CHAPTER 3
STUDY AREA AND DATA COLLECTION

3.1 GENERAL

This chapter contains the brief idea of Water Resources in Gujarat, Climate of Gujarat and overview of sub-agroclimatic zones of Gujarat. Thereafter, the description of the study area and the data required for the study are provided.

3.2 WATER RESOURCES OF GUJARAT

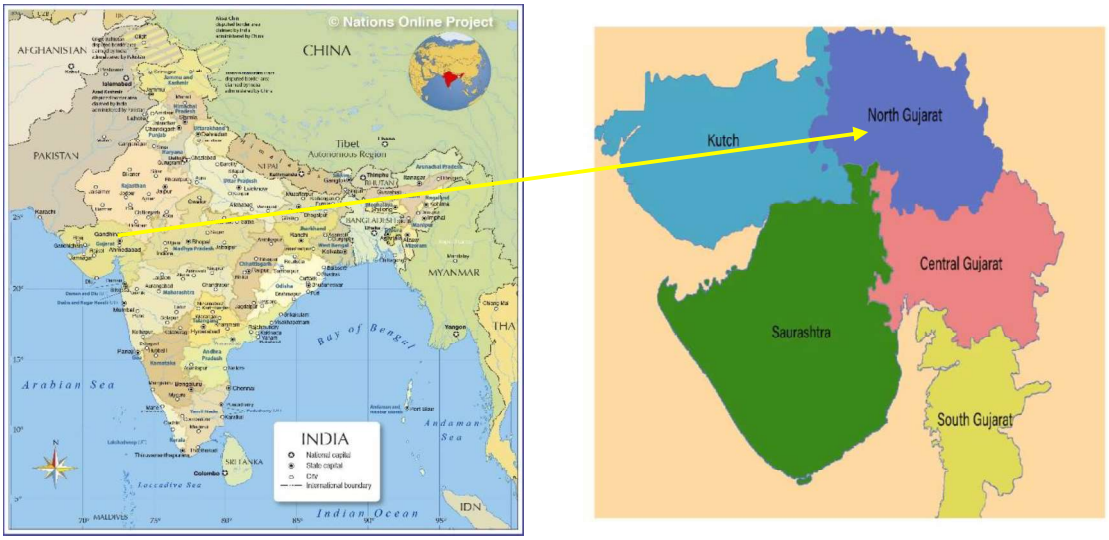

Figure 3.1: District Map of Gujarat

The main source of water for Gujarat is surface water. The State has 185 river basins and the available quota of water in the State is 55608 million cubic meters, out of which, 38100 million cubic meters is surface water, which is only 2% of the entire quota of surface water of the country. Moreover, the available quota of surface water is also not distributed properly. Gujarat, Saurashtra and Kutch have water resources of 89%, 9% and 2% respectively, against this, the total geographical area of these regions is 45%, 31% and 24% respectively. The underground water resources of State are 17508 million cubic meters. Above Figure 3.1 shows the district map of Gujarat state

The quota of available surface and underground water is used for drinking purpose, industries, agriculture and hydral power, fisheries etc. Out of which, nearly 80% quota is used for agricultural production, in which irrigation also plays an important role.

3.3 WATER RESOURCES OF NORTH GUJARAT

North Gujarat constitutes 23 percent area of Gujarat state where 34 percent of population lives. The biggest problem in agriculture and domestic life is “Water” for drinking and irrigation. Average rainfall of the whole region is 600 mm. It varies a lot and is the highest (around 900 mm) in eastern part of north Gujarat. It reduces as one proceeds towards west. The agricultural situations in north Gujarat are marked by erratic rains in quantum and space that often leads to scarcity conditions especially in less rain endowed areas like Banaskantha, Sabarkantha and part of Patan.

North Gujarat, Saurashtra and Kutch regions of the State are scarcity-prone areas having a famine condition almost every two to three years, whereas the South Gujarat faces a heavy damage human life and property due to flood situation almost every year. Moreover, valuable quota of water drains out in the ocean. The State has faced severe famines during 1972-73, 1985-88 and 1999-2000.

