Abstract of the Chapter:

Drought caused due to deficiency of rainfall is a complex natural hazard. Unlike other environmental disasters, it starts slowly, has a long duration and covers a vast area. In India, it upsets the country's food security by seriously affecting our agricultural economy, which is heavily dependent on monsoon. The Government of India has declared seventy six districts of the country as drought prone. Drought causes economic, social and environmental loss quite frequently. Management of drought needs proper storage and usage of rain and ground water in drought prone areas.
CHAPTER - I
INTRODUCTION

Water is among the most fundamental requirements that nature provides to sustain life for plants, animals and humans. The total quantity of fresh water on earth could satisfy all the needs of life over the earth if it were evenly distributed and accessible. But the fact is water is not evenly distributed or accessible to large section of global population. Unbalanced water distribution causes flood and drought in a region. Proper storage and usage of water for livelihood are the managemental aspect of this study, which is very much relevant in a drought prone state of Gujarat.

A. DROUGHT AS A NATURAL HAZARD
A.1. Meaning Of Drought:
Drought or a distressed situation caused by lack of rainfall, is a deadly natural environmental hazard. It is directly related to one of the basic requirements of any form of life (i.e. water, air and food) that is, water and is indirectly related to food because crops and other plants and animals exclusively depend on water. Droughts resulting from accumulative effect of water scarcity cause extensive and enormous damage to agriculture and natural vegetation and therefore cause famine and starvation to human and animal population of the region concerned.

The meaning and definition of drought is a difficult proposition because there are many variations in the interpretation of drought from one region to another and also from one person to another. Drought clearly involves a shortage of water (water supply minus water need), but can really be defined only in terms of a particular need. The most common view of drought is a deficiency of rainfall, but the link between rainfall and water, which becomes available to meet a demand is complex. Therefore definition of drought relates not only to water needs but also to the complex set of factors involved to supply that need through the hydrological cycle. Thus, not the amount of total annual rainfall that matters for drought or flood conditions, (which are the two extremes of hydrological cycle) rather it is the regularity and irregularity of rainfall that matters more. For example, a more persistent and reliable amount of 200 MM. of annual rainfall may not be the cause of concern of agriculturists in a dry region because their agricultural activities would be adopted to this meager amount of rainfall, but receipt of

*Numbers in the text indicate the relevant references in the bibliography
only 200 MM. of annual rainfall for a few years in continuation or even in a single year in those areas that receive normal annual rainfall of 800 MM. to 500 MM. can cause crop failure and consequently disastrous drought conditions may prevail. Thus, it can be said, that drought is related to the failure of the usual rains at a particular time and place, since most activities using water will be geared to that which is normally available (J.B.Hobbs, 1980).

It is thus obvious that, rainfall is the main parameter for the determination of droughts, but rainfall values, however, have limitations as drought indicators. So many definitions and indices incorporate other parameters such as evaporation, run-off humidity, air temperature, solar radiation, wind, soil, moisture, stream flow and plant conditions (J.B.Hobbs 1980).

Most of the definitions of drought are based on the parameters of precipitation, which are as follows:-

a) **C.G.Bates** -- Annual precipitation is 75% or less of normal precipitation and monthly precipitation is 60% or less of normal monthly precipitation.

b) **J.C.Hovt** -- Annual and monthly rainfall is less than 85% of normal rainfall.

c) **D.A.Ramdas** -- Drought is an occasion when the actual rainfall fell short of the normal by more than twice the mean deviation.

d) **Tannehill** -- Drought belongs to the class of phenomenon which is popularly known as 'spells of weather'.

e) **Hoy** -- In humid and semi-arid climate, droughts do not occur until the annual precipitation is as low as eighty-five percent of the mean.

f) **Linsley** -- Drought is a sustained period of time without significant rainfall.

g) **Thomas** -- A drought is a meteorological phenomenon and occurs when precipitation is less than the average and when deficiency is great enough and longs enough to hurt people.

h) Henry (1906), Gibbs and Mahar (1967), Cocheme and Frequin (1967) etc. have also considered rainfall as the best indicator of drought.

i) Among the definitions used in the USA -- A year having less than 85 percent of the normal precipitation; a period of at least 21 days when the precipitation is less than 30 percent of the normal.

j) In **European Russia** -- Drought is a period of 10 days with a total rainfall not exceeding 0.2".
k) British Rainfall Organization --

   i. **Absolute Drought**: When there are at least 15 consecutive days with less than 0.01 inch of rainfall per day.

   ii. **Partial Drought**: When there are at least 29 days having mean rainfall of 0.01 inch or less.

   iii. **Dry Spell**: When 15 consecutive days receive less than 0.04 inch of rainfall per day.

All the aforesaid definitions are based on rainfall. It is true that rainfall is the crucial variable to identify drought in a region, but on the basis of rainfall the intensity of drought cannot be measured, because the other variables like temperature, wind velocity, sunshine, evapo-transpiration, soil texture, stage of crop growth and antecedent rainfall also contribute a lot to produce the situation of drought. Therefore many of the definitions are based on the factors other than rainfall, are as follows:

a) **Landsberg** -- Drought is a biological phenomenon rather than a climatic phenomenon, and it shall be defined separately for each plant species and soil environment.

b) **Shastry** -- Drought begins when plant can no longer recoup water from the soil as quickly as it is lost by transpiration.

   But the same condition can prevail due to the human induced factor for which the water table of an area is depleted, so the plant also cannot receive enough water for their sustenance.

c) **Thornthwaite and Mather** -- As per their water balance approach, drought is a situation in which the amount of water needed for maximum evapo-transpiration exceeds the amount obtainable by precipitation and from soil.

d) **American Meteorological Society** -- Drought is a period of abnormally dry weather sufficiently prolonged for lack of water to cause hydrologic imbalance (i.e. crop damage, water supply shortage etc.) in the affected area.

e) **Russel** -- Drought in Australia is a period of months or years during which little rain falls and country gets burnt up, grass and water disappear, crop become worthless and sheep and cattle die.

f) **Maunder** -- Drought is a period of moisture deficiency, as the amount of water needed for evapo-transpiration exceeds the amount available in the soil.

g) **C.H.M. Van Baval** -- Drought exist on those days when available soil moisture is equal to or less than the needed for satisfactory growth of the dominant crops.

h) **James and Gallegher** -- Drought is an economic situation recognizable in crop failure.
The area which has evenly distributed rainfall throughout the year and where irrigation is not practiced, a dry period of a several weeks may constitute a serious agricultural drought. On the other hand, country like India and many of the other tropical and sub-tropical countries, which receive most of the rainfall during the rainy season (June - September) and their agricultural practices are associated with distinct seasonal water regime, failure of monsoon adversely affects "kharif crops" and causes drought conditions. According to India Meteorological Department (I.M.D.), the drought in India is a situation occurring in any area when the mean rainfall of a year is less than 75% of the mean annual rainfall. I.M.D. classified drought in two broad categories:-

i. **Severe Drought**: When the deficiency of rainfall exceeds 50% of the normal rainfall.

ii. **Moderate Drought**: When the deficiency of rainfall is between 25% and 50% of the normal rainfall.

As per the Irrigation Commission(1962), drought is the result of an imbalance between the soil moisture and evapo-transpiration needs of an area over a fairly long period, so as to cause damage to the standing crop and reduction in crop yield. The rainfall plays the key role and the crucial variables are its distribution, its variability and its capacity to meet the evapo-transpiration needs. The Irrigation Commission has identified the drought affected areas as those areas with a rainfall less than 19 c.m. and even 75% of this rainfall is not received in 20% or more of the years and where irrigation is less than 30% of the cropped areas.

Meaning of drought also depends upon the uses and **expectations of the people**, which are as follows:

From the point of view of an agriculturist, drought is a 'demand' situation when inadequate availability of moisture for the growing crops severely affects the total agricultural yield. From a meteorologist's point of view, it is a situation of scant and erratic rainfall resulting in unavailability of minimum required moistures for the crops. Again for a hydrologist, it is a situation of receded ground water level below 15 meter of depth, rendering it unavailable for the use of common people.

A.2. **Drought And Other Hazards Related To The Shortage Of Water**:
Drought is mainly confused with aridity, water shortages or desertification But there is quite a difference in the meaning of drought and other various categories of dryness (Figure No. 1.1.) -
a. **Aridity**: It is a permanent natural condition and a stable climatic feature of a given region. The main features of aridity are:
   i. Overall low moisture
   ii. High solar energy
   iii. Extreme variations in daily temperature
   iv. Highly variable precipitation in time and space
   v. Low annual mean rainfall
   vi. Low carrying capacity of land

b. **Drought**: It refers to a temporary feature of climate or to regular or unpredictable climatic changes. The main characteristics of drought are:
   i. Low rainfall as compared to normal mean rainfall
   ii. Uncertain frequency, duration and severity of rainfall
   iii. Unpredictable occurrence of rainfall
   iv. Overall diminished water resources
   v. Diminished average carrying capacity of ecosystem

c. **Water shortages**: Water shortages occur because of man induced work, reflecting the problem with temporary water deficiencies in small area, especially in dry season. The main characteristics of water shortages are:
   i. Ground water overdraft
   ii. Reduced capacities in reservoir
   iii. Increased run-off
   iv. Decreased recharge
   v. Altered carrying capacity

d. **Desertification**: It is a part of process of alteration of the ecological regime often associated with aridity or drought but also can be brought by man-made activities which change the surrounding environment to a significant degree. The main features of desertification are:
   i. Loss of soil nutrients
   ii. Damaged soil surface and sub-surface, resulting overuse of land resources
   iii. Increased flash flooding and runoff
iv. Desertification and loss of carrying capacity of soil.
v. Receding of ground water resources.
vi. Increase in salinization.

To bring out the differences of drought with other various categories of dryness, it is organized along with the conceptual categories.

Figure No. 1.1.
Types Of Xeric Regime

<table>
<thead>
<tr>
<th>Temporary water balances</th>
<th>Permanent deficiencies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drought</strong></td>
<td><strong>Aridity</strong> (or desert)</td>
</tr>
<tr>
<td><strong>Xerisia</strong> or dryness</td>
<td><strong>Desertification</strong></td>
</tr>
</tbody>
</table>

Source: Model by Vujca Yevjrvich in 'Coping with Drought' [99]

A.3. **Drought And Famine:**

Just as poor rainfall is not the single and direct cause of drought, drought is not the single and direct cause of famine. It is true that famine is a result of drought in a region which has diminished the water resource and food products but a natural hazard which affects the crop of an agricultural region can also bring a famine. People do not starve in a drought related famine simply because there is not enough production of food, but also due to the unavailability of food in a region.

