MONITORING AND ESTIMATION ON DROUGHT PRONE AREAS OF TUMKUR DISTRICT BY USING GIS AND STANDARDIZE PRECIPITATION INDEX (SPI) FOR TUMKUR DISTRICT, KARNATAKA.

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Abstract:

Drought is a natural phenomenon that has occurred in all ages of Earth and its effects have become more evident in recent years, with population growth, raising the water consumption and urbanization and globalization. Drought is one of the natural disasters that is the results of shortage rainfall lower than normal range or expected rainfall. If this shortage rainfall persists for a long period, such as one season or many years, due to this reason the Aquatic needs are not able to provide related to human activities and the environment. A large historical dataset are required for the study of drought which involves complex communication between the meteorological and climatological data. Tumkur had been suffering from an epic drought in 2016 drought in this area affected to Agriculture crops, vegetation pattern and ecology. Therefore, the present study has been conducted to find the drought variation from the year 1996 to 2016 and climate changes indexed in Tumkur district by using the data sets of rainfall, humidity, temperature and wind speed values. The study has been analyzed different method of statistical-probability based on GIS and SPI for Tumkur district.

KEY WORDS: Drought, Climate change, SPI, GIS, Tumkur, Karnataka, India

1. INTRODUCTION:

Drought is a single most important natural disaster often influence to human life and action. Researchers have developed and design a number of tools to define the, begin, effect, severity, and end of the droughts. Drought indices take thousands of data on RH, rainfall, temperature, streamflow, wind speed, humidity etc. analyze the data at different time, fields and turn the data into a comprehensible big picture. The beginning of drought and ends is difficult to determine. To identify the drought the various indicators such as rainfall, wind speed, temperature, streamflow, and more are used to track these indicators to monitor drought. Drought is one of the main natural causes of agricultural, economic, and environmental damage (Burton et al. 1978; Wilhite and Glantz 1985; Wilhite 1993). Drought is generally characterized by short or long period rainfall, precipitation over an extended period, in one season or more, the drought cause impact on requirement of water for peoples, Vegetables and animals. There is any legally accepted definition and description of drought in India. Some states to refer the climate condition, resort to their own definitions of drought. State Government is the final authority to declaring a region as drought affected. In the particular region of the state droughts can occur under different climate conditions but their affects and recurrent are more occur in arid and semi-arid situations (Singh, 2003). The concept of drought change from a place to another place depending upon normal climatic conditions, agricultural practices, available water resources and the various socio-economic attributes of a region. Arid and semi-arid areas are most vulnerable from drought in the globe, which occurring with varying magnitudes but now in India fundamentally the drought phenomena is change. The regions with high rainfall and humidity often face severe water scarcities. The evidence of drought and point out the 'changing face' of drought in India is growing fast, with examples of Cherrapunji in Meghalaya and Jaisalmer in Rajasthan area. Cherrapunji is one of the world's highest rainfall areas, with over 11, 000 mm annual rainfall, now every things is change and area faces drought for almost nine months of the year, and the western part of Jaisalmer district of Rajasthan, one of the driest parts of the India, is recording around 9 cm of rainfall in a year. In recent years, there have been many methods to develop new drought indicators, or to improve existing indicators and methods (González and Valdés 2006; Tsakiris et al. 2007, Keyantash and Dracup 2004). Most researchers related to study about drought analysis and monitoring systems have been using the standardized precipitation index (SPI). The Standard Precipitation Index shows the actual precipitation relative to the probability of precipitation for different times in a region. The SPI index is based on precipitation and it can be used at different time scales, the index allows it to be useful for both applications in short-term agricultural and long-term hydrological. In SPI classification is divided to extremely wet to extremely drought in between shows the percentage of intensity of drought and wet. When a drought is occurring the SPI is continuously shows negative and reaches an intensity of -1.0 or less. The event ends when the SPI becomes positive and precipitation in a region is increase.