Despite proportion of irrigated area of cultivated land in north Gujarat is more (49%) than Gujarat (32%) yet it faces severe scarcity of water availability as compared to other regions of Gujarat. Major source of irrigation is ground water. Dug wells and tube wells are the major source of irrigation and consummately cover over 88 % of the irrigation resources as compared to 80% irrigation water supply through wells in Gujarat.

Only 15 % of the rainfall percolates in the soil there by storing over 225 crore cubic meters of rain water annually as ground water. The withdrawal of ground water is 350 crore cubic meters per annum thereby creating an average annual deficit of ground water as 125 crore cubic meters. Surface water availability per capita in north Gujarat is 124 cubic meters per year as compared to 735 and 274 cubic meters per year in South & Central Gujarat and Saurashtra, respectively. Thus north Gujarat is the most stigmatic for the over withdrawal of ground water with water lift in many talukas particularly in Mehsana district having approached critical level of over 500 m. Due to over withdrawal of ground water, ground water table has been going down by 2 to 4 meters per year.

3.4 CLIMATE OF GUJARAT

The climate of Gujarat is also varied and can be divided into three seasons:

(1) Hot and dry season from May to June;
(2) Warm and rainy season from June to September; and
(3) Cool and dry post-rainy season from October to April (Agro climatology of Gujarat).

The north-western part of the state is dry, with less than 500 mm of rain every year. In the more temperate central part of the state, the annual rainfall is more than 700 mm. In the southern part, rainfall averages 2000 mm per year. Incidence and distribution of rainfall, particularly in Saurashtra and Kutch regions and in the northern part of Gujarat is highly erratic.

As a result, these regions are very often subjected to drought. Most of the rain (90-95% of the annual total) falls during the period of June to September, when the southwest monsoon prevails. The north- west monsoon does not occur in Gujarat state. In the winter temperatures averages between 12º and 27º. In the summer temperatures average between 25º and 46º and have been known to reach as high as 48ºC.

3.5 AGRICULTURE SCENARIO OF NORTH GUJARAT

North Gujarat is described as arid and semi-arid region with high temperatures. The rainy season being short (July–August), the biggest problem in both agriculture and daily life is water. The water is very precious due to scarce and bad quality of ground water. The high temperatures, sandy soils, scarce water and high wind velocity combined together make very precarious agricultural situation in the region that often leads to water stress during post–anthesis and grain development period in Kharif crops. Contrarily, high temperatures, both during seeding and maturity, are the main yield–limiting factors in Rabi crops. The summer and spring crops are feasible only where water is available. As such the selection of crop depends primarily on quantum and distribution of rainfall, water availability, appropriate temperature window and such other natural resources.

3.6 SUBAGROCLIMATIC ZONES OF GUJARAT

The Subagroclimatic zones of Gujarat is discussed here and Figure 3.2 shows of different subagroclimatic zones of Gujarat.

Southern Hills
This is small but largely a tribal belt covering the districts of the Dangs and Valsad. The area receives about 1793 mm of rains and the climate is semiarid, dry, sub humid, and the soil is deep black, coastal alluvium. About 43 % of the area is under forests and a similar proportion is cultivated. Irrigation is spread over about 24 % of the cultivated area.

Southern Gujarat
This subzone, covering the districts of Surat and Bharuch, has seen rapid industrial development in the recent decade or so. Over half of the land is cultivated and about a fifth of the cultivated area is irrigated. The area receives little less than 974 mm of

annual rainfall. The climate is semiarid, dry, subhumid, and the soil is deep black, coastal alluvium.

Middle Gujarat

Although this area is well developed industrially, it is also the most agrarian in Gujarat. Nearly two-thirds of the area is under cultivation and nearly a third of this is irrigated. Rains reduce progressively as one moves into North Gujarat. In the middle areas, which include Vadodara, Panch Mahals, and Kheda districts, the precipitation is of the order of 904 mm annually. The climate is semiarid and the soil is medium black.