The International Labour Organisation (ILO) studied the famines in Bengal (1943), Ethiopia (1973) and Bangladesh (1974). It is found that famine had its victims by class and occupation. There are many other factors at work, besides scarcity of food. During 1942, total food stocks were below the level in Bengal, but were within the normal range of fluctuation. Due to the wartime inflation, the purchasing
power of the people was decreased. So, they could not buy enough food for them. In Ethiopia, the lack of food was a highly localised phenomenon. Richer farmers had dismissed labourers and household staff because of low yields, so there were no wages to buy food. Dr. John Rivers of International Disaster Institute explained that throughout the famine, Ethiopia was a net exporter of food. In Bangladesh, there was actually more food available during 1974 per person, than in famine years. But flood had disrupted local industries and thus people lost their employment opportunities and naturally people could not buy their food.

In each case, people's options to purchase food were diminished. Those who suffered most were the landless labourers and the pastoralists, who had to sell their cattle, to survive, at a time when there was no market for cattle.

B. TYPES OF DROUGHT
Types of drought are classified in various ways, taking different parameters related to physical and climatic characteristic of an area. The principal characteristic is rainfall as drought is directly related to water scarcity.

Here types of drought are classified in three different groups:

1. Drought due to scarce rainfall.
2. Drought depending on the universal hydrological cycle.

B.1. Drought Due To Scarce Rainfall:
Scientists have tried to define a distressed situation caused by lack of water into three categories of drought depending on the meteorological, hydrological and agricultural aspects. In general terms they are:

a. **Meteorological Drought**: Meteorological drought is a situation when the actual rainfalls do not arrive in time or less than the climatologically expected rainfall over a wide area.

b. **Hydrological Drought**: Hydrological Drought is associated with marked depletion of surface water and consequent drying up of lakes, rivers and reservoirs except deep geological aquifers. A hydrological drought follows, if a meteorological drought is sufficiently prolonged.
c. Agricultural Drought: Agricultural drought occurs when the soil moisture is inadequate to support a healthy growth of crops to the stage of maturity.

To these three basic types of drought, Mortimer (1989) adds Ecological drought, when the productivity of a natural ecosystem (i.e., common pastures) falls significantly.

![Type Of Drought And Its Impact](Source: U.R.Rao, 1996, Space technology for sustainable development and further developed by the author)

B.2. Drought Depending On The Universal Hydrological Cycle:

Climatic classification of Thornwaite, 1948,\textsuperscript{a,75} is based on the rational approach on water balance which itself has been developed from the universal hydrologic cycle. According to Thornthwaite there are five major groups of climate, namely,

- Perhumid (A),
- Humid (B),
- Sub humid (C) -- Moist sub-humid (C1)
  - Dry sub-humid (C2),
- Semi Arid (D),
- Arid (E)

The perhumid and the humid climatic groups belong to the humid category, while the two dry climates, the semi arid and the arid, have drought proneness or can be said as regions having permanent
feature of drought. The subhumid category of climate possesses critical water balances that fluctuate from year to year and are therefore, liable to incidence of droughts of various kinds.

Thornthwaite (1947) has recognized droughts as of three kinds:

a. The permanent droughts of the driest climates,

b. The seasonal droughts in climates having well-defined rainfall and dry seasons,

c. The contingent droughts resulting from irregular and variable occurrence of rainfall.

a. **Permanent droughts** are the characteristic of arid climates in which sparse and hardy types of vegetation are fully adopted to severe water shortage and agriculture is impossible without irrigation.

b. **Seasonal droughts** are found in climates that have well-defined rainy and dry seasons. Most of India which has a typical monsoonal climatic regime suffers from this kind of droughts whose incidence, duration as well as cessation are usually well-known and established by ages of observation, experience and record. Agriculture is successfully practiced in these zones by adjusting the dates of planting and harvesting and also by choosing crop varieties of the proper seasonality, duration and drought-tolerance.

c. **Contingent droughts** result from the rainfall being irregular and variable and which may occur in any season almost anywhere but are typical of and more frequent in the sub-humid climates, the so-called “borderline” climates with moist and dry types on either side. One of the challenging problems of drought climatology is the rational understanding and effective combating of these contingent droughts whose incidence, duration, severity as well as frequency are quite unpredictable.

B.3. **Drought On The Basis Of Spatio-Temporal Pattern Of Rainfall:**

Drought can also be classified by spatio-temporal nature which are as follows:

a. **Permanent drought**: It represents the climate with sparse vegetation, without streamflow and runoff, except when a rare rain occurs.
b. **Seasonal drought**: it is found in climate that have well-defined rainy and dry seasons. Here the natural vegetation is made up of plants that produce seeds during the rainy season and then die, also those plants that remain alive but become dry in dry season. Streamflow in such cases is periodic, including the largest streams which may become completely dry during the dry season.

c. **Unpredictable drought**: It occurs mainly from abnormally low rainfall or when the rainfall is irregular and variable. It can occur in any area, but mainly occurs in sub-humid and humid climates. Important characteristic of these types of drought is, they are brief and irregular and often affect relatively small areas.

d. **Invisible drought**: It refers to marginal water deficiency that tends to cut crop yields, especially when water must be supplied to the crops with irrigation to compensate for a prevailing deficiency.

![Spatio-Temporal Pattern Of Drought](image)

**Source**: Developed by the author

C. **SPATIAL DISTRIBUTION OF DROUGHT:**

C.1. **Drought Prone Areas In India:**

The Royal Commission in 1927 has remarked that agriculture in India is a gamble of monsoons. The erratic nature of the Indian monsoon with long dry spells accompanied by high temperature is responsible for creating drought conditions. Out of the net sown area of 140 million hectares, about 68% of the area are reported to be vulnerable for drought conditions. Seventy-six districts have been identified wholly or partly as drought prone and the same have been selected for assistance under Drought prone Area Programme. They are distributed all over India in 13 States. However, they are
concentrated mainly in the western and central zones covering Gujarat, Rajasthan, Haryana, Maharashtra, Karnataka and Andhra Pradesh (Figure No. I.4.). About 50% of the drought prone area are classified as severe where frequency of drought is regular. The drought prone condition is related to erratic and inadequate rainfall. Thus, the total area affected by inadequate rainfall in our country is about 32.4% of the total geographical area (1,070,000 sq.km.). Co-efficient of variation of rainfall, derived from historic data indicate occurrence of drought once in three to four years in major parts of the country. The average density of population in the drought prone area, as per the census of 1971, is 112 persons per sq.km. as compared with the country's average density of 178 persons per sq.km. The general range of population in drought prone districts is from 1.2 million to 2 million. In India, there are certain well-defined tracts of drought and can be divided into three zones\(^5\):

a. Desert and semi-desert regions
b. Chronic drought prone region
c. Scattered pockets of drought.

a. Desert and semi-desert regions cover an area of about 600,000 sq.km. and form a rectangular tract that stretches from Ahmedabad to Kanpur (to form eastern and southeastern border), from Kanpur to Jullander (to form northeastern and northern boundary) and from Jullander to Rann of Kachchh along the western International border. The region is characterized by low rainfall ranging between 350 MM. and 750 MM. per annum but the extreme western deserted areas receive even less than 350 MM. of annual rainfall. This zone includes whole of Rajasthan and Gujarat, western and south-western parts of Punjab, most of Haryana, south-western parts of Uttar Pradesh and a narrow strip along the western and north-western border of Madhya Pradesh. There is practically no impact of drought in Punjab and Harayana because sufficient irrigation facilities are available. The areas having no irrigational facilities are the worst drought affected and famine areas of the country.

b. The second chronic drought prone zone forms a rectangular tract which spreads over the rain shadow areas of the western ghats. In fact, this zone is situated to the east of Western Ghats and extends over a width of 300 k.m. It includes south western Andhra Pradesh, eastern Karnataka (east of Western Ghats). This region covers 370,000 sq.km. of an area and is characterized by highly erratic mean annual rainfall of less than 750 MM.
c. Beside the aforesaid two broad zones of severe droughts there are some scattered pockets of droughts in the country, such as Tirunelveli district located to the south of Vaigai river, Coimbatore area, Palamau area of Bihar, Purulia district of West Bengal, Kalahandi region of Orissa etc., The scattered pockets of drought prone area covers about 1,00,000 sq. k.m. of area.

The total area thus affected by inadequate rainfall is a little over one million sq.km. Of the total gross cultivated areas of the country, about 56 million hectares are subject to inadequate and highly variable rainfall.
INDIA
DROUGHT PRONE DISTRICTS


* Name of the districts corresponding to the number is given in Appendix No. 1.
C.2. Severity Of Drought In Gujarat:

Large areas of Gujarat State are situated on the periphery of southwest monsoon zone and receive only 90% of the precipitation from the southwest monsoon. As a result of uncertain, scanty and erratic rainfall pattern, certain areas of the state are subject to recurrent scarcity and drought conditions.

Gujarat has a total land area of 195,984 sq.km. covering 19 districts and 184 talukas. Out of which 58 talukas covering 11 districts are designated as ‘drought prone areas’ by the Irrigation Commission report, 1972. (Figure No. I.5.). these 58 talukas cover 69,322.5 sq. km's. of an area which is 48.68% of the Gujarat State and 13% of the drought prone areas of the country. This in turn affects 9,427,115 people which is 22.86% of the total population of the State as per the census of 1991.

Table No. I.1.

