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# Assessment of Meteorological Drought using Drinc and GIS in Tiruttani Block of Thiruvallur District, Tamil Nadu, India

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***Abstract*— Drought is one of the climatic Disasters and it is complex phenomenon. The main reason for Drought is deficiency of precipitation. Mainly drought can be classified into four types they are meteorological drought, hydrological drought, agricultural drought and socio-economic drought. The present paper summarizes the assessment of meteorological drought using India Meteorological Department (IMD) method and Standardized Precipitation Index (SPI) method. SPI was calculated for 3months, 6months and 12months time scales using a program SPI_SL_6.exe, developed by the WMO (World Meteorological Organization) in 2012 and DrinC software developed by National Technical University of Athens. The meteorological vulnerability map generated in GIS platform will help to concentrate more on problematic areas to prepare mitigation measures to reduce the impact of drought of the study area.**

***Keywords*— SPI ;Drought ; IMD; Meteorological vulnerability.**

## I. INTRODUCTION

The main reason for drought is lack of monsoon rainfall. Tamil Nadu State has four distinct rainfall climates such as the southwest monsoon (June-September), northeast monsoon (October-December), winter (January-February), and summer (March-May). Nearly 30 percent of annual rainfall is recorded in the southwest monsoon and 50 percent during the northeast monsoon, mostly from cyclonic activity. The State receives nearly 80 percent of its annual rainfall during the northeast monsoon. Although the northeast monsoon has a major impact on rainfall distribution and cropping pattern in the State, drought occurs mostly in the southwest monsoon or kharif season (June-September), when water demand always exceeds rainfall [4]. During the normal period, the average rainfall is 1035 millimeters (mm) but during drought, rainfall is 694 mm, representing a 39 percent of water shortfall. Since the State is entirely dependent on rains for recharging its water resources, monsoon failures lead to acute water scarcity and severe drought (UN system of organization, 2012).

In 2010, the State has eight drought-prone districts covering 833,997 square kilometers or about 64 percent of the total area prone to drought. It is evident that the State is prone to frequent droughts situation on various intensity and almost all the districts are subject to prolonged drought condition. The Thiruvallur district having the study area is not exceptional from this phenomenon [4]. In the year 2017, the government of Tamil nadu announced, all 32 districts in Tamil nadu hit by drought .In this paper, the two software's DrinC developed by National Technical University of Athens and SPI_SL_6.exe, developed by the WMO (World Meteorological Organization) in 2012 are used to find Meteorological Drought in different Time scales. Drought severity Index value is finally used to create Meteorological Vulnerability map and in GIS platform.

## II. STUDY AREA

### *A. Location Details*

Out of 14 blocks in the Thiruvallur district, Tiruttani is the 13th largest block covering an area of 186 Sq.Km. Tiruttani block consists of 24 village panchayats. The area taken up for study is Tiruttani block, which is situated between $79^0 30' 30''$E and $79^0 36' 0''$E and $13^0 7' 30''$N and $13^0 13' 0''$N. The study area is shown in Fig 1.

### *B. Rainfall Details*

Rainfall is the main parameter in meteorological drought analysis. The three rain gauge stations rainfall were used in the analysis. The average annual and monsoon seasonal values of rainfall for all stations were analyzed and presented in Table I.R.K.Pet and Tiruttani receives more rainfall during southwest monsoon (June, July, August and September) and Pallipattu receives more rainfall during northeast monsoon (October-December). The study area received an average annual rainfall of 1035mm. The average southwest and northeast contribute 424 mm and 481 mm. The northeast monsoon contributes maximum rainfall in compared with the southwest monsoon in Tamil Nadu State. But in this study area, the analysis shows that both the seasons contribute more or less same quantum of rainfall.

Twenty nine years of monthly data during 1987 to 2015 were analysed and mean monthly rainfall values were arrived for all the stations and presented in Table II. It was noted from the result that all stations receive high rainfall during November and lowest rainfall is recorded in January at Tiruttani and R.K.Pet and in March at Pallipattu rain gauge stations.

