 2013-19 of Gujarat state was recorded 1006.5, 605.6, 584.3, 604.9, 815.0, 485.3 and 1067.8 mm respectively (Kaur & Purohit 2014, 2016a, b; Purohit & Kaur 2017; Yadav *et*

al. 2018, 2020, 2021). The highest rainfall was received in the Valsad district *i.e*. 2804.1, 1970.1, 1461.2, 2459.1, 2705.8, 2302.1 and 3210.7 mm annually for the year 2013-19. Whereas, the lowest annual rainfall was recorded in the Kachchh district for the year 2013-18, *i.e*. 652.1, 290.8, 294.2, 493.3 and 131.2 mm and in 2019, 712.8 mm was lowest recorded for the Banaskantha district (Kaur & Purohit 2014, 2016a, b; Purohit & Kaur 2017; Yadav *et al*. 2018, 2020, 2021).

3.4 Forest Cover and Types:

According to the Forest Survey of India report (FSI 2019), Gujarat covers 14,857.33 km^2 area of forest, which is 7.57% of the state geographical area of the state. For the forest canopy density classes, the state has 377.90 km^2 (0.9%) under Very Dense Forest (VDF), 5,092 km^2 (2.60%) under Moderate Dense Forest (MDF) and 9,387.43 km^2 (4.78%) under Open Forest (OF). According to FSI (2019), district Kachchh covered a 2,345.29 km^2 area with the highest forest cover followed by Junagadh and the Dangs district with 1,693.31 km^2 and 1,362 km^2 respectively. The lowest forest cover is in the Anand district *i.e*. 50.48 km^2.

As per Champion & Seth (1968), forests in the state belongs to five major sub-groups *viz*., 3B (South Indian Moist Deciduous Forests), 4A (Littoral Forests), 4B (Swamp or Tidal Forests of (Southern Tropical Dry Deciduous Forests), 6B (Northern Tropical Thorn Forests, which are Mangroves) and 5A further divided into 31+1 (Champion & Seth 2005; FSI 2019). Different forest types are as follows.

3B: *South Indian Moist Deciduous Forests*

3B/C1b: Moist Teak Forest

3B/C1c: Slightly Moist Teak Forest

3B/C2: Southern Moist Mixed Deciduous Forest

3B/2S1: Southern Secondary Moist Mixed Deciduous Forest

4A: *Littoral Forests*

4A/L1: Littoral Forest

4B: *Tidal Swamp Forests*

4B/TS1: Mangrove Scrub

4B/TS2: Mangrove Forest

5A: *Southern Tropical Dry Deciduous Forests*

5A/C1a: Very Dry Teak Forest

5A/C1b: Dry Teak Forest

5A/C3: Southern Dry Mixed Deciduous Forest

5B: *Northern Tropical Dry Deciduous Forests*

5B/C2: Northern Dry Mixed Deciduous Forest

Degradation Stage of Dry Deciduous Forests

5/DS1: Dry Deciduous Scrub

5/DS2: Dry savannah forest

5/DS3: *Euphorbia* scrub

5/DS4: Dry Grassland

Edaphic Climax Types in Dry Deciduous Forests

5/E1: *Anogeissus pendula* Forest

5/E2: *Boswellia* Forest

5/E3: Babul Forest

5/E5: *Butea* Forest

5/E8c: *Salvadora - Tamarix* Scrub

5/E9: Dry Bamboo Brake

Seral Types of Dry Deciduous Forests

Primary Seral Types

5/1S1: Dry Tropical Riverain Forest

Secondary Seral Types

5/2S1: Secondary Dry Deciduous Forest

6B: *Northern Tropical Thorn Forests*

6B/C1: Desert Thorn Forest

6B/DS1: *Ziziphus* Scrub

6B/DS2: Tropical *Euphorbia* Scrub

Edaphic and Degradation Types of Thorn Forests

6/E2: *Acacia senegal* Forest

6/E3: Rann Saline Thorn Forest

6/E4: *Salvadora* Scrub

6/DS1: *Cassia auriculata* Scrub

6/1S1: Desert Dune Scrub

Plantation/Trees Outside the Forests (TOF)

3.5 Wetlands of Gujarat:

Wetlands are the inland or coastal water ecosystem where the area remains waterlogged or overwhelmed with water permanently or seasonally, they are the discrete ecosystems. In India, Gujarat stands as a third state after Andaman & Nicobar Islands

(18.52%) and Daman & Diu (18.46%) as its wetland area contributes an unmatchable area of 34,749.50 km^2 in Gujarat state (17.56%) of the country (SAC-ISRO 2011; ISFR 2019). Wetlands in the state are natural or man-made, inland or Coastal wetlands comprise Lakes, Ponds, Waterlogged, River/Stream, Reservoirs, Barrage, Tanks, Salt Pan, Salt Marshes, Lagoon, Creek, Beaches, Intertidal Mud Flat, Mangroves and Coral Reefs. The coastal wetlands are dominating the state includes intertidal mudflat (22,603.65 km^2), creek (1,498.98 km^2) and salt marsh (1,442.68 km^2). Besides coastal wetlands, inland wetlands include rivers or streams (2,758.77 km^2) and reservoir or barrage (2,489.79 km^2) is the major wetlands in the state. Area wise, Kachchh district has the highest wetland (23609.09 km^2) followed by Jamnagar (1986.56 km^2) and Bharuch (1124.53 km^2). The lowest area of wetland encompasses Gandhinagar which is 42.63 km^2 (SAC-ISRO 2011). Eight major wetlands occur in the state *viz*., Nalsarovar lake, Khijadiya wetland, Pariej Irrigation Reservoir, Vadhvana Irrigation Reservoir, Thol Irrigation Reservoir, Nani Kakrad, Great Rann of Kachchh and Little Rann of Kachchh.