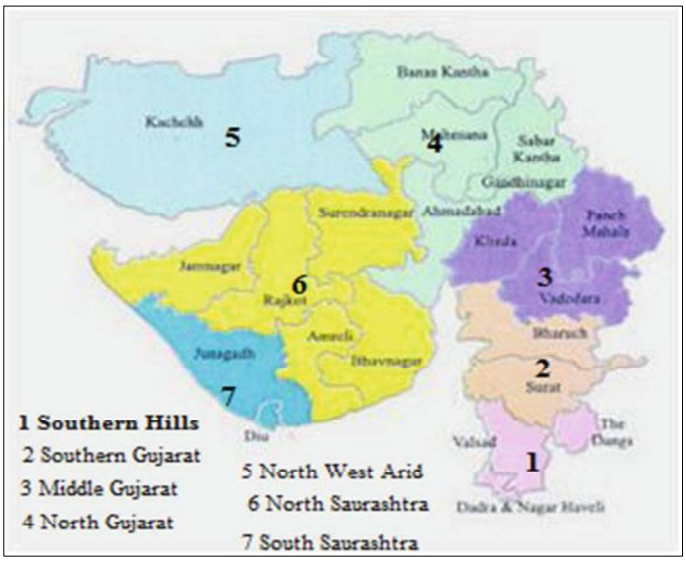

Figure 3.2: Sub Agroclimatic zones of Gujarat

North Gujarat

This subzone covers Banaskantha, Mehsana, Sabarkantha, Gandhinagar, and Patan districts. Land productivity is very low. Rainfall is only around 735 mm per annum. The climate is arid to semiarid and the soil is gray brown coastal alluvium. About 63 % of the area is cultivated and a little over a third of this is irrigated. The chief source of irrigation is ground water. However, in some areas, there is overdrawal of ground water.

Northwest Arid

This is the vast expanse of the Kachchh district. Rainfall is only about 340 mm per annum, the climate is arid to semiarid and the soil is gray brown, deltaic alluvium. Less than 13 % of the area is cultivated. Nearly one-third of the geographical area is wastelands.

North Saurashtra

This subzone includes the districts of Amreli, Bhavnagar, Jamnagar, Rajkot, and Surendranagar. The region receives 537 mm of rainfall and the climate is dry,

subhumid. The soil is medium black calcareous. About 63 % of the area is cultivated, of which 24 % is irrigated. Agricultural productivity is relatively high in Saurashtra essentially because of the cultivation of groundnut in this region.

South Saurashtra

The South Saurashtra subzone includes only the district of Junagadh at the southwestern end of the state. This area receives little better rain than the nonsouth Gujarat parts of the state. The annual precipitation is about 844 mm, the climate is dry, subhumid, and the soil is coastal alluvium, medium black. About 56 % of the region is cultivated.

From the above subagroclimatic zones North Gujarat is chosen for study. The description of study area is given below section.

3.7 DETAILS OF NORTH GUJARAT DISTRICTS

The details of North Gujarat districts is discussed below. Also, the districts of North Gujarat is shown in Figure 3.3

Figure 3.3:Districts of North Gujarat

Districts of North Gujarat

1. Banaskantha
2. Gandhinagar
3. Mehsana
4. Patan
5. Sabarkantha

Banaskantha District

Banaskantha district is situated between 23° 33' to 24° 45' North latitude and 72° 15' to 73° 87' East longitude. Banaskantha District includes the area around the Bank of Banas River. The administrative headquarters of the district is Palanpur is also a largest city. The Geographical area of the Banaskantha district is 10630 km^2. The annual average rainfall of Banaskantha district is 863.01 mm and average temperature of Banaskantha district is 26.97° C. The district map of Banaskantha district is shown in below Figure 3.4