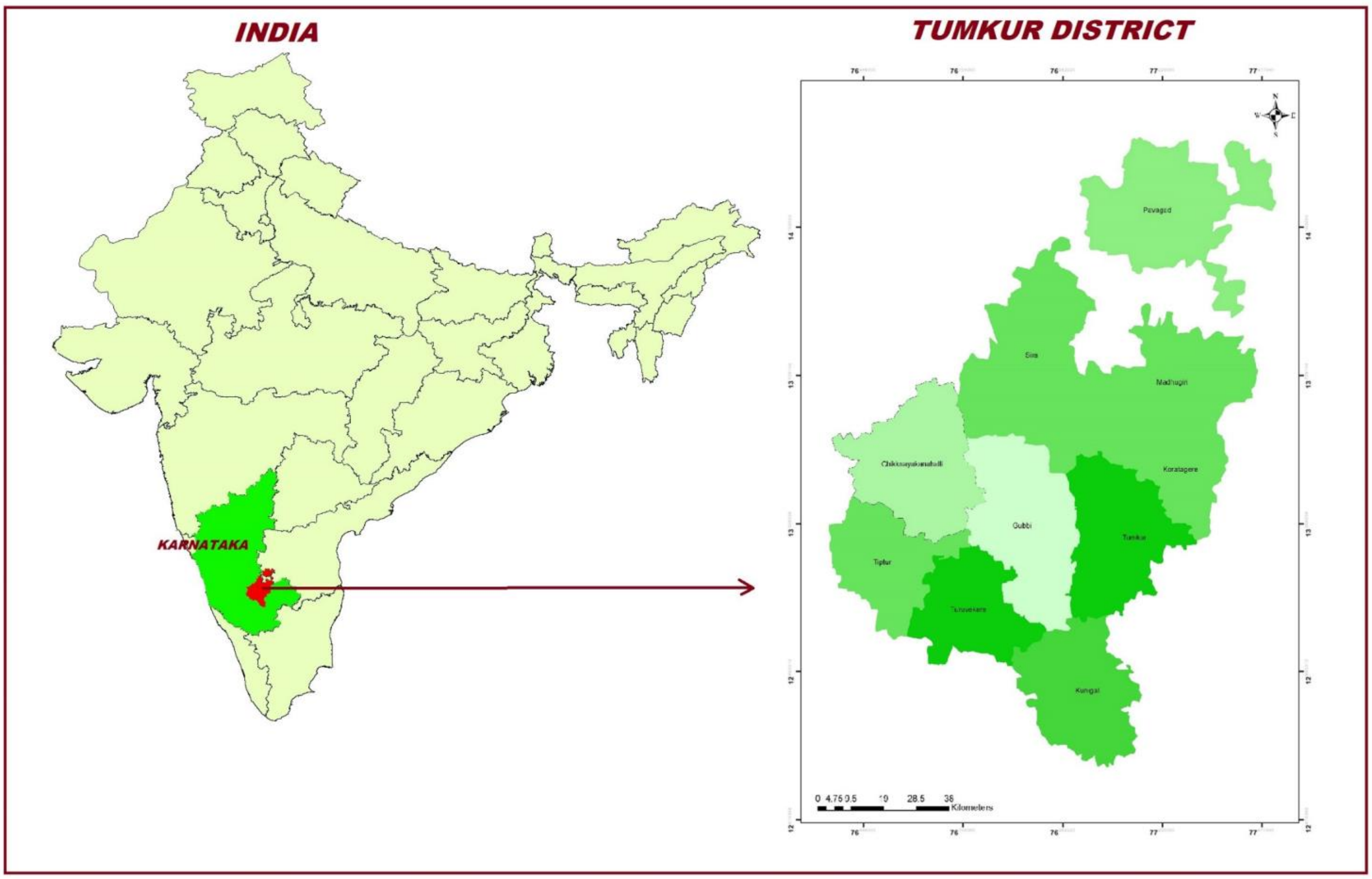


Fig.1: Location map of Tumkur District, Karnataka

2. LOCATION OF THE STUDY AREA:

Tumkur (Tumkuru) City, is the headquarter of Tumkur District. It was the old part of Mysore state and now is located in Karnataka state. Tumkur district is surrounded on all sides by lands belonging to the neighboring districts and has no natural boundary such as sea, river or mountain ranges on any side except a big batholith of granite. The landscape consists mainly of, undulating plains interspersed with a sprinkling of hills.

Tumkur district has 10,597 Sq.Kms and is located between 12 45 'and 14 20' of North Latitude and between 76 20' and 77 37' of East Longitude. It is on the North by Ananthapur district of Andhra Pradesh, on the South by Mandya district, on the East Chikkaballapur and Bangalore districts and on the West by Chitradurga and Hassan districts. With population 26,78,980(in (2011 with 10 Taluks.The Tumkur district is one of " Maidan " (

plain) districts of the State. Generally, this is an open tract except in the South of Kunigal Taluk, where the land is wooded and hilly. The other parts are undulating plains, intercepted with cluster of all and well-grown trees. The open part of the district maintains generally even level above the sea; but Pavagada Taluk, and Sira Taluk are at a considerably lower level than the rest.

Methodology:

Monitoring the drought need large historical datasets and these involve complex interrelationships between climatological and meteorological data. A time series of remotely sensed images (Landsat TM5), covering 20 years of landsat ETM + 7, were used to obtain landuse change information, using the post-classification comparison technique (Lillesand and Kiefer, 2000). One of the important parameter for monitoring is rainfall, the amount and distribution influence the type of vegetation in a region. To analyze the changes in the climate due to changes in rainfall and identification the areas facing and affecting drought risk. Precipitation data from 1996 to 2016 were categorized into excess, normal, deficit and drought years.

Standardized Precipitation Index (SPI):

Researchers at Colorado State University (McKee et al. 1993; McKee et al. 1995) designed the SPI in 1993 to be a relatively simple, year-round index applicable to the water supply conditions important to Colorado and as a supplement to information provided by the PDSI and a second drought index, the Surface Water Supply Index (Shafer and Dezman 1982).

The variety of timescales allows the SPI to monitor short-term water resources, such as important for soil moisture and agricultural production and longer-term water resources such as in different level groundwater resources in many different watersheds. SPI is the number of standard deviations in accumulation of precipitation is calculated from the climatological average. Some of the SPI index parameters are different from other climates. The ability to check different timescales is allows droughts to be identified and monitored for variety types of drought. SPI will specified the meteorological drought around the world (Lincoln 2009).

The Standardized Precipitation Index (SPI) is an indicator to classify and characterize meteorological drought in a range of timescales. On short timescales, the SPI is related to soil moisture, while at longer timescales, the SPI can be related to groundwater and reservoir storage. It can be calculated for any time scale; various monthly and multi-monthly time scales are shown here. In recent decades, many studies using the SPI were undertaken.

Advantages of the Standardized Precipitation Index (SPI):

It is simple in input the precipitation
Showing and describe the drought is n time scale
Describe dry and wet period at the same way
It can be compared in regions with different weather condition.
It can be created for differing periods of time, 1-to-36 months.
The standardization of the SPI allows the indicator to determine the frequency of current drought.
It requires only monthly precipitation. Describe dry and wet period in the same way.

Disadvantages of the Standardized Precipitation Index (SPI):

Short time periods (1, 2 month) regions with low precipitation can give misleading SPI values.
Short time period (1, 2 month) regions with low precipitations can give misleading SPI value, access to a long, reliable temporal time scale, most work is for meteorological drought.
Access to a long, reliable temporal time series.

The aggregated monthly precipitation data series of 3 months was used in the present study in the Tumkur region. This was then followed by computing the SPI values which were used in drought monitoring, classification and assessment.