Drought Prone Districts Of Gujarat By Percentage Of Area And Population, 1991

<table>
<thead>
<tr>
<th>S.No.</th>
<th>District</th>
<th>% Of Drought Prone Area In Total Area Of The District</th>
<th>% Of Total Drought Affected Population In Total Population Of The District</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Jamnagar</td>
<td>30.05</td>
<td>30.08</td>
</tr>
<tr>
<td>2.</td>
<td>Rajkot</td>
<td>32.00</td>
<td>20.66</td>
</tr>
<tr>
<td>3.</td>
<td>Surendranagar</td>
<td>89.39</td>
<td>89.33</td>
</tr>
<tr>
<td>4.</td>
<td>Bhavnagar</td>
<td>48.45</td>
<td>55.22</td>
</tr>
<tr>
<td>5.</td>
<td>Amreli</td>
<td>62.84</td>
<td>61.86</td>
</tr>
<tr>
<td>6.</td>
<td>Kachchh</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>7.</td>
<td>Banaskantha</td>
<td>48.82</td>
<td>33.67</td>
</tr>
<tr>
<td>8.</td>
<td>Mahesana</td>
<td>57.09</td>
<td>44.37</td>
</tr>
<tr>
<td>9.</td>
<td>Ahmedabad</td>
<td>73.53</td>
<td>20.8</td>
</tr>
<tr>
<td>10.</td>
<td>Kheda</td>
<td>31.57</td>
<td>21.29</td>
</tr>
<tr>
<td>11.</td>
<td>Bharuch</td>
<td>26.33</td>
<td>18.84</td>
</tr>
</tbody>
</table>

Grand Total 48.68 (95395.5 sq.k.m.) 22.86 (9427115)


♦ List of drought prone talukas with their area and population is given in Appendix Number 2

Compare to many other districts of the State, Banaskantha district comprises of a small percentage of area and population under the vicinity of drought. But the district has been selected for the study as it has a contrasting type of climatic conditions. In spite of having enough rainfall in the eastern section of the district, drought exists on the western side. This brings in an issue of management of water in the district.
Introduction


Figure No. 1.5.

GUJARAT
DROUGHT PRONE TALUKAS

* Name of the talukas corresponding to the number is given in Appendix No. 2.

C.3. Spatial Distribution Of Drought Prone Areas In Banaskantha District:

All the drought prone talukas of Banaskantha district are located near Rann of Kachchh or the southern talukas of Rajasthan State. The drought prone talukas are confined on the western part of the district, which is covering an area of 6201.7 sq. km, that is 6.5% of the total drought prone area of the State and 48.82% of the total area of the district (Figure No. 1.6). The total population living in the drought affected area of the district is 728,233 (1991), which is 7.72% of the total persons living in the drought affected areas of Gujarat and 33.67% of the total population of Banaskantha district. The drought prone talukas of the district as identified by Irrigation department, 1972 are:

1. Wav,
2. Santalpur,
3. Radhanpur,
4. Tharad and
5. Dhanera.

Drought in the district is mainly meteorological as it occurs due to the deficit in total rainfall which results in an imbalance in water supply. After that if the percentage of aridity index increases, meteorological drought is further followed by hydrological, agricultural and ecological drought. Due to the lack of rainfall, soil loses its natural moisture and aridity index increases. High aridity index causes low crop yield and leads to the loss of vegetation and grass cover which further affects the supply of fodder for cattle. The recent drought in the district (1999-2000) is an example of an ecological drought. The drought in the district has diminished the resources of water and grass; forcing farmers to look for some relief work to earn their livelihood and cattle rearers to migrate in some areas in search of fodder and water for their animals.

As the data collection in this research work has already been finished at the mid of the year, 2000, the drought year of 2000 is not included in the study. Paper cutting of the recent drought is given at the end of the thesis.
D. HISTORICAL BACKGROUND OF DROUGHT IN GUJARAT:

History of drought is divided into two periods. In the first period, that is, before 20th century, there is no authenticity of data as the information is gathered from different sources. In second period, the data is collected from different government reports.

D.1. Drought Before Twentieth Century:

Drought is not new to the people of Gujarat State. Kautilya in his Arthashastra has referred the incidence of occurrences of drought resulting into famine and the measures taken to mitigate it in ancient India. But the earliest authentic records regarding scarcity and famine that are available for Gujarat, Saurashtra and Kachchh relate to the 17th and 18th century. The failure of rain in 1630-31 resulted famine in Gujarat.7 “Life”, says Abdul Hamid Lahori in Badshahnama, was offered for a loaf, dog flesh was sold instead of goat's flesh and pounded bones of the animals were mixed with flour for sale. In this dreadful calamity, more than a third of population of Gujarat was destroyed and cities and districts were left bare of inhabitants. In 1650 rain failed in Gujarat, again in 1659-60 Gujarat with Sindh and western coast were affected due to unfavourable seasons and want of rain. Gujarat area including Saurashtra and Kachchh, is reported to have been visited by great famines during 1681-82, 1696, 1718-19, 1731-32, 1747 and 1791-92.

During the 19th century, the first famine came during 1812-13 in Kachchh and North Gujarat. In 1813, there were destructive floods throughout Saurashtra. Monsoon failed in 1877 in Gujarat with Bihar, United Provinces (U.P.), North Western Provinces, Punjab, North Eastern Rajputana, Central Provinces, West Konkan and Hyderabad Meteorological Divisions of the country. During this famine the production of crop was hardly one fourth of the average production and prices were double of the normal rate. There is a great scarcity of fodder in many tracts and not a grass was seen for miles. A large number of cattle died and many were driven to Himalayas or sold to butchers in North Western Provinces.8 Monsoon was highly deficient in 1899 over large parts of the western, central and southern India. The total rainfall in 1899 was 7.3” against a normal annual rainfall of 30.02”. Sir John Eliot, the government meteorologist, estimated afterwards that the drought of 1899 was the greatest in its extent and intensity, which India had not experienced during the last two centuries. In this way, the 19th century was marked by general conditions of scarcity in one or the other parts of the State, mainly due to scanty or unseasonable rainfall.
D.2. Recent Period (From Twentieth Century):

Description of some of the earlier famines of the twentieth century makes a pathetic reading. Drought in 1918 was the most severe experience, faced not only by Gujarat but also by the country during the last hundred years. Mortality rate due to starvation alone was staggering and a large number of villages were left desolate.\(^{132}\) This was obvious with the fact that the country had shown a decreasing trend of population in a decade of 1911-1921. Severity of drought had also increased as the entire agricultural economy was dependent heavily on rainfall and no organized relief measures were provided to people. There were 13 moderate and 15 severe types of scarcity experienced in different parts of the country during 1900 to 1987.

According to the approximate probability of deficient rainfall worked out by *India Meteorological Department* for different meteorological sub-divisions, the probability of recurrence of a period of a highly deficient rainfall is once in three years for Gujarat.

Some of the areas in the State are still subject to nature’s fury and are not free from vagaries of the monsoon. The incidence of scarcity conditions in the state from 1960-61 to 1987-88 can be seen in table I.2. Severe drought is noticed for three consecutive years from 1985 to 1988 in the State.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>POPULATION AFFECTED</th>
<th>VILLAGES AFFECTED</th>
<th>% OF VILLAGES AFFECTED TO TOTAL NO. OF INHABITED VILLAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-61</td>
<td>2303454</td>
<td>2516</td>
<td>13.54</td>
</tr>
<tr>
<td>1961-62</td>
<td>322860</td>
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<td>0.26</td>
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<td>1962-63</td>
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</tr>
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</tr>
<tr>
<td>1966-67</td>
<td>4692404</td>
<td>5662</td>
<td>30.47</td>
</tr>
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<td>1967-68</td>
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<td>21158</td>
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<td>2862705</td>
<td>2586</td>
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<tr>
<td>1974-75</td>
<td>16300000</td>
<td>12716</td>
<td>69.58</td>
</tr>
<tr>
<td>*1975-76</td>
<td>—</td>
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</table>
Number Of Villages Affected By Drought From 1960-61 To 1987-88 In Gujarat

<table>
<thead>
<tr>
<th>Year</th>
<th>Drought</th>
<th>Villages</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>1976-77</td>
<td>---</td>
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<tr>
<td>1977-78</td>
<td>NA</td>
<td>3720</td>
<td>20.25</td>
</tr>
<tr>
<td>1978-79</td>
<td>NA</td>
<td>1525</td>
<td>8.34</td>
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<tr>
<td>1979-80</td>
<td>5990000</td>
<td>1818</td>
<td>10.08</td>
</tr>
<tr>
<td>1980-81</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1981-82</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1982-83</td>
<td>NA</td>
<td>8324</td>
<td>46.17</td>
</tr>
<tr>
<td>1983-84</td>
<td>---</td>
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<td>---</td>
</tr>
<tr>
<td>1984-85</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1985-86</td>
<td>NA</td>
<td>13390</td>
<td>74.27</td>
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<tr>
<td>1986-87</td>
<td>NA</td>
<td>11631</td>
<td>64.52</td>
</tr>
<tr>
<td>1987-88</td>
<td>NA</td>
<td>15004</td>
<td>83.24</td>
</tr>
</tbody>
</table>


* No scarcity condition was declared in any area of the state.

NA = Not available

E. CAUSES OF DROUGHT:

E.1. General Causes Of Drought:

There are three major causes of drought as far as rainfall is concerned

a. late onset and early withdrawal of the monsoon,

b. lean rainfall due to paucity of depression and low pressure systems and

c. prolonged breaks in monsoon rainfall.

a. Due to the late onset of monsoon, production in Gujarat is often below the target (The Economic Times, Ahmedabad, November 14,1998). Late onset had affected the production of groundnut in 1998-99 by a loss of six lakh tonnes or Rs.900 crore.

Alike late onset, early withdrawal of the monsoon from Rajasthan in 1998 between second and the last week of September had a very adverse affect on the crops. An assessment of the crop failure shows that the Jodhpur division was the worst affected district with a large-scale loss in cereals and pulses, the two maincrops of the division. The loss in cereal range from 35% to 90% in Jalore district, which is the worst affected with 90% loss. State had also lost 35% to 90% in pulses and oilseeds. The overall estimate indicates a very gloomy situation in the State.
Till date, the physical mechanisms that lead to the late onset and early withdrawal of the monsoon from a region is not fully understand. Micheal Palmerino, senior agricultural meteorologist at Weather Services Crop in Massachusetts, has predicted the onset of India’s monsoon be late in the year of 2000. His prediction is based on the movement of jet stream over central Asia. Improvements in prediction on such meteorological situation lean heavily on the monitoring facilities of climate. With more information on cloud structure and wind direction etc, one may be able to anticipate conditions that are likely to lead to a late or an early onset. Research is going on in this subject.

b. The second aspect is concerned with a global view of weather. The Monsoon Experiment (MONEX) of 1979 suggests that there are meteorological telecommunications that link up the passage of depressions and low-pressure system with events occurring in other parts of the world. The southern oscillation, is an example of a meteorological link on a global scale.