Figure 3.4: District map of Banaskantha

Gandhinagar District

The Geographical location of the Gandhinagar district is 23º 21’ North latitude and 72º 63’ East longitude. Gandhinagar district is an administrative division of Gujarat and the state capital. The Geographical area of the area of 1728 km².The Main River passing through is meshvo and Sabarmati. The southwest monsoon brings a humid climate from mid-June to mid-September., The average annual rainfall is around 803.4 mm. The average maximum temperature is around 29°C, the average minimum is 14°C.The district map of Gandhinagar district is shown in below Figure 3.5

Figure 3.5: District map of Gandhinagar

Mehsana District

Mehsana, Gujarat, India lies between 23º 58' North latitude and 72º 36' East longitude. Mehsana district borders with Banaskantha district in the north, Patan and Surendranagar districts in west, Gandhinagar and Ahmedabad districts in south and Sabarkantha district in the east. Mehsana, Gujarat district elevation is 83 meters height that is equal to 272 feet. The district has an area of over 4391 km^2.The average rainfall in Mehsana district is 697 mm. The maximum temperature of the district is 43º and the minimum temperature is 12.3º. The district map of Mehsana district is shown in below Figure 3.6

Figure 3.6: District Map of Mehsana

Patan District

Patan is a district in Northeast of Gujarat state of India. Geographical location of the district is 23º 83' North latitude and 72º 12' East longitude. The district occupies an area of 6023 km². The climate of this district is characterized by a hot summer and general dryness in the major part of the year. Summer is very hot and winter is too cold. The cold season is from December to February. After February there is rapid increase in the temperature. May is the hottest month. The River flowing through Patan district is Banas. The average rainfall in Patan district is 630 mm. The maximum temperature of the place is 44.28º and the minimum temperature is 18º. The district map of Patan district is shown in below Figure 3.7

Figure 3.7: District Map of Patan

Sabarkantha District

The Sabarkantha district is the part of North Gujarat and lies between 23º 03' to 24º 30' North latitude and 72º 43' to 73º 39' East longitude and, covering an area of 4188 km^2.It is surrounded by Banaskantha and Mehsana districts in the west; Ahmedabad, Gandhinagar, Kheda and Panchmahals districts in the south and Sirohi, Udaipur and Dungarpur districts (Rajasthan) in the north and east. Hathmati, Sabarmati, Khari, Meshwo, Vatrak, Mazum, and Harnav are the main rivers flowing through this district. The climate of this district is characterized by a hot summer and dryness in the non-rainy seasons. The annual rainfall varies between 214 mm to 1,801 mm. The annual average rainfall is 863.01 mm and average temperature is 26.97º C. The district map of Sabarkantha district is shown in below Figure 3.8

Figure 3.8: District map of Sabarkantha

3.8 DATA COLLECTION AND SOURCES

The Meteorological data for North Gujarat region has been procured from India Meteorological Department (IMD), Pune. It consisted of the monthly precipitation, maximum temperature, minimum temperature, relative humidity, potential evapotranspiration are collected from 1901 to 2002, total of 102 years. These monthly climatological records have been used to identify the Meteorological drought years and rainfall deficient seasons over North Gujarat districts.

Similarly for hydrological and agricultural drought analysis various band data collected from Landsat 5 images for 1992 to 2005, Landsat 7 band images for 2005 to 2012 and Landsat 8 band images for 2013 to 2019 from the satellite sources. These Landsat images data collected for months of March, April and May. These months reflect the highest vegetation variation per year so the analysis and drought severity will be assessed during this period. The sources of satellite images data and sensor ID, Path/Row is shown in below Table 3.1.