The selection of the Gamma distribution function in particular region was preferred in this study as it is appropriate for time of rainfall data and changes in temperature. The Gamma distribution is expressed in terms of its probability density function.

$$g(x)=\frac{1}{\beta^{\alpha}\Gamma(\alpha)}x^{\alpha-1}e^{-x/\beta}\quad for\ x>0$$

In this formula α is the shape parameter, β is scale parameter, x is the rainfall amount (mm), Γ(α) is the value taken by Gamma function, The Γ(α) is the value defined by a standard mathematical equation called Gamma function and -x is mean rainfall (mm).

$$\Gamma(\alpha)=\int_0^{\infty} y^{\alpha-1}e^{-y}dy$$

$$\beta=\frac{\bar{x}}{\alpha}$$

Where; α, β, x have the same meaning as given in Equation 1, and A is a sample statistic.

$$A=\ln(\bar{x})=\frac{\ln x}{n}$$

n is the number of observations

$$SPI=-\left(k-\frac{c_0+c_1k+c_2k^2}{1+d_1k+d_2k^2+d_3k^3}\right)for\ 0<H(x)\leq 0.5$$

$$SPI=+\left(k-\frac{c_0+c_1k+c_2k^2}{1+d_1k+d_2k^2+d_3k^3}\right)for\ 0.5<H(x)<1$$

The value of k in SPI + and SPI - were determined using K given as:

$$k=\sqrt{\ln\left(\frac{1}{H(x)^2}\right)}\ for\ 0<H(x)\leq 0.5$$

$$k=\sqrt{\ln\left(\frac{1}{1-H(x)^2}\right)}\ for\ 0.5<H(x)<1$$

The process of calculate the SPI following this flowchart using a monthly time step in rainfall and temperature. In this study, the SPI values were calculated using a monthly time step

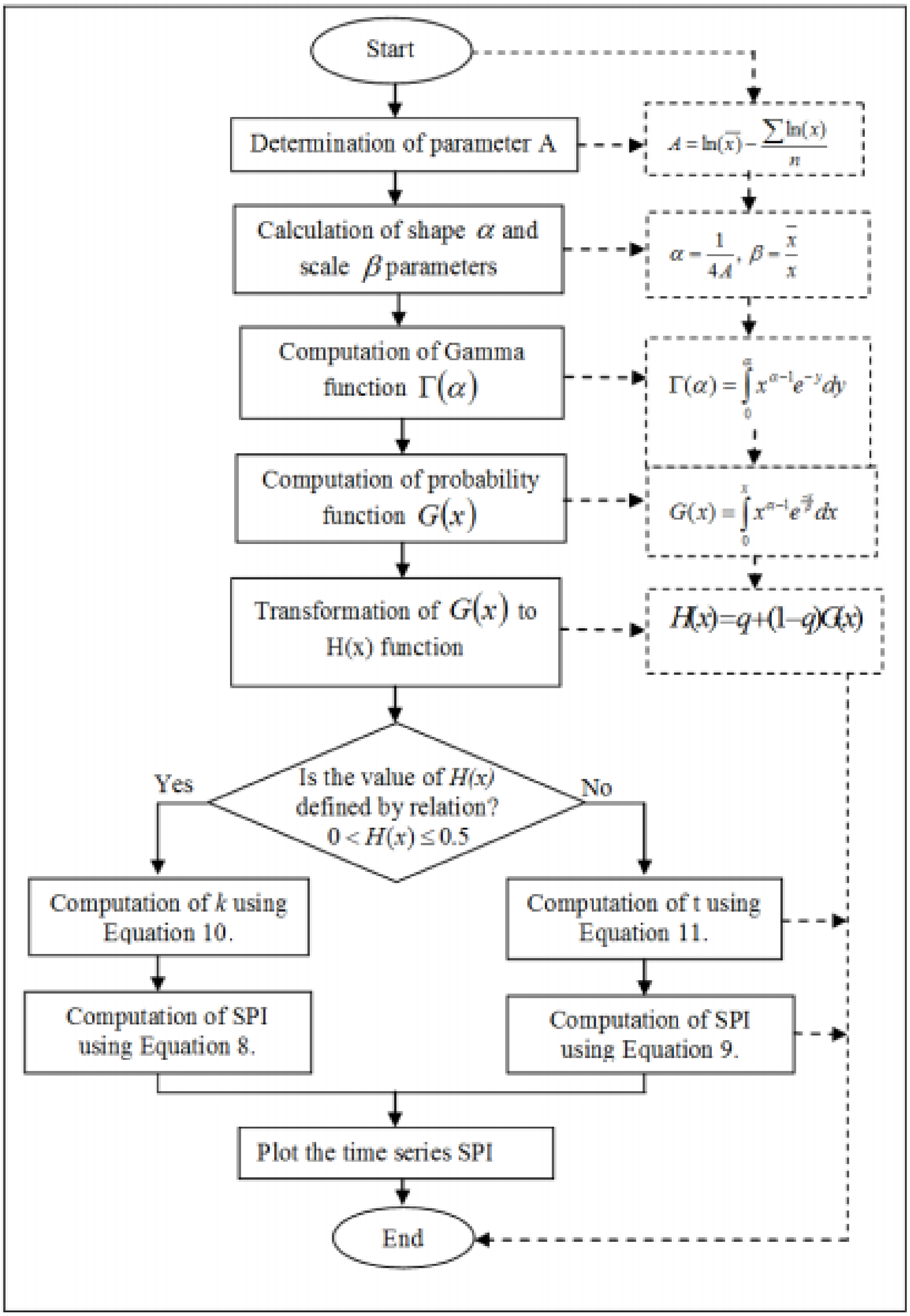


Fig.2 Flow chart for SPI computation.

3. ANALYSIS

Calculation of the SPI for a specific time period at any location requires a long-term monthly precipitation database, whatever long period data for more than 30 years shows better result for SPI . The probability distribution function is determined from the long-term record by fitting a function to the data. The cumulative distribution is then transformed using probability is equal to the normal distribution with a mean of zero and standard deviation of one so the SPI value are really in standard deviations (Edwards and McKee 1997).

SPI values account for a normal distribution, it can be expected that these values to a standard deviation of approximately 68% of the time, within two standard deviations 95% of the time, and within three standard deviations 99% of the time. A related interpretation would be that an SPI value of less than -1.0 occurs 16 times in 100 years, an SPI of less than -2.0 occurs two to three times in 100 years, and an SPI of less than -3.0 occurs once in approximately 200 years.

The drought analysis is carried out with 20 years (1996-2016) rainfall data of Tumkur district rain gauge station it revealed that the normal rainfall is about 800 mm. to refer the prepared map and precipitation data for last years and preparing the SPI data shows the distribution the drought in Tumkur district and shows which taluks may have more drought in future.