Many worldwide meteorological organisations believe that El Nino is linked with unusually warm surface-current in the south Pacific ocean off the south American coast, which occurs once in a few years around December. This phenomenon is associated with drought in Africa, India, Australia region and floods in south American coastal countries. It is true that, all the four serious droughts that have occurred in India over the last 120 years have been El Nino years, still we cannot make a conclusion that El Nino is the only factor to bring drought in India. As the physical factors for El Nino are not known, only statistical relationship between drought an El Nino can be drawn. According to many well-known scholars from meteorological department, El Nino is just one of the parameters taken into account while preparing a long range forecast for the country. Other than El Nino factor, some of the senior scientists of Space Applications Centre, Ahmedabad, believe that volcano eruption also affects the rainfall pattern of the Indian continent.

c. The last aspect, namely, prolonged break in rainfall is again intimately linked with the dynamics of the monsoon. Past rainfall data suggest that prolonged breaks in monsoon rainfall have a tendency to occur towards the second half of the season, that is, in August and September. Thus in 1974 and in 1979 most parts of north west India suffered a break in monsoon rains for a period ranging from six to eight weeks. The evidences suggest that these breaks are sometimes linked with a quasi-stationary anticyclone circulation that establishes itself over northwest India. This anticyclone circulation inhabits
the upward motion of air and there is less chance of rainfall as a consequence. The meteorological process leading to this type of circulation, is not yet well understood.74

D.2. Causes Of Drought In Banaskantha District:
Rainfall is not the only cause of drought in the district, there are also some other factors which share the causes of drought and differ from region to region. Banaskantha district lies on the east of Rann of Kachchh in the northern part of Gujarat state. District has many causes for drought, those are as follows:

a. The southwest monsoon carrying moisture does not enter the region easily. It passes from Maharashtra and south Gujarat, leaving the other parts of the State quite dry.

b. There is no perennial river in Gujarat except a few in south Gujarat. Out of total 185 rivers in the State, 168 rivers are in drought prone areas and all of them are non-perennial and account for less than 20% utilization of surface water.

c. Banaskantha district of Gujarat is located to the north of 23 1/2° N (Tropic of cancer). In these parts of latitude, the tropical wind coming from the equator, subsides, so the warm tropical wind comes downward. Hence, whatever moisture the region has, is evaporated due to subsidence, and convection does not occur for the formation of cloud.

d. Gujarat is in the tropical zone and the Tropic of cancer passes over the State. Thus, the Sun shines directly over the region during summer season. During the whole year, Gujarat and Rajasthan receive 5.8 kilowatt per hours per sq.m. per day of solar radiation, which is higher than any other states of the country. Hence, the rate of evaporation is higher in this region compared to the other zones. If this region, with the similar quantity of moisture, has been located under the temperate zone, then whatever moisture content the region has would have been enough for cultivation. The mean daily pan-evaporation in Banaskantha district ranges between 4-5mm/day in the month of May. During the year, the evaporation increases from January and reaches its maximum value in May.

e. Gujarat receives much of its rainfall from the southwest monsoon. The monsoon season begins with the southern district of Gujarat. Sometimes Gujarat gets cyclic rainfall also. Cyclic depressions
Introduction
cut across the country from east to west or from Bombay area and give rainfall here. The normal annual rainfall of Vadodara is 1839.1 mm with 60 rainy days which is the highest among all the districts in the State. But the amount of rainfall decreases towards the north as the monsoon current loses moisture while moving from south to north. That is why, the normal annual rainfall of the Banaskantha district is 577.9 mm with 24.9 rainy days, which is very erratic, scanty and unpredictable.

f. Large fluctuations of annual rainfall on both temporal and spatial scales are observed in the district. The eastern part of the district receives as much as 750mm of rain as it is located in the vicinity of Aravallis and Abu hills, whereas the western part receives less than 450mm of annual rainfall which includes Tharad, Wav, Santalpur and Radhanpur talukas.

g. No rivers or rivulets pass through Deodar, Tharad and Wav talukas of the district. Water accumulated by monsoon rain in ponds or reservoirs is available upto the month of February. The water table is also high in these talukas, especially in Wav, but water is unpotable as it is saline. There are no other prospects of natural water in these talukas. So, the government tankers provide the water to the villages of Wav taluka during summer to meet the demand for domestic use.

h. Banaskantha district receives mean annual rainfall of 577.9 mm with 24.9 rainy days during June to September. The length of all the rivers in the district is short and flow along the steep slope of the Aravallis. Therefore water in river runs away to the Rann of Kachchh, generating floods or water logging in rainy season and drought in summer in the western part of the district. The Rann has very low slope and the water table is high. So a single, heavy rainfall can create floods in the Rann area.

i. Western part of the district is lying next to the Rann of Kachchh, which was once an inlet of the Arabian Sea, but it has been uplifted and silted up by the enormous volume of mud poured into it by the small rivers discharging into it from the east and north east. This tract is a saline marshy plain, hardly above sea level. The western part of the Banaskantha district (Wav and Santalpur) is located next to it, which is also low-lying area and not much above the sea level.

j. Ninety five percent of the annual rainfall in the North Gujarat is received only through monsoon during June to September months. Hence failure in monsoon creates water crisis in the region.
F. FACTORS CONTRIBUTING TO THE DEVELOPMENT OF DROUGHT PRONE TALUKAS

It is a general view that most of the drought prone areas are also the backward areas, as drought restricts the socio-economic development of an area. But it is found that in Gujarat, only sixteen drought prone talukas are also the backward talukas of the district, which is approximately 28.57% of the total drought prone talukas of the State. Improvement of irrigation facilities and development of secondary and tertiary sectors are the major reasons of socio-economic development for the forty three drought prone talukas of the State, which are as follows:

⇒ Development of secondary occupation; like various industries in Ahmedabad, Rajkot and Bharuch talukas and development of ports in Kachchh, Jamnagar, Bhavnagar and Bharuch has helped the drought prone talukas of the respective district to develop by providing a source of earning other than agriculture.

⇒ Well-developed mode of transportation has given mobility to the people, which helped them to migrate easily to some other area during the critical period of drought or dry season of the year and hence, providing them the opportunity to earn.

⇒ City provides occupation in secondary and tertiary sectors. Therefore cities like Ahmedabad, Rajkot, Bharuch and Jamnagar have provided numerous employment opportunity not only to city people but also to the villagers settled near these cities.

⇒ All the major rivers of Gujarat are tapped for the irrigation purpose. Therefore, talukas near these rivers have enough water to irrigate their fields even during summers. Thus, increase in total production has helped them to increase their total income.

⇒ In Jamnagar and Kachchh, agriculture with scarce rainfall and saline soil is not enough to sustain people. But salt industries in these districts have acted as a substitute to agriculture by providing people a source of income unaffected by scarce rainfall.

⇒ Agriculture in drought prone talukas provides irregular amount of income. Therefore in some places, people have diverted themselves to some other occupations, which are not affected by
Introduction

Drought or scarce rainfall. For example, Patola sarees of Patan and tourist places area have helped many drought prone areas to develop themselves.

The drought prone talukas of Banaskantha district have sandy soil, they also lack in mineral resources and industries. These talukas are far from any urban area and do not have proper transportation for socio-economic development. Efforts are needed to develop the drought prone talukas by developing the non-agricultural activities, as it is practiced in other drought prone but developed talukas of the State. With this hope that drought prone areas can be developed through integrated development system of various aspects, Banaskantha district is chosen for the study.

G. IMPACT OF DROUGHT

Drought is somewhat different from the other major natural disasters. Floods, earthquakes and cyclones start in a comparatively sudden manners, having a relatively short duration and are restricted to local influence. Drought in contrast starts slowly, having long duration, being of the creeping and pervasive nature, covers vast areas. Floods, cyclones and earthquakes are disasters associated with extreme events, drought is the extreme hydrologic result of the non-occurrence or less than normal mean rainfall of an area. Basically drought is a slow evolution that seldom causes dramatic losses of human life (except in famine) but it effect is long lasting in economic sector for the region and its people.

G.1. Impact Of Drought On Environment:

Rural India is still based on the traditional methods of living style from house to field. Drought shows its first mark on environment which consequently affect people. The general environmental impacts are as follows:

Due to scarce rainfall and over exploitation of ground water aquifers, it gets depleted and due to capillary action, agricultural fields gradually become saline. Scarce rainfall and vegetation are not able to hold the topsoil, therefore the wind erosion becomes active in this region. Thus, the topsoil of agricultural field is swept away with wind and saline soil from Rann of Kachchh or desert is deposited in the field. Consequently, there is a problem of salinization and desertification in areas near Rann. It is estimated that between 50,000 to 70,000 sq.km. of land are going out of production every year in the world because of desertification. Exposed fields during drought, without having agriculture, make soil loose and dry and it is prone to erosion and desertification.
There is a decrease in land carrying capacity, as many plant species decrease due to lack of water, which directly affect the animal species. In a way, whole food chain is disturbed during drought. There is also a loss of forest cover due to lack of water and desertification by human being to fulfill their needs for fuel and food. It has a major impact on the productivity of cropland in the long run, as it increases the soil erosion and loss of soil fertility. (Figure No. 1.7.)

Areas having sandy soil and semi-arid climate with scarce rainfall, both man and environment affect each other for their existence which leads to unemployment and forced migration from the area. Insufficient rainfall decreases water quality in a region. Therefore water is not enough for agriculture and cattle which leads to poor yield and productivity per unit of cattle and consequently it leads to poverty due to resource degradation.

Figure No. 1.7.

A Schematic Model On Man In A Drought Prone Environment

Source: Developed by the author

Effect of drought can be seen on different levels of society starting from a small agricultural field to international market. V. Yevjevich has given a range of possible social consequences in his book.
"Coping with Drought", which is modified in the context of the Indian circumstances in the following figure.

Figure No. 1.8.