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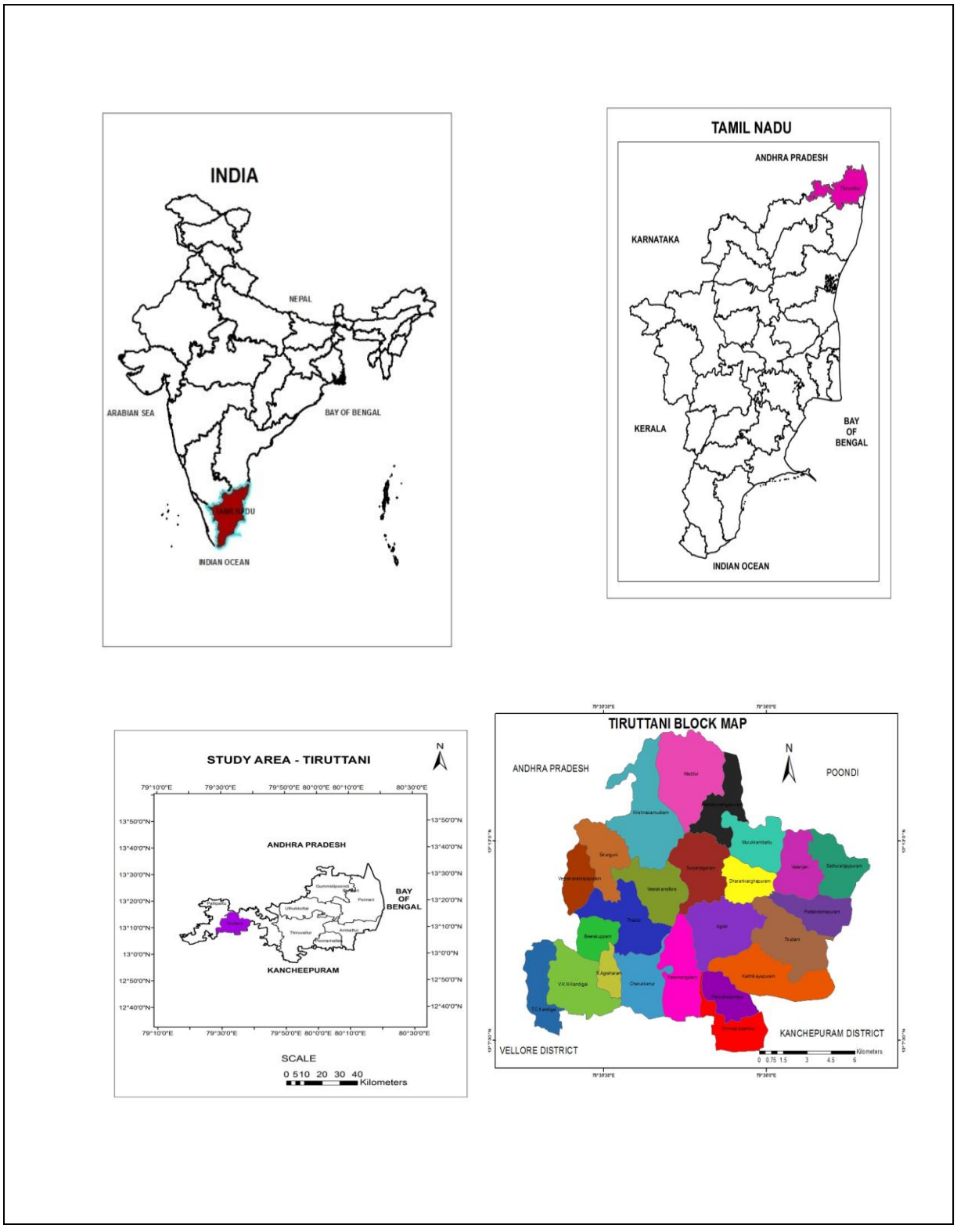


Fig.1. Location map

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TABLE I. AVERAGE ANNUAL AND SEASONAL RAINFALL

| S.No | Name of Station | Average Annual rainfall(mm) | Average Seasonal rainfall (mm) | |
|---|---|---|---|---|
| | | | *Southwest* | *Northeast* |
| 1 | Tiruttani | 1008.00 | 442.20 | 390.10 |
| 2 | Pallipattu | 1083.17 | 360.50 | 588.61 |
| 3 | R.K Pet | 1014.40 | 469.90 | 465.29 |
| Average (in mm) | | 1035 | 424 | 481 |

TABLE II. MEAN MONTHLY RAINFALL

| S.No | Months | Mean Monthly Rainfall (mm) | | |
|---|---|---|---|---|
| | | *Tiruttani* | *Pallipattu* | *R.K Pet* |
| 1 | Jan | 11.00 | 90.73 | 3.29 |
| 2 | Feb | 19.72 | 10.56 | 5.76 |
| 3 | Mar | 27.49 | 3.303 | 6.486 |
| 4 | Apr | 47.61 | 6.69 | 15.826 |
| 5 | May | 75.07 | 23.83 | 47.88 |
| 6 | Jun | 74.13 | 76.92 | 61.02 |
| 7 | Jul | 107.75 | 77.28 | 127.02 |
| 8 | Aug | 116.41 | 104.41 | 129.46 |
| 9 | Sep | 143.87 | 101.89 | 171.49 |
| 10 | Oct | 146.13 | 226.11 | 168.89 |
| 11 | Nov | 152.17 | 263.06 | 187.52 |
| 12 | Dec | 91.76 | 99.44 | 118.80 |

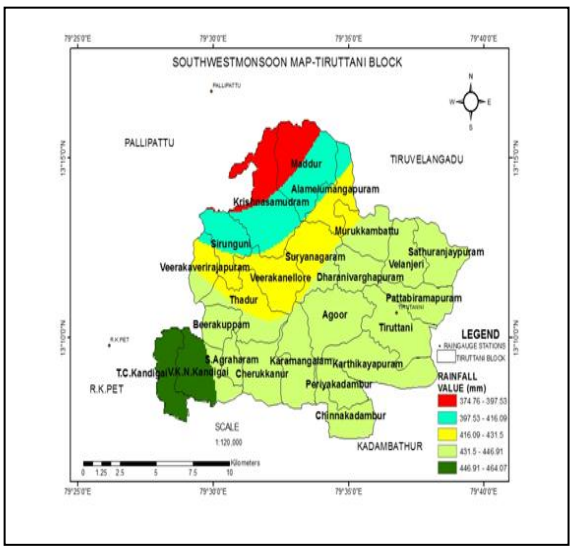


Fig.2 Twenty nine years average southwest monsoon rainfall