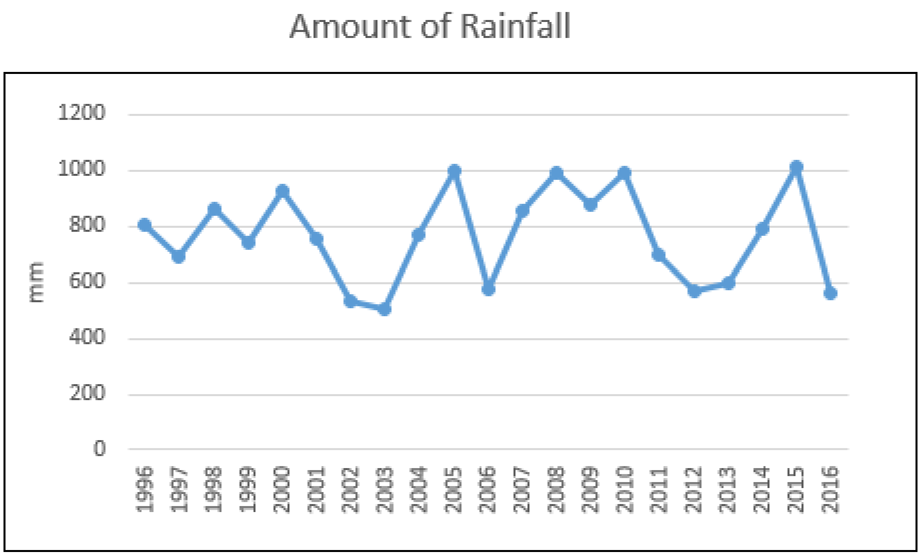


Fig 3: Average of amount of rainfall during 1996 to 2016 in Tumkur District

The amount of precipitation and other indexes with in SPI formula have cumulative probability in different classification. In many paper to study the SPI, the gamma distribution is found to fit the precipitation data very well (Saunders 2002) and to provide the best model for describing monthly precipitation. The SPI, often has the z score, is the number of standard deviations always from the mean at which an event occurs. The 3-month SPI value provides a comparison of accumulated precipitation over that specific 3-month period with the mean precipitation total for the same annual period as calculated over the full study period.

Table 1:Standard of SPI value and classification in the study area

SPI Value	Classification	Cumulative probability (%)
2.0 or more	Extremely wet	2.3
1.5 to 1.99	Very wet	0.4
0 to 0.99	Moderately wet	34.1
0 to -0.99	Near normal	34.1
-1 to -1.49	Moderate dry	9.2
-1.5 to -1.99	Severity dry	4.4
-2 or less	Extremely dry	2.3

For illustration purposes, Figure 4 shows drought conditions on yearly time series for selected rainfall gauging stations at Tumkur district, located at the lower and higher elevations of the basin respectively. Both the time series SPI and the precipitation were plotted for ease of comparison as given in Figure 4 for the selected meteorological stations. The time series plot show that the SPI varies with the yearly precipitation within the study period. The SPI for meteorological stations presented are objectively selected to represent severe drought in different taluk.

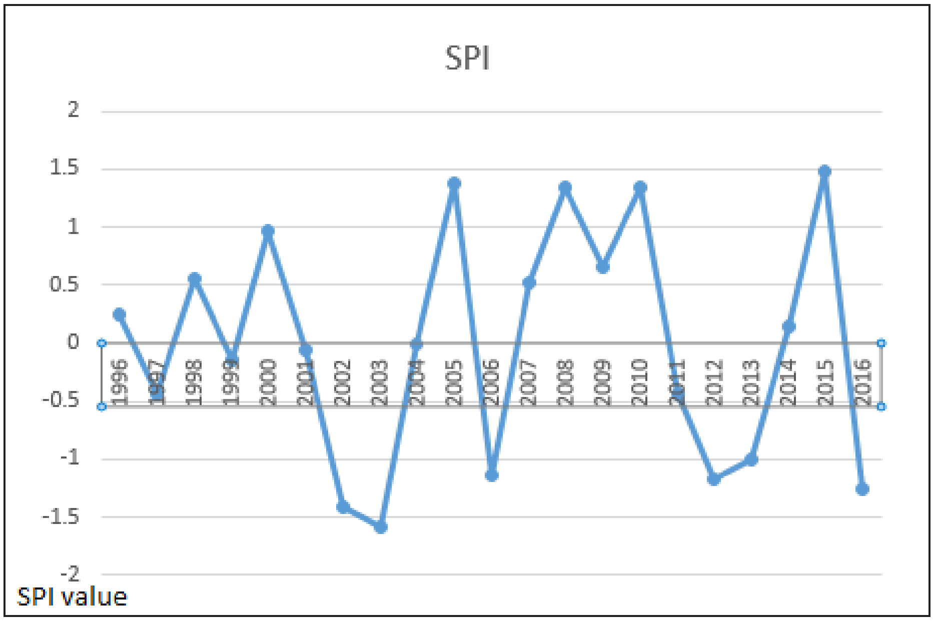


Fig 4: SPI value to show the severity of Drought in the study area

Advantage of using remote sensing and GIS is more than other common methods, mainly in handling large amounts of data at different scales and mapping them. GIS make wider application of statistical analysis, merging cartography, and database technology, for interpretation, collation, mapping and covering existing features as a vector data or non-spatial data on various aspects of risk and drought vulnerability. GIS is useful in spatial and non-spatial data as well as in the combination of spatial data from various sources and GIS is useful to identifying and describing spatial associations in data and using model for prediction and different types of analysis(proximity analysis, network analysis, tabular analysis), digital terrain model. The standardized precipitation index (SPI) is computed and analyzed using 20 years of precipitation data recorded in many observation stations in Tumkur district.

Table 2: examples of the Situation of Drought to refer the amount of rainfall and SPI value

Year	Rain	SPI	Situation
1996	807.83	0.245988	mildly dry
1997	693.99	-0.44146	mildly dry
1998	859.44	0.557646	mildly dry
1999	741.99	-0.1516	mildly dry
2000	927.86	0.970814	mildly dry
2001	757.1	-0.06036	mildly dry
2002	532.98	-1.41375	moderatly dry
2003	504.02	-1.58863	severely dry
2004	767.05	-0.00027	mildly dry
2005	995.56	1.379635	moderetly wet
2006	578.1	-1.14128	moderatly dry
2007	854.47	0.527634	mildly dry
2008	990.83	1.351072	moderetly wet
2009	875.9	0.657043	mildly dry
2010	990.53	1.34926	moderetly wet
2011	695.51	-0.43228	mildly dry
2012	572.25	-1.17661	moderatly dry
2013	601.15	-1.00209	moderatly dry
2014	789.84	0.137352	mildly dry
2015	1013.32	1.486883	moderetly wet
2016	559.27	-1.25499	moderatly dry
mean pre	767.0948		
standard d	165.5983		

Spatial Distribution of Drought shows the severities of drought is increase and except the Tumkur and Kunigal taluks others taluk suffering the drought.