Range Of Possible Social Consequences Of Drought

- **WORLD**
  1. Starvation and famine
  2. International conflict
  3. Disruption of world social system
  4. Severe health Effects
  5. Competition for food within drought affected countries

- **NATION**
  1. Health Effects / Food shortage
  2. Rising Prices
  3. Foreign trade losses
  4. Economic loss in government budget

- **REGION**
  1. Increased unemployment
  2. Increased migration intensity
  3. Regional instability
  4. Disruption of regional economic sectors

- **AGRICULTURIST**
  1. Migration due to lack of income
  2. Loss of annual income
  3. Increased indebtedness
  4. Unhygienic food

Source: V. Yevjevich and further developed by the author

Impact of prolonged drought includes ecological, economic, social, demographic and even political aspects. Prolonged drought conditions in a given region change the biotic component of the natural ecosystem because some species of plant and animal perish as they cannot stand extreme drought conditions, some animals migrate to other places and hence there is a marked decrease in the population of certain animal species, some animals die of hunger and starvation. There is a stiff competition for food due to the scarcity created by drought among the animals which result in the elimination of weaker animal.

The economic impact of drought includes economic losses mainly due to marked decrease in agriculture production, livestock, yield and even industrial production because of short supply of water and sometimes of raw material. The social impact includes, migration, which leads to division in family life. Due to poor economic status, marriages and other social functions get postponed for a period. Demographic impact of drought includes depopulation of regions and temporary migration of affected people. Usually male and young people migrate during drought to support their family, therefore only children, females and old peoples are left in the village. Political significance of extreme conditions include the change of political power due to acute shortage of food grains caused by crop failure due
to droughts and increase in the dominance of the countries having surplus food supply on drought affected poor countries that have surplus food supply on drought affected poor areas.

G.2. Impact Of Drought In Terms Of Domestic Needs:
During drought the water table falls in all ground water sources, even the available water of several wells turns brackish or saline, so there is an acute shortage of water needed for human being for different purposes. For example, during the drought period of 1985-87, 10402 villages in Gujarat and 700 villages in Rajasthan were reported to have been affected by acute scarcity of drinking water. Water was being supplied to these villages by tankers and bullock cart. In many drought areas, the woman folk of the house had to walk for four to five kilometers every day to bring water for drinking purpose. As the ground water level continued to drop, many dug-wells were deepened and many new tube-wells were made and repaired by the government.

People did not have bath or could not wash their clothes in dry season for months when the temperature was more than 40 degree centigrade in Banaskantha district. There was also a change in consumption behavior during drought conditions, as there was also a scarcity of food, which is governed by low production and high price. During the drought years of 1985-87, the Central Government along with the State Government of Gujarat had contributed Rs.86 crores to tackle the drinking water supply in the State.

G.3. Impact Of Drought On Cultivation:
Life in India is primarily based on agriculture which is dependent for its very existence on the southwest monsoon. The monsoon is said to be the pivot upon which the whole economic life of farmers’ swings. Hence, late onset or inadequate rain pull down the shutters of agriculture and industry. Statistics reveal, that there is a clear cut downfall of area, production and yield of crops in all three agricultural seasons of the year 1985-'87 (one of the severe drought year of the state) in Gujarat, when mean annual rainfall of the state was 383.39 mm, which is 444.61 mm less than the normal annual rainfall of the State (828 mm).
The loss of Kharif and Rabi crops was likely to be 33.83% and 72.30% respectively. The overall loss during the drought year was in the order of 48.66%. The loss in the case of oilseed was 35.61% and in cotton was 32.29%. Due to inadequate rainfall during drought, water is not enough in the ground-aquifers to irrigate the rabi crops, which is fully dependent on irrigation for its growth. Therefore, rabi crop is the most affected crop in any drought year.
In a drought condition there is a change in cropping pattern. Farmers go for drought resistant or dry crops instead of rain fed crops. Loss is more to the small landholders as they do not have enough capital for irrigation. Data also reveal that there is a downfall in area irrigated by different sources during drought.

Table No. I.4.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Sources</th>
<th>1979-80</th>
<th>1984-85</th>
<th>1986-87</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Government Canals</td>
<td>146</td>
<td>117</td>
<td>95</td>
</tr>
<tr>
<td>2.</td>
<td>Tanks</td>
<td>12</td>
<td>9</td>
<td>—</td>
</tr>
<tr>
<td>3.</td>
<td>Wells</td>
<td>1965</td>
<td>2588</td>
<td>2523</td>
</tr>
<tr>
<td></td>
<td><strong>Net area irrigated</strong></td>
<td><strong>2123</strong></td>
<td><strong>2714</strong></td>
<td><strong>2618</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Gross area irrigated</strong></td>
<td><strong>2222</strong></td>
<td><strong>2913</strong></td>
<td><strong>2791</strong></td>
</tr>
</tbody>
</table>

Source: Season and crop report, Directorate of Agriculture, Ahmedabad, Gujarat State

Due to the decline in ground-water during drought years (1984-85 to 1986-87), the water in canals and tanks also decreases, which leads to the decrease in area that is irrigated by these sources. During drought farmers deepen their wells and tanks, in the higher altitude districts, i.e., Danta, Palanpur and Dhanera talukas and bore wells on river beds, to utilize as much water as possible to irrigate their field. Due to drought condition, there is a great loss of crops in villages from 1980-81 to 1989-90 in Banaskantha district, which is shown in table I.5.

Table No. I.5.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Years</th>
<th>Number of revenue villages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1980-81</td>
<td>---</td>
</tr>
<tr>
<td>2.</td>
<td>1981-82</td>
<td>71</td>
</tr>
<tr>
<td>3.</td>
<td>1982-83</td>
<td>995</td>
</tr>
<tr>
<td>4.</td>
<td>1983-84</td>
<td>---</td>
</tr>
<tr>
<td>5.</td>
<td>1984-85</td>
<td>172</td>
</tr>
<tr>
<td>6.</td>
<td>1985-86</td>
<td>924</td>
</tr>
<tr>
<td>7.</td>
<td>1986-87</td>
<td>1278</td>
</tr>
<tr>
<td>8.</td>
<td>1987-88</td>
<td>1279</td>
</tr>
<tr>
<td>9.</td>
<td>1988-89</td>
<td>5</td>
</tr>
<tr>
<td>10.</td>
<td>1989-90</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>4732</strong></td>
</tr>
</tbody>
</table>

Source: District Collectorate, Banaskantha District
During dry weather, there is an increase in multiplying of weeds, insect activities and predators, which decrease the total production of crops. Hence, the uncertainty of rainfall is the biggest challenge to the Indian agriculture, as the success and the failure of agricultural economy of a region are intimately connected with the occurrences of the monsoon.

G.4. Impact Of Drought On Employment Pattern:
"16.4 lakh labourers were provided employment on relief works during the peak period of 1986-87 in Gujarat". This simple statement on a memorandum given by the Central team on the scarcity of 1986-87 in Gujarat by State government shows that how much the employment pattern was affected on the villages of the State, where more than 56% of the total main workers are cultivators or agricultural labourers.

Continuous drought from 1985 to 1987 forced even large farmers having more than 50 acres of land, to work in relief camps organised by the government. Nearly 153.49 lakh population in the State was affected during this period, out of which 1,422,661 persons were agricultural labourers, 476595 persons were small farmers and 511422 persons were from the group of marginal farmers. During the drought year of 1985, State government had fixed Rs.11/- per day per head as scarcity wages to labourers working in relief camps. Not only the farmers of the village were affected, all other families of cobbler, blacksmith and carpenter had to move out from their usual work as they did not have any customer to serve in the village. Cattle rearers had to migrated to other green belts of the State or the neighbouring states. Many of them even sold their cattle in unprofitable prices to butchers. Farmers have either migrated or worked in relief camps. Migration took place mainly towards the greener belt, where they worked as agricultural labourer or to the cities where they worked as a labourer in different shops and markets.

G.5. Impact Of Drought On Forest Cover:
Forest plays a vital role in the economy by supplying timber, fuel, fodder and variety of other products for households and industry. It also helps to preserve ecological and environmental balance. It improves the percolation of rainwater, reduces salinity, maintains soil fertility and acts against floods and soil erosion. The total area under forest was 19392 sq. k.ms. in 1992-93 on Gujarat, that is 9.89% of the total area of the state.
During droughts, the area under forest is affected, as it is deforested for fuel and fodder use and in turn it affects adversely the soil and agro-climatic situation. As per the information given by villagers, the forest area had decreased after the continuous drought of 1984-87. Due to the unavailability of enough information from forest department at a macro level, it is not possible to prove the fact but as we go for micro level study, we can find that drought had an effect on forest area.

**G.6. Impact Of Drought On Cattle Or Dairy Products:**

The total livestock population of Gujarat is 17343 thousand which is 3.9% of the country's livestock population, according to 1991 census. In Gujarat, there are 10285 milk co-operative societies which have 36 chilling plants, 1123175 societies and 1844212 members. But drought on every alternate year affects the dairy development, as the number of cattle perish due to lack of fodder and grass.