3.6 Drainage and Water Resources of Gujarat:

Gujarat is encompassing several natural and man-made water resources *viz*., oceans, rivers, lakes, streams, ponds, wells and step wells. North Gujarat has three major rivers basins, namely, Sabarmati, Rupen and Saraswati, all these are seasonal rivers. The minor rivers of this region are Sipu, Khari, Meshwa, Hathmati, Harnav, Majham and Watrak. Central Gujarat receives moderate rainfall and topographically possesses comparatively steeper slope, these regions have perennial rivers like Mahi and Narmada that bring runoff from their upper catchments located in Rajasthan and Madhya Pradesh, respectively. The main tributary rivers of Mahi are Shedhi and Panam. The Dhadhar river originates from Pavagadh hills and runs south-west side and join the sea in the south of the Gulf of Khambhat. Orsang is a tributary river of Narmada. The major rivers of south Gujarat are Tapi, Purna, Ambica, Par, Kolak and Damnganga. Tapi originates from the part of central India (Satpura ranges, Madhya Pradesh) and runs west side towards south Gujarat to the Arabian Sea. Other rivers of south Gujarat originate from the Sahyadri ranges and flowing west side towards the Arabian Sea. Saurashtra has several large and small seasonal rivers constituting about 84 river basins. The major rivers are Shetrunji, Machhu and Bhadar. The northerly flowing important rivers draining into the little Rann and/or Gulf of Kachchh are Aji, Machhu, Morvi, Malia, Bambhan and Phulka, Und, Dhrol, Rangmati, Sasoi, Phulzer and Ghi. In the Southwestern or southwardly flowing rivers are Bhadar, Bhogat, Wartu, Ozat,

Maduvanti, Megal, Hiran, Saraswati and Shingoda. On the east side flowing rivers are two Bhogawo rivers. South-east or south side flowing small rivers of Saurashtra are Malan, Rawal, Machhundri and Dhatarwadi. Kachchh has a small rivulet carrying a small amount of seasonal river flow. All of them start from the central portion due to the hilly ranges that form watersheds. Some rivers flow towards the south to the Arabian Sea, some others flowing towards the north in the Rann of Kachchh, some flows towards the south-east side in the Little Rann of Kachchh. The main rivers of Kachchh are Bhukhi, Kaila, Kankavati, Khari, Matiiweriwali, Nara, Niruna, Rukmavati, etc. A higher rainfall for a short duration causes flash floods in this region.

3.7 Soil of the state:

The state is bestowed with a wide range of micro and macroclimates of soil. The soil system has developed over many millions of years. The major soil types of Gujarat state are alluvial soil, black soil, lateritic, hill soils and desert soils (Kulkarni 1985).

Alluvial soil further divides into alluvial sandy to sandy loam soils, alluvial sandy loam to sandy clay loam and coastal alluvial soils. Sandy loam soils to alluvial sandy are known to occur in the regions of north Gujarat area mainly in Banaskantha and Mehsana district. This type of soil is formed by wind blowing from the Kachchh desert. Alluvial sandy loam to sandy clay loam soil found in Ahmadabad, Kheda, Gandhinagar, Mehsana and Vadodara. This type of soil is less productive and having a small amount of Potassium. Coastal alluvial soils are known to occur in the coastal area of Saurashtra, Kachchh and the South Gujarat area. The texture of this type of soil is sandy clay loam to clay in nature.

Black soil is the dominating soil type divided into four sub-types of soils *viz*., shallow black soils, medium black soil, deep black soils and mixed red and black soils. Shallow black soils are found in the Saurashtra and central Gujarat area. This type of soil is light grey in color and poor infertility because of sandy clay loam texture. Medium black soil is known to occur in Sabarkantha and Panchmahal district. This type of soil is calcareous in nature. Its texture is slightly silt loam to clay type. Deep black soil is found in Ahmedabad, Kheda, Anand, Bharuch, Surat, Valsad, Vadodara, Junagadh and Porbandar. This type of soil is dark brown to very dark greyish brown. The texture is clay-like, which is the most fertile soil of the state. Mixed red and black soil is found in some parts of south Gujarat. The texture of this type of soil is clay loam to clay, with stony material. In actual term, lateritic soil is not naturally found in the state. However, there is dense forest vegetation and heavy rain (precipitation) leads to the formation of

these soil types. This is particularly found in Valsad and the Dangs district. Hill soil is found in the hilly eastern belt of the north, central and south Gujarat area. This type of soil is shallow and composed of under composed rock fragments, which is poor in fertility. In the little and greater desert of Kachchh, Desert soil is found naturally. The soil is deep to light grey in color. It is a sandy-sandy loam through silt clay loam. This type of soil has highest content of salt and is very rich in gypsum.