Table 3.1: Satellite Images data with Path and Row

Satellite/ Spacecraft ID	Sensor ID	Path/Row	Spatial Resolution
Landsat 5	TM	148/43, 148/44 149/43, 149/44	30m
Landsat 7	ETM+	148/43, 148/44 149/43, 149/44	30m
Landsat 8	OLI_TIRS	148/43, 148/44 149/43, 149/44	30m

In order to achieve the aim of the study, satellite image, were downloaded from the U.S. Geological Survey website (i.e., landsat.usgs.gov). Landsat 4 and 5 (launched on 16 July 1982 and 1 March 1984, respectively) containing 28 satellite images; Landsat 7 (launched on 15 April 1999) including 26 satellite images; and Landsat 8 (launched on 11 February 2013) with 11 satellite images. Landsat images are a collection of high resolution satellite imagery, with a spatial resolution of 30 m. Below Table shows detail description of various Landsat images band characteristics.

Landsat 4-5 Thematic Mapper (TM) images consist of seven spectral bands with a spatial resolution of 30 meters for Bands 1 to 5 and 7. Spatial resolution for Band 6(thermal infrared) is 120 meters, but is resampled to 30-meter pixels. Approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi). Below Table 3.2 shows the Landsat 4-5 Band Characteristics in detail.

Table 3.2: Landsat 4-5 Band Characteristics

Band No.	Description	Wavelength (mm)	Band No.	Description	Wavelength (mm)
1	Blue	0.45-0.52	**5**	Shortwave Infrared (SWIR) 1	1.55-1.75
2	Green	0.52-0.60	**6**	Thermal	10.40-12.50
3	Red	0.63-0.69	**7**	Shortwave Infrared (SWIR) 2	2.08-2.35
4	Near Infrared (NIR)	0.76-0.90			

Landsat 7 Enhanced Thematic Mapper Plus (ETM+) images consist of eight spectral bands with a spatial resolution of 30 meters for Bands 1 to 7. The resolution for Band8 (panchromatic) is 15 meters. All bands can collect one of two gain settings (high or low) for increased radiometric sensitivity and dynamic range, while Band 6 collects both high and low gain for all scenes. Approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi).Below Table 3.3 shows Landsat 7 Band Characteristics in detail.

Table 3.3: Landsat 7 Band Characteristics

Band No.	Description	Wavelength (mm)	Band No.	Description	Wavelength (mm)
1	Blue	0.45-0.52	**5**	Shortwave Infrared (SWIR) 1	1.55-1.75
2	Green	0.52-0.60	**6**	Thermal	10.40-12.50
3	Red	0.63-0.69	**7**	Shortwave Infrared (SWIR) 2	2.09-2.35
4	Near Infrared (NIR)	0.77-0.90	**8**	Panchromatic	0.52-0.90

Landsat 8 Operational Land Imager (OLI) **and Thermal Infrared Sensor** (TIRS) images consist of nine spectral bands with a spatial resolution of 30 meters for Bands1 to 7 and 9. New band 1 (ultra-blue) is useful for coastal and aerosol studies. New band 9 is useful for cirrus cloud detection. The resolution for Band 8 (panchromatic) is 15 meters. Thermal bands 10 and 11 are useful in providing more accurate surface temperatures and are collected at 100 meters. Approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi). Below Table 3.4 shows Landsat 8 Band Characteristics in detail.

Table 3.4: Landsat 8 Band Characteristics

Band No.	Description	Wavelength (mm)	Band No.	Description	Wavelength (mm)
1	Coastal	0.430 - 0.450	**6**	SWIR 1	1.570 – 1.650

	Aerosol				
2	Blue	0.450 - 0.510	**7**	SWIR 2	2.110 – 2.290
3	Green	0.530 - 0.590	**8**	Panchromatic	0.500 – 0.680
4	Red	0.640 - 0.670	**9**	Cirrus	1.360 – 1.380
5	Near Infrared	0.850 - 0.880	**10**	TIRS 1	10.60 – 11.19
			11	TIRS 2	11.50 – 12.51

For the present study various data is collected from the different online sources and organizations is mention as below.

- http://www.indiawaterportal.org/
- http://www.imd.gov.in/
- www.earthexplorer.usgs.gov
- www.landviewer.org