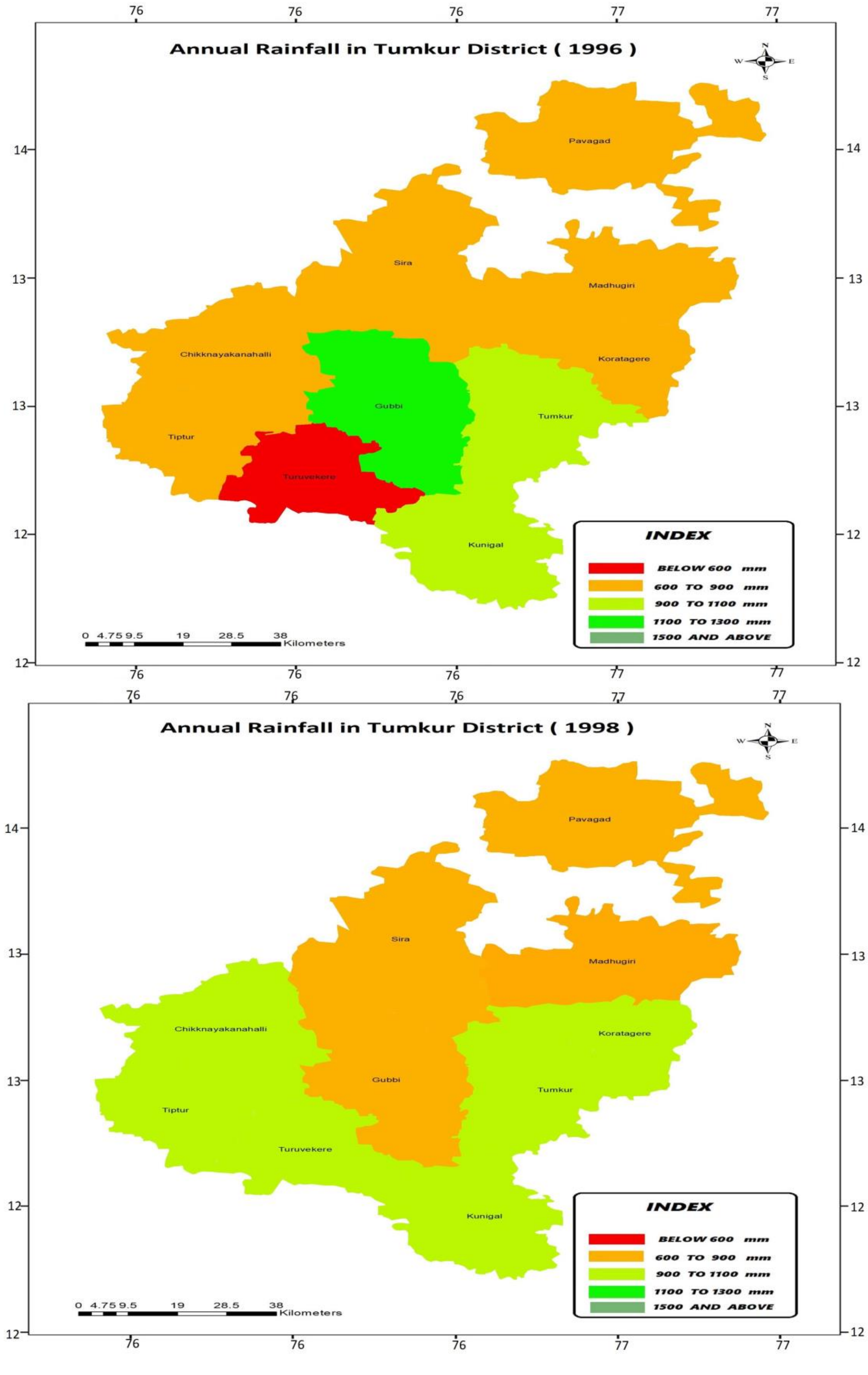
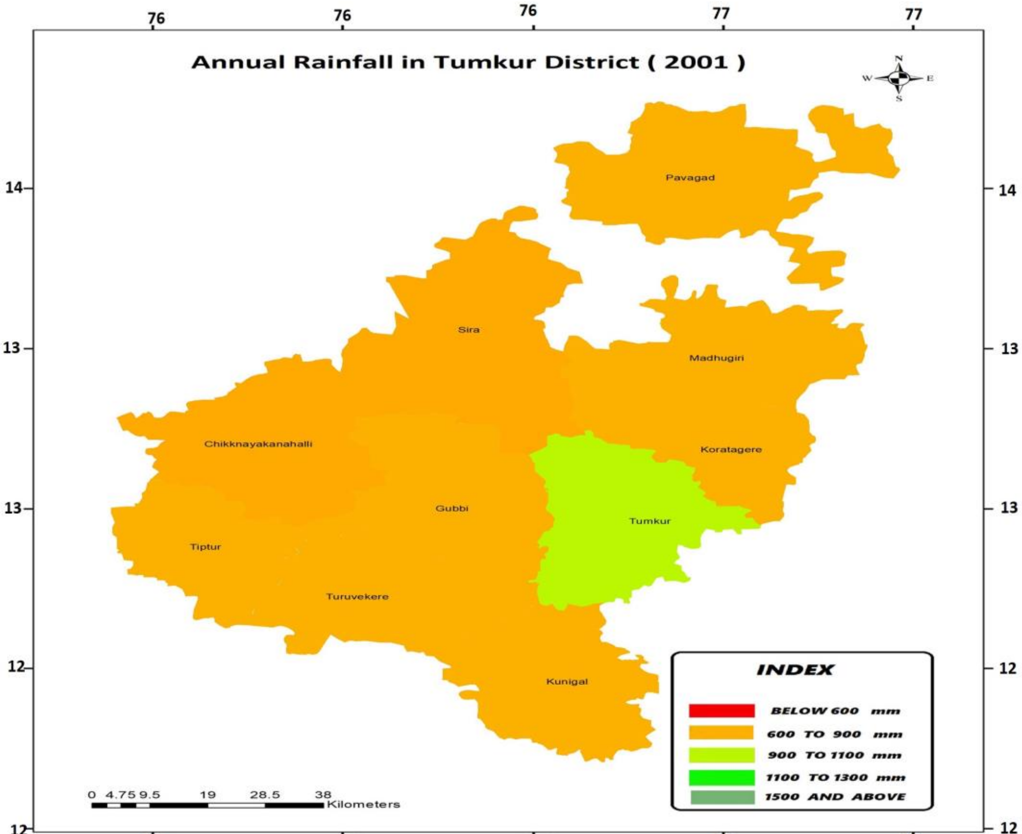