Due to the low rainfall the wild grasses that normally grow on the common pastures during the monsoon season, fail to grow. So, shepherds graze their cattle on agricultural plots which have failed crops due to insufficient rainfall. But competition over rights to individual plots leads to several conflicts. Due to the low fodder stock, the price of fodder increases. In 1984-85 to 1986-87 drought, grass, which in normal years cost RS. 6 per 100 bundles was sold for RS. 40/- per 100 bundles. Many shepherds were forced to migrate with their cattle to a green belt or to sell their cattle at much lower prices as they were not able to keep them. Many cattle died due to lack of fodder and water. So there was a decrease in the number of cattle wealth. Most of the people abandoned their cattle on the road as they are not getting a customer to sell them even at a half rate. During the drought year of 1986-87, over 8 crore kgs of grass was moved from Valsad district to Kachchh, Saurashtra and North Gujarat districts and distributed through 525 grass depots or fodder banks. To save the cattle population, government and many NGO's had opened cattle camps in various scarcity-affected areas. More than 3 lakh heads of cattle were admitted in various cattle camps, (panjrapoles* and *gaushalas). As per the estimation made by the Scarcity Department of Gujarat, total 90.97 lakh cattle in State and 9.60 lakh cattle in Banaskantha district were affected during the drought period of 1985-1987. (Table No. - I.6.)
Table No.1.6.
Number Of Cattle Population Affected During The Drought Year Of 1986-87 In Gujarat

<table>
<thead>
<tr>
<th>Name of the district</th>
<th>Cattle population affected (in lakhs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Amreli</td>
<td>0.57</td>
</tr>
<tr>
<td>2. Junagadh</td>
<td>0.86</td>
</tr>
<tr>
<td>3. Bhavnagar</td>
<td>5.55</td>
</tr>
<tr>
<td>4. Rajkot</td>
<td>4.16</td>
</tr>
<tr>
<td>5. Jamnagar</td>
<td>4.94</td>
</tr>
<tr>
<td>6. Surendranagar</td>
<td>6.95</td>
</tr>
<tr>
<td>7. Kachchh</td>
<td>2.80</td>
</tr>
<tr>
<td>8. Banaskantha</td>
<td>9.60</td>
</tr>
<tr>
<td>9. Mehsana</td>
<td>9.37</td>
</tr>
<tr>
<td>10. Sabarkantha</td>
<td>9.79</td>
</tr>
<tr>
<td>11. Ahmedabad</td>
<td>5.19</td>
</tr>
<tr>
<td>12. Kheda</td>
<td>4.86</td>
</tr>
<tr>
<td>13. Panchmahals</td>
<td>10.44</td>
</tr>
<tr>
<td>14. Vadodara</td>
<td>11.25</td>
</tr>
<tr>
<td>15. Bharuch</td>
<td>2.92</td>
</tr>
<tr>
<td>16. Surat</td>
<td>1.72</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90.97</strong></td>
</tr>
</tbody>
</table>

Source: Memorandum to the Central team on scarcity, Govt. Of Gujarat, 1986-87.

Figure No.1.10.

CATTLE POPULATION AFFECTED DURING THE DROUGHT YEAR OF 1986-87 IN GUJARAT

Source: Memorandum to the Central team on scarcity, Govt. Of Gujarat, 1986-87
G.7. Impact Of Drought On Industry:

Gujarat is the third largest industrial region (Ahmedabad-Vadodara-Bharuch-Surat belt) of the country. This region has developed the cotton textile industry, followed by rayon, petrochemical, match, petroleum refining, pharmaceutical, potteries and glassware, leather goods and a wide variety of engineering units. One of the initial reasons for the development of this region is the cheap availability of raw cotton from its hinterland. Latest data available is of 1994, show that there are 16325 factories working in the State which employ approximately 810,000 workers.

Industries of the State are dependent on agriculture and forest for their raw material, hence, during droughts the production of industries are mainly affected. During drought, maximum decrease can be seen on sugar production as inadequate rainfall restrict the proper growth of the crop, that is why it is also sold as fodder in these periods.

Due to lack of adequate supply of raw material and water, production of industries is affected which leads to heavy loss for companies. So to minimize the loss, companies cut the number of labour and consequently it increases the unemployment in a region which forces the people to migrate in some other region for search of livelihood.

After a three consecutive years of drought from 1984-85 to 1986-87, many factories were closed down due to lack of raw material in 1987 and 1988. There is also a decreasing trend in number of labour in of 1985, 1987 and 1988 (Table No. 1.7.)

<table>
<thead>
<tr>
<th>SL. No.</th>
<th>Year</th>
<th>Number of working factories</th>
<th>Average number of workers employed daily in working factories</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1980</td>
<td>10674</td>
<td>635689</td>
</tr>
<tr>
<td>2.</td>
<td>1983</td>
<td>12586</td>
<td>689269</td>
</tr>
<tr>
<td>3.</td>
<td>1984</td>
<td>12734</td>
<td>668017</td>
</tr>
<tr>
<td>4.</td>
<td>1985</td>
<td>13067</td>
<td>663614</td>
</tr>
<tr>
<td>5.</td>
<td>1986</td>
<td>13498</td>
<td>674618</td>
</tr>
<tr>
<td>6.</td>
<td>1987</td>
<td>13045</td>
<td>666749</td>
</tr>
<tr>
<td>7.</td>
<td>1988</td>
<td>12836</td>
<td>638302</td>
</tr>
<tr>
<td>8.</td>
<td>1990</td>
<td>14513</td>
<td>747569</td>
</tr>
<tr>
<td>9.</td>
<td>1994</td>
<td>16325</td>
<td>810000</td>
</tr>
</tbody>
</table>

Source: Chief Inspector of Factories, Gujarat State, Ahmedabad.
G.8. Movement Of Cattle And People Over Space:
Drought causes depopulation of regions and temporary migration of affected people and animals. There are three main reasons for migration: (1) during drought, the local tenancy and labour markets do not absorb adequately the pool of available labour, (2) many small farmers and marginal farmers cannot afford the irrigation costs to cultivate crops in the dry season and, (3) lack of fodder and water causes migration of cattle rearers to green belts with their cattle.

There is a frequent migration of people from drought affected areas of Maharashtra, Gujarat and Rajasthan in India. Due to prolonged severe droughts for three consecutive years (1984 to 1987) in Gujarat and Rajasthan, a large number of people temporarily shifted to South Gujarat, Madhya Pradesh, Uttar Pradesh and Bihar, together with their cattle or sold them at much lower prices due to lack of fodder. During the continuous drought of 1984-87, in Lodhrani and Rachhena village of Banaskantha district, all the shepherd households, migrated with most of their animals to green belt area in South Gujarat. Statistics reveal that every 3rd year about 3 million people of drought prone area migrate along with their livestock to some other place in our country. This type of migration is rather a forced movement which causes disturbance to family life in these areas.

G.9. Overall Loss Of Income:
The impact of drought prone areas on the nation’s economy is significant and decisive. They are the major producer of Groundnut, Bajra, Sorghum, Ragi, Maize, Tour etc. They account 25% to 33% of the total collection of these crops. They are also the major livestock raiser. Gujarat has 3.9% of country’s livestock population. Gujarat has 10285 number of milk co-operative societies. About 25% of the agricultural population of the country is found on drought prone areas. Scarcity and drought affect the economy of all primary (agriculture, forestry and livestock) and secondary (Food, cotton, wood, paper, sugar and other textile industry) activities drastically.

There is a severe strain on the financial resources of the Nation due to the exorbitant expenditure on relief measures needed in the drought prone areas. During the decade of 1960-70, the expenditure on drought relief was nearly RS. 5776.53 lakhs. During the VTh plan period the total expenditure on relief was RS. 17482.5 lakhs. The scheme of distributing food grains at subsidized rates has been extended in the Drought Prone Areas and Desert Development Programme Areas from June 1, 1992. About 80 lakhs people living in 80 talukas of the state have been covered under this programme.132
### Table No. I.8.

**Expenditure Incurred On Scarcity Work In Gujarat From 1960-61 To 1975-76**

<table>
<thead>
<tr>
<th>Year</th>
<th>Expenditure incurred on scarcity work (RS. In lakhs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-61</td>
<td>50.43</td>
</tr>
<tr>
<td>1961-62</td>
<td>2.21</td>
</tr>
<tr>
<td>1962-63</td>
<td>72.28</td>
</tr>
<tr>
<td>1963-64</td>
<td>108.64</td>
</tr>
<tr>
<td>1964-65</td>
<td>43.15</td>
</tr>
<tr>
<td>1965-66</td>
<td>85.66</td>
</tr>
<tr>
<td>1966-67</td>
<td>692.08</td>
</tr>
<tr>
<td>1967-68</td>
<td>731.50</td>
</tr>
<tr>
<td>1968-69</td>
<td>631.94</td>
</tr>
<tr>
<td>1969-70</td>
<td>3358.64</td>
</tr>
<tr>
<td>1970-71</td>
<td>1035.67</td>
</tr>
<tr>
<td>1971-72</td>
<td>62.78</td>
</tr>
<tr>
<td>1972-73</td>
<td>3190.77</td>
</tr>
<tr>
<td>1973-74</td>
<td>5051.79</td>
</tr>
<tr>
<td>1974-75</td>
<td>8141.50</td>
</tr>
<tr>
<td>1975-76</td>
<td><strong>5768.00</strong></td>
</tr>
</tbody>
</table>

**No scarcity condition was declared in any area of the State.**

The outlay is a spill over the previous year.


### Figure No. I.11.

**Expenditure Incurred On Scarcity Work In Gujarat From 1960-1961 To 1975-76**

Drought not only paralyse the economy of the region but also creates a social problem, which needs proper attention at the time of its occurrence. The intensity of the drought in Gujarat during the continuous drought year of 1985-88 could be measured from the following facts:

- 73% of the total villages in Gujarat were declared to be scarcity affected.
- Over 63.73% of the villages faced acute problems of drinking water supply problems.
- 16.4 lakh labourers were provided employment on relief works, during peak period.
- 3 lakh head of cattle were admitted to emergency cattle camps, (gaushalas and panjrapols).
- Over 80,000 tons of grass was moved from South Gujarat to the scarcity affected areas.
- State Government implemented Rs.86 crores of cash programme to mitigate the problem of drinking water supply.
- Gujarat government had estimated a financial requirement of Rs.42986.63/- for scarcity relief expenditure during the drought year of 1987-88.

The Government of India had approved total ceiling of Rs.147.44 crores for the financial year of 1986-87 and 1987-88 to meet with the expenditure on drought relief operation.

H. NEED TO DEVELOP DROUGHT PRONE AREAS:

The drought prone tracts are most vulnerable to ecological degradation leading to indefinite income which consequently results in migration and other social deprivation. The chronic drought affected areas of the country include 67 districts which is 19% of the total geographical area (60,00,000 sq.km.). Therefore, such a large area cannot be neglected in the overall development process of the country.

Economically the drought prone areas have a fairly large impact on the nation's total food economy. DPAP (Drought Prone Area Programme) districts of India have major contribution in total production of ground nut, bajra and sorghum, as these crops accounts for about 1/4 to 1/3 of the country's total production. These districts also account for about 12% of the total rice production of India. Thus the development of drought prone regions will not only stabilize the agricultural economy but also stop a cost-push inflation, which is caused due to shortage of agricultural production in the whole economy.