Fig 5: Annual rainfall and SPI values prepared maps from 1996 and 1998



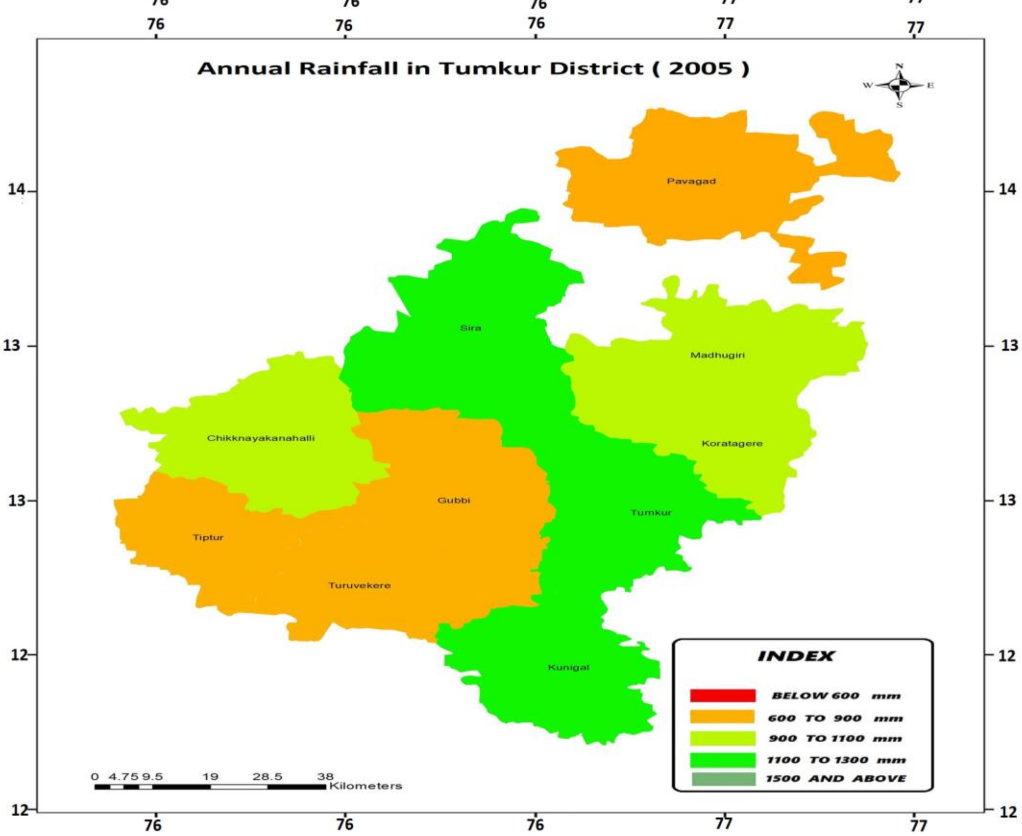


Fig 6: Annual rainfall and SPI values prepared maps from 2001 and 2005

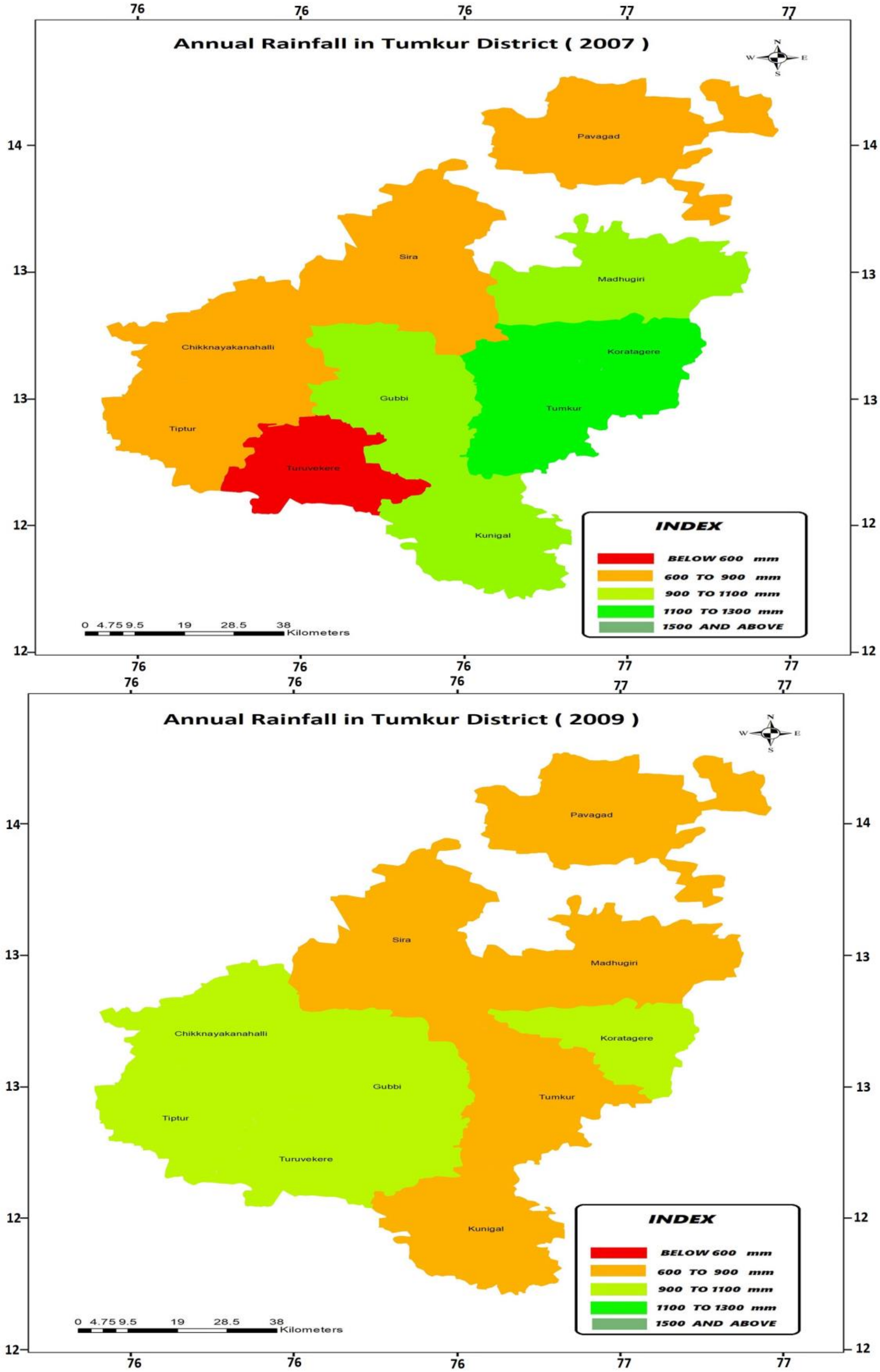
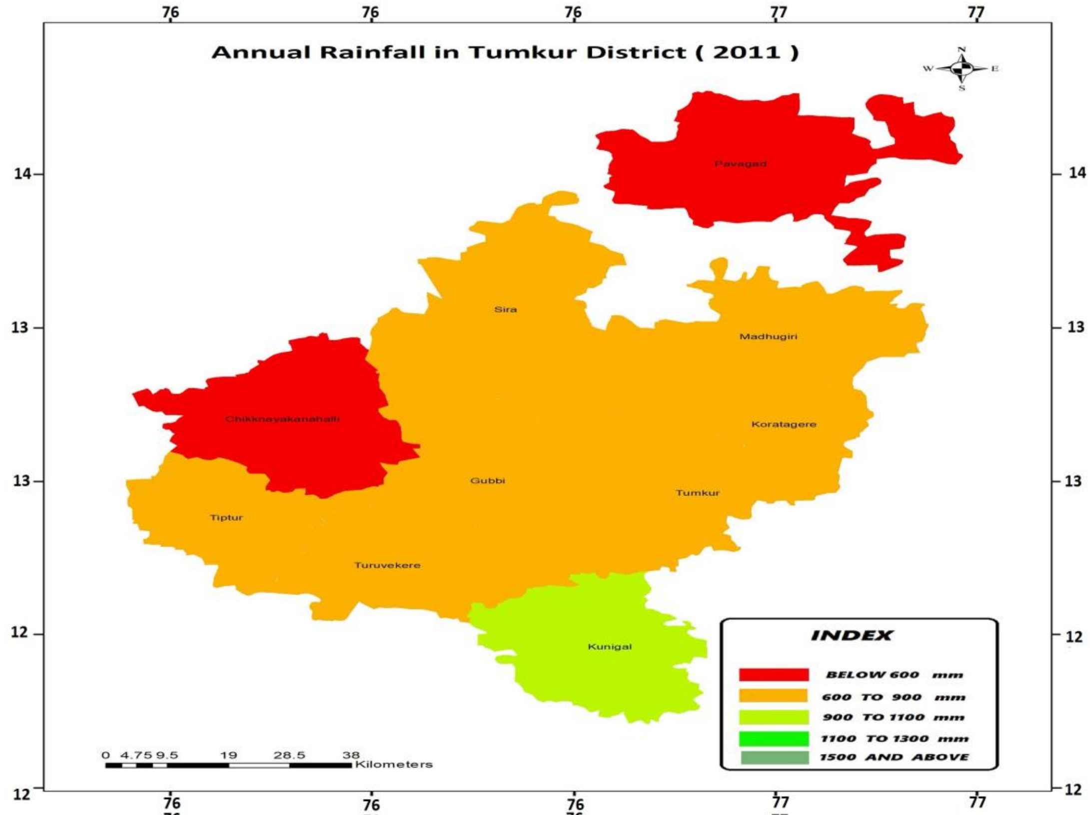