Drought not only paralyses the rural economy but also affects the urban centres of the region. Due to out-migration of selective young male adults, rural areas are left with children, old and female population. This results in unbalanced working population in the rural areas, which is not able to take...
care of all the agricultural activities. Migration of rural population to urban centres increases the pressure on the economic, social and physical resources of the centre. Hence, it is essential to develop both rural and urban areas as an integrated development programme for a region as a whole.

I. METHODS OF MANAGEMENT OF DROUGHT:
Drought is a nature induced disaster caused when the available source of water, e.g., rainfall, surface and underground water is not able to meet the minimum need of a human being. Hence, objective of every drought mitigation policy is conjunctive use of water from the moment it reaches the soil or vegetation. Most of the time our planning strategies for the development of drought prone area follows the policies adapted in the western European countries where not only the rainfall characteristic but also other physical and socio-economic condition is different from our monsoon system.

Table No. 1.9.

<p>| Conceptual Difference Between The Drought Prone Areas Of Western Countries And India |
|---------------------------------|---------------------------------|---------------------------------|
| India                           | Western European Countries      |
| 1. Average rainfall in a rainy day | Average rainfall on a rainy day is about 15mm to 20mm in all over the plains, whether it be a rainy place like Calcutta or an arid place like Jaisalmer. | In western Europe, average rainfall is about 2mm a day, that is, about one tenth of what it is for India. |
| 2. Rainfall distribution in a year | In India, rainfall is confined to four months of a year, i.e., from June to September. So, the people have to collect water for the rest of the year which is almost eight months in a year. This uneven distribution of rainfall creates the problem of drinking water even in area receiving rainfall more than 2000mm. | In western countries, rainfall is well distributed throughout the year. Therefore, rainfall deficit in a month can create a water scarcity for the standing crop but water will be enough to fulfill the compulsory need of a human being. |
| 3. Annual rainfall and its duration | Total annual rainfall in India is higher than most of the countries but it receives its rainfall in a very short period. A place having forty days of rainfall receives its total rainfall in hardly 100 hours and of this 10 percent (about 10 hours) of the hour accounts for the half of the total annual rainfall. | In western countries annual rainfall is less but number of rainy hours is more than that of our country. |
| 4. Variation in pattern of rainfall | The greatest problem of Indian rainfall is its spatial and temporal diversity. Added to this is the large variation in annual rainfall from year to year. | Even distribution of rainfall throughout the year does not affect much if the rainfall in a particular month is less than the average. |</p>
<table>
<thead>
<tr>
<th>5. Rate of erosion</th>
<th>high velocity of runoff due to heavy rainfall during monsoon leads to high rate of erosion resulting in siltation of reservoir or river mouth.</th>
<th>Due to low intensity of rainfall in a day, soil erosion is not that much high in these countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Soil moisture</td>
<td>Heavy rainfall in a short span of time allows high runoff rather than recharging the soil. This consequently results in low groundwater storage.</td>
<td>In western countries, rain falls in a fine division throughout the year allowing high concentration of soil moisture recharging.</td>
</tr>
<tr>
<td>7. Evapo-transpiration</td>
<td>In India, annual evapo-transpiration exceeds annual rainfall received by most of the area. Therefore water is deficit most of the year.</td>
<td>In western countries annual rainfall exceeds annual evapo-transpiration rate resulting in water surplus in most of the year.</td>
</tr>
<tr>
<td>8. Meaning of drought</td>
<td>Drought in India means not only deficit of water for plant growth but also lack of water, even for human consumption. In other words, drought in India is generally an ecological drought.</td>
<td>Drought is defined as the condition in which water is insufficient to ensure maximum growth of a plant. In western countries, drought is usually of meteorological or of hydrological type.</td>
</tr>
<tr>
<td>9. Effect of rainfall variability on crop production</td>
<td>In our monsoonal type of climate, rainfall is the major source of irrigation in most of the drought prone areas, hence if rainfall fails excessively then water is not enough to support a single crop in a year in most of the areas.</td>
<td>High soil moisture and even distribution of rainfall through out the year helps the crop to sustain even in low rainfall than normal. Even if a crop in a particular season fails the second crop in a year is able to retain the economic condition of an area.</td>
</tr>
</tbody>
</table>

Source: Developed by the author.

Hence, planning strategies adopted by the western countries to mitigate drought condition cannot be applied in our country. We have to develop our strategies as per the available physical and human resources of a region. Water deficiency is the cause of drought in any region. Thus, a management of drought means adequate supply of water required to support the life of every living being, which includes vegetation of an area also.

In a semi-arid district like Banaskantha, rainfall is the only source of water as rivers in the district are also ephemeral and monsoonal. Thus, management of drought in the district ultimately rests on the management of rainwater received in the four months (June - September) of a year. Most of the cropping pattern in our country is adopted according to the rainfall received by the respective areas. Areas where rainfall is high wet crops (crops require high quantity of water) are usually practiced, i.e., rice, sugarcane etc., whereas dry regions are the principal grower of dry crops, like pearl millet, sorghum, pulses, castor etc. Still drought affects 16% area in 77 districts of our country which are mainly in arid and semi-arid areas. (Report of the Irrigation Commission, 1972). The chronically drought...
affected areas coincide with extremely arid areas like western part of Rajasthan and Kachchh. Rainfall in these areas is not sufficient for a single crop in a year but these areas have adopted their living style with this minimal availability of water. Effect of drought is maximum in semi-arid areas of the country. Due to high deviation of rainfall in these areas, probability of drought is more than 0.3%. Drought is mainly ecological type in these areas where water is not sufficient even to meet the thirst of the people and cattle. In this type of situation, an organised method is required to fight with condition of drought. Mitigation of drought does not mean relief work during drought period to be done but there should be long term projects before the arrival of drought, to minimize its effect. Strategy to handle the drought condition requires following steps:

- Identification of drought prone areas in the country.
- Proper research work to study the pattern of rainfall for forecasting its onset sufficient early, so that necessary steps can be taken earlier.
- Study the other physical and human resources of the area to determine other problems and its effect on the process of development.
- To develop an integrated development strategy where efforts should be more in the direction of creating permanent assets which would help to solve the agrarian problems of these chronic scarcity affected areas for a long period.
- Exercises in identification and development of drought prone areas are meaning less without proper follow-up action. Thus, evaluation of development work is needed for rectification of side effects of any development project.

All development works ultimately rest on the financial infrastructure of the region and on the policies of those in power. Other than this success of development project lies on the acceptance of the local people of an area. The people’s participation is essential for the development of an area.

**J. MAJOR OBJECTIVES OF THE STUDY:**

The major objectives of this study are to understand the effect of drought on various parameters of environment, both physical and human. The study seeks to know the other factors working with drought, to make it one of the backward regions of the State. The study aims to come up with such methods that will help to develop this drought prone backward district as one of the progressive districts of the State. To achieve these goals, the following points are kept as the major objectives of the study:
2. To demarcate the drought prone areas and drought years, as per the definition of Irrigation Department, in Banaskantha district.
3. To study the aridity index of the district over space.
4. To know the spatial pattern of land capability in the district.
5. To calculate the integrated developmental potential model of the district.
6. To study the spatio-temporal impact of drought on social and economic aspects at meso (taluka) and micro (village) level.
7. To evaluate the various planning strategies carried out in this area by Government Organisations, NGO’s and people to combat with drought and backwardness prevailing in the region.
8. To suggest planning strategies for drought prone areas through integrated measures.

K. LITERATURE REVIEW:

Drought, its causes and effects, differs a lot from one to other region. Therefore process of management also changes accordingly. This is why, researchers from different regions have described the “drought, its effect and management” as per the area selected for the study or work. Literature review has been divided into three parts:

1. Conceptual aspects of drought,
2. Regional studies on drought and
3. Planning and development of drought prone areas.

K.1. Conceptual Aspects Of Drought:

Pattern and causes of drought varies from place to place, depending upon the normal climatic conditions, available water resources, land-use, agricultural-practices and other economic activities of the region. Therefore, the approach to delimit the drought prone areas and its causes, to calculate the intensity of drought and type of drought prevailing in area are presented in various ways by different scholar.

Many worldwide Meteorological Organisations\textsuperscript{143} believe that El-Nino brings lean rainfall in India, Africa and Australia. El-Nino is a Spanish word, meaning warm current of the (Christ) child. Peruvian fisherman have coined this word to describe an unusually warm surface current off the coast of Peru in South-America, which occurs once in a few years, around December. It is abnormally warm (maybe...
7°C) compared to the normal situation of most years. El-Nino is a local symptom of a global scale perturbation in the circulation of the atmosphere and also in the Pacific ocean. But very few scientists see some connection between El-Nino and the monsoons in India. D.R.Sikka, former director of the Indian Institute of Tropical Meteorology, Pune said that whenever the El-Nino phenomenon has occurred, 60% of the time India had a bad monsoon. J.Srinivasan, chairperson, Centre for Atmospheric Studies, Indian Institute of Science, Bangalore, says that whenever there was unusual warming or cooling of the east Pacific, global circulation patterns have changed and hence, rainfall in India is affected. Richard Grove, Prof. of environmental history at the Australian National university, feels that El-Nino will have a direct effect on the monsoons in India. He told that "when you get a strong El-Nino, the Indian monsoon fails, you can demonstrate that historically. The biggest famines in Indian history were linked with the El-Nino effects."

Some of the scholars of India thinks that El-Nino is affecting the Indian monsoon but it is not the only factor of drought in India. According to Vasant Gowrikar, Ex-Director General of IMD and is the creator of the Monsoon Prediction model with 16 parameters in India, El-Nino is just one of the parameters taken into account while preparing a long range forecast. According to K.S.Sivasami, Professor at the Centre for the Study of Regional Development, JNU, "Indian Monsoon prediction is currently based on an empirical 16-parameter model which the IMD has been using successfully since 1988 to predict monsoons. If we analyse monsoon rainfall data since 1951 onwards, it is clearly seen that there is no direct relation between El-Nino and the Indian monsoon. There are many years in the past when El-Nino has occurred, but India has witnessed good monsoon."

Other than El-Nino factors, Dr. P.S.Desai, N.K.Vyas and H.J.Andharia of Space Applications Centre, Ahmedabad, believe that volcano eruption also affects the rainfall pattern of the Indian continent. Volcanoes inject aerosols into the atmosphere which reach the stratospheric heights and attenuate the solar insolation. This causes lowering of surface temperatures and modification of temperature gradients. The change in the heat transport, brought about in this way is likely to affect the global weather and possibly the Indian monsoon also. Usually the low latitude volcanic eruption are associated with drought years of monsoon because the low latitude aerosol takes only a few weeks to spread around the globe, even if they occur upto July of a given year. But the high latitude eruptions are generally associated with above average monsoon but not with excess rainfall, as the high latitude
aerosol takes a few months time to spread around the globe, so they do not affect the rainfall of the same year, they may affect the monsoon of the following year.

N.B.K. Reddy and V.R. Singh in “Delimitation of drought prone areas of India - A geographical approach”\textsuperscript{75} has identified and delimited drought prone areas in India by considering three parameters, i.e., climatic characteristic, soil factors and agronomical and socio-economic condition.

C.D. Despande in “Drought prone areas and the human response”\textsuperscript{75} and A.K. Tewari in “Perception of drought hazard among the people of drought prone area in arid lands of India : A case study”\textsuperscript{75} stated that response of human regarding the disaster should be studied as it affects the adoption and adjustment to arid areas. His concepts are of great help for understanding the perception of different groups in a village community.

K.R. Chowdhury in “Concepts, approaches and methodology for delimitation of sub-area in drought prone areas”\textsuperscript{75} has stated that drought prone area should be divided into sub-areas, as drought prone areas have variations in productive factors and are vast enough for making concentrated efforts for development.

In his paper “The problem of droughts: What can the geographer do” by B. Arunachalam\textsuperscript{75} has discussed drought as per the people living in the area and then suggested that geographer should synthesize the results of researcher working in different disciplines on a spatial frame.

In a paper of “Drought prone areas of India - Problems and perspectives” R.K. Narayan,\textsuperscript{75} has given a list of drought prone talukas in India, based on the concept of Irrigation Commission. He has also discussed various methods and technologies can be used for the integrated development plan for drought prone areas.

In her paper named “Famines Relief Administration in Madras Presidency 1800 to 1900”, Ms. Usha Murthy\textsuperscript{75} has discussed the geographical features of the Madras presidency from 1800 to 1900 with special reference to climatic influences and their relationship with famine. She has also attempted to study the important famines in the selected area between 1800 and 1900 and the relief measures undertaken by British Government to famines during the said period.
In their paper "Droughts and famines in Rayalseema : A study of spatial-temporal pattern", B.Venugopal and Ms.R.Geetha has studied the general climatic features of Rayalseema and then divided the area according to the frequency of drought in Rayalseema. They made a conclusion that the western and north-western parts of Rayalseema are more prone to drought then the rest of the area.

In "Desertification and drought prone areas", N.B.K.Reddy and M.Uttara Prabhu has discussed the global perspective about desertification and different mitigation method. They have also discussed the drought prone areas of India and DPAP programme working at macro level.

All the above conceptual views about drought, its causes and delimitation of drought prone areas are in macro level or in district level. It seems that within drought prone district, the intensity and causes of drought vary. In this research work, drought is considered as a temporary weather phenomenon caused due to insufficient rainfall or when the water is not enough to fulfill the demand of people. Mean annual rainfall, number of rainy days in a year, intensity of drought and percentage of area having irrigation facility are considered as principal parameters for the delimitation of drought prone area in Banaskantha district, the study area of this thesis.

K.2. Regional Studies On Drought:
Different scholars have used different methodology to delimit the drought prone areas and its affect on a particular region. V.P.Subrahmanyam and Ms. B.Hema Malini in their paper "Drought prone areas of Andhra Pradesh" has identified the drought prone areas of Andhra Pradesh with the help of isopleath map of annual and seasonal rainfall variability's in A.P. they also worked out the aridity indices of A.P. by Thornthwaite's procedure.

In "Annual potential water deficit in Andhra Pradesh" by Nreependra K. Singh has made an isopleath map of annual potential water deficit according to Penman potential evapo-transpiration method of A.P.

In a paper named "Evaluating water resources in the light of climatic fluctuation in Israel", H.L.Striem concluded that the climatic fluctuation in Israel occur in an irregular pattern, the minimal...
cycle of which is at least 20 years. The long-term average for the range between decadal maxima and minima is less than half the range of the known extremes. A band at ± 215 mm distance from the curve joining decennial means will envelop 90% of all cases of the annual rainfall series, and its ups and downs show the validity of the abstraction of wet and dry sub-periods. Hence the frequency distribution of annual rainfall within the sub-period leading up to the present is a much better guide to an extrapolation for the oncoming, say, five years, than the long-term distribution.

In their paper named "Telangana - Rainfall variability an aspect of drought", M.J.Subhramanyam and K.Surender Reddy75 have investigated the variation of southwest monsoon (kharif season) and relation of rainfall with crop yields in order to assess the impact of drought. With the help of number of drought years in 30 years and co-efficient of variability of rainfall, they tried to demarcate the area of severe drought prone areas in Telangana.

Moris Deutsch, Pieter Van Dongen, Robert Anderson and Peter Gilruth122 have identified hydrogeological features of Kenya with the help of Landsat Multispectral Scanner (MSS) data in their paper "A methodology for application of thematically enhanced landsat MSS film data in direct support of hydrological investigations in Kenya". As hydrogeologic significant feature areas deemed favourable for the ground water development in the country.

On the basis of mean rainfall, number of rainy days and percentage of irrigated land, Irrigation Commission has demarcated the drought prone area of the district during of 1972. After that nobody has revised the drought prone areas of the district, as the percentage of irrigated land has changed a lot after that year. This study has tried to demarcate the drought prone areas of the district by taking the recent parameters.

K.3. Planning And Development Of Drought Prone Areas:
On the basis of spatial and temporal pattern of drought and its effect on different aspects of man and environment, different planning strategies are suggested to develop the drought prone areas accordingly. As the problems of drought prone areas differ from area to area, thus, various researchers, as per the need of an area has suggested various planning strategies.
WMO has given emphasis on understanding of seasonal climatic anomalies for the seasonal predictions of drought. This in turn will lead to greater capability to prepare and respond to drought and its management. WMO has also given emphasis in water resource management and assessments to cope with natural hazards of floods and drought.\textsuperscript{122}

To meet the increasing demand of water, research, no longer precede the commercial exploitation of water resources in Israel. Therefore, in a paper named “Research and development as an integrated element in water resources management in Israel” by Miriam Waldman and Yehuda Shevah\textsuperscript{122} have said that the research and development activities have to be fully integrated in water resource management programmes on an on-going basis in a country.

In “Development Strategy for Drought Prone Areas”, L.S. Bhatt\textsuperscript{75} has suggested that a single programme for all drought prone areas of the country is not advisable. Therefore development programme should formulated of (a) national strategies for development of drought prone areas, (b) regional strategy for development, appropriate to different types of areas (c) a long term spatial development framework and (d) short term development plans.

“Some socio-economic and demographic implications in planning for drought prone areas of Maharashtra” by B. Arunachalam\textsuperscript{75} is based on two complimentary tasks: (a) to assemble existing knowledge and to present it in a coherent form so that a meaningful understanding of the basic ills that lie at the root of the regional problem is aided, and (b) to elaborate a plan of action.

B. Hymavathi\textsuperscript{75} in her paper named “Some aspects of the development of drought prone areas” has suggested that in a drought prone area, where irrigation by canals is not feasible, irrigation should be provided by ground water. Rotation of drought resistant crop should be developed to decrease the evapo-transpiration rate and avoid the crop failure. She has also suggested the diversification of activities to reduce the regional economic disparities.

In their paper “Interdisciplinary Approach to the Integrated Development of Drought prone Areas” B.L. Bhandi and D. Vasudeva Rao\textsuperscript{75} have suggested interdisciplinary approach by (a) irrigation, (b) soil conservation, (c) forest and pasture, (d) horticulture, (e) animal husbandry, (f) fisheries, (g) sericulture, (h) industries and (I) PWD, to mitigate the severity of drought on a permanent basis, to develop
agriculture and also to generate employment opportunities in the region for all classes of people, particularly for small and marginal farmers and agricultural labourers.

In "Some aspects of Strategy and Planning for Agricultural Development in Drought Prone Areas" K.R.Chowdhary has discussed about the objectives of planning for drought prone areas, present level of agricultural production and problems of analysis. He had also given the methods to increase the agricultural production and also to increase the economic reliability of drought prone areas.

In "Sustaining Environment in Water Resources Projects", S.Chandra said that water resource development should be designed to build the environment rather than destroying it. This can be achieved by attaining a judicious mix of development and environment by creating consciousness amongst the builders and populace and by enforcing the environment standards strictly.

G.N.Reddy in his paper "A Strategy for the Diffusion of Agricultural innovations in DPAP Areas" has suggested that to provoke small and marginal farmers for the adoption of new technology, extension workers have to work through community for the community.

John W.Hernandez in "Criteria for potential sites for irrigation with saline waters in New Mexico" has identified and discussed criteria for the location of favourable sites for irrigation of crops with slightly and moderately saline waters in the arid southwestern state of New Mexico. These criteria falls into three categories: (a) crop production criteria; (b) economic and firm efficiency factors; and (c) public welfare, conservation and environmental concerns.

G.Lakshmaiah Naidu has said in his paper "Interdisciplinary Approach for Integrated Development of Drought Prone Areas" that to transform the drought scene from drought prone areas, interdisciplinary integrated development of drought prone areas should be encouraged in National planning. Interdisciplinary development programme includes not only the development of agriculture and cattle output but to enrich the total quality of life and its availability at minimum levels to all sections of the population, socio-economic systems, infrastructure, technology, level of education, health facility should be developed.
Planning strategy vary according to the need of an area. Banaskantha district is declared as the "drought prone district" of the State by Irrigation Commission but the eastern part of the district have enough rainfall and irrigation facility to grow three crops in a year, whereas, the western part of the district can grow only one crop in a year. This uneven distribution of water can be mitigated by proper distribution of water, development of available water resources and proper change and development of agronomic practices. Uneven distribution of water resources is not the only cause of drought, poor physical and human resources also increase the severity of drought in western talukas. Therefore, an integrated planning strategy is needed to minimise not only the severity of drought but also for the overall development of the region.