Fig 7: Annual rainfall and SPI values prepared maps from 2007 and 2009



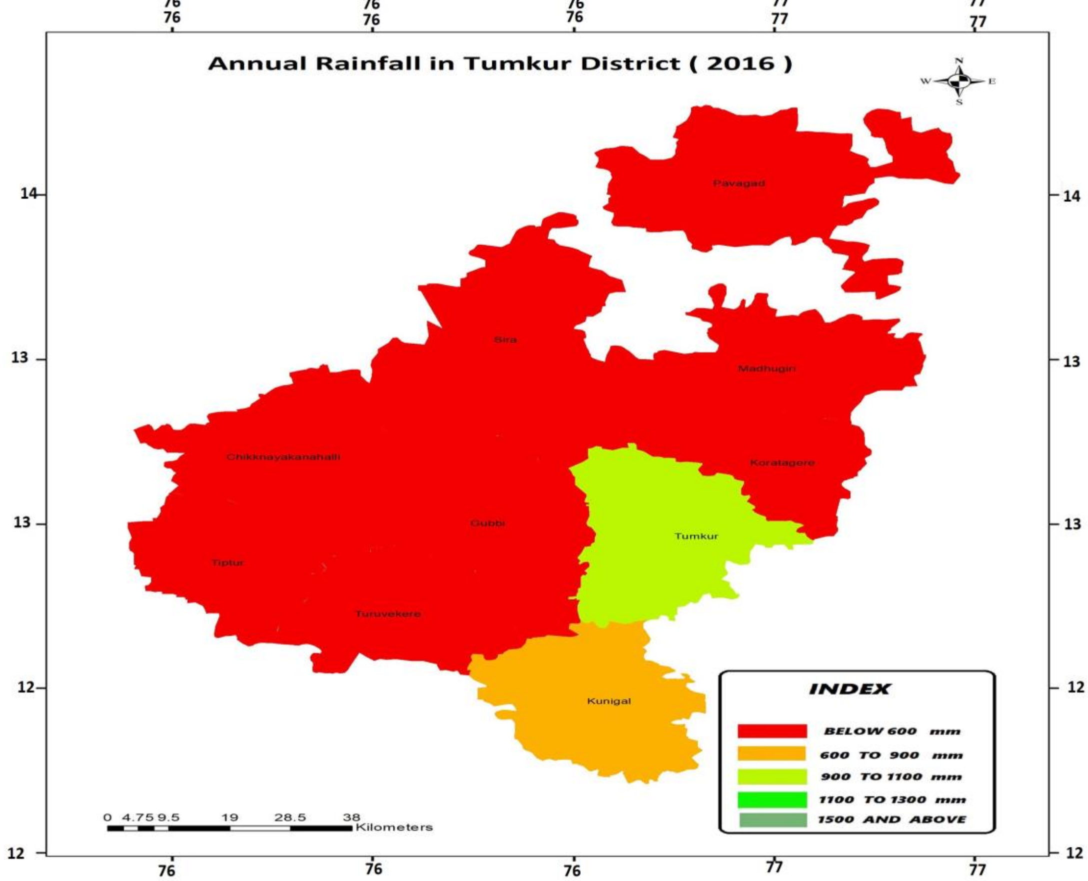


Fig 8: Annual rainfall and SPI values prepared maps from 2011 and 2016

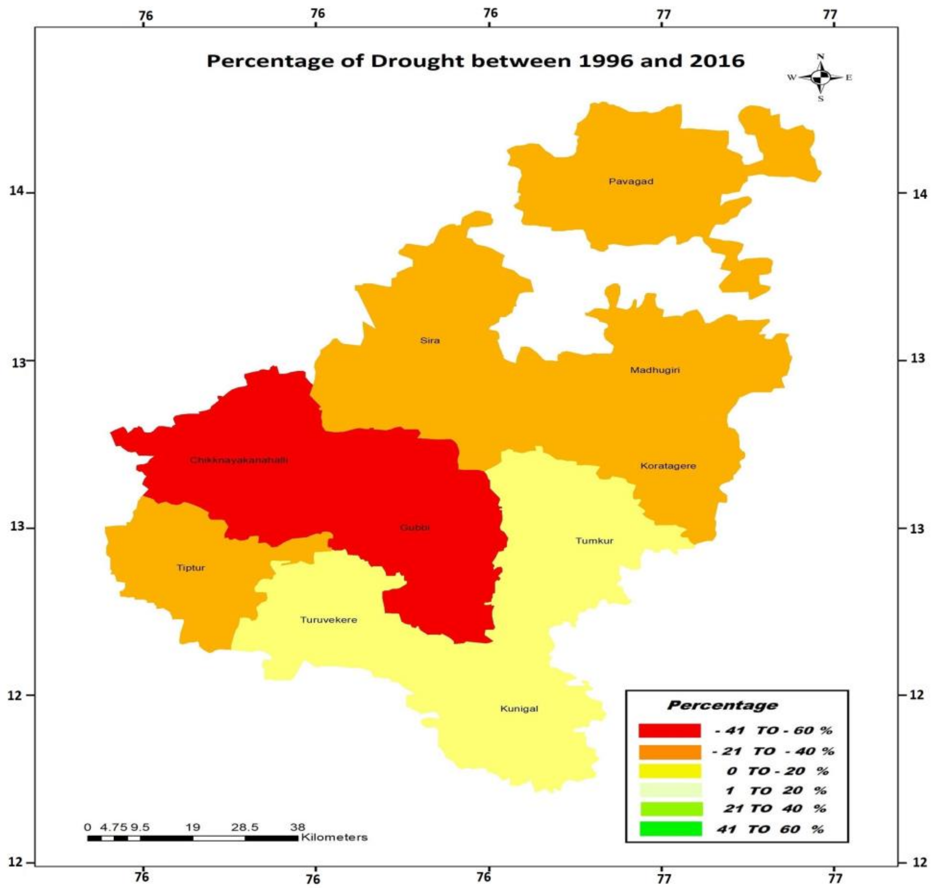


Fig 9: Percentage of changes in dry situation and severity

4. CONCLUSION

The present work has been found to be successful in assessment of drought in the Tumkur district. Drought monitoring and climate change is done with different types of analyses of variables rainfall on the different places. There are many other methods that can use in this process, SPI method and satellite image change detection are the most useful methods. In this study assessed the spatio-temporal drought characteristics for the Tumkur using the SPI drought index. The process of environmental degradation migration and land-use patterns are helpful for the changing patterns of drought phenomena. Efficient, accurate and reliable information on drought with spatial and attributes and temporal coordinates is important to communicate the potential risk to the specific vulnerable parts of the society and different parts of specific area. Calculating the SPI in the perfect method, monitoring the drought which that are based on an intention method are distinctive at each station and area. These thresholds are useful in drought decision making and possible damages and losses. From SPI in different time series, episodes of severe and extreme droughts are identified at many stations throughout the study period. As observed in the provided diagrams, the lowest rainfall is in 2003 was 504 mm, indicating that SPI= -1.58 severely day therefor still not cross to extremely dry. Amount of rainfall in 2016 is 560 mm with SPI= -1.25 shown moderately dry is not in high in range of dry in 2003. As refer to collected data the amount of rainfall and nomination the SPI in different parts of Tumkur shown the droughts from 1996 till 2016 appear in alternative years. After one hard rainy year become one to three less rainy (dry) year. The lack of the dry year will be amend. We recommend to have very accurate research in this area to prepare the map and data for last full decade to find out more about the alternative mildly wet, mild wet, moderate drought or more than this. One of the cause of drought in the studied area was the continues drought for more than 3 years in the area as effected to the agriculture and water resources in the Tumkur District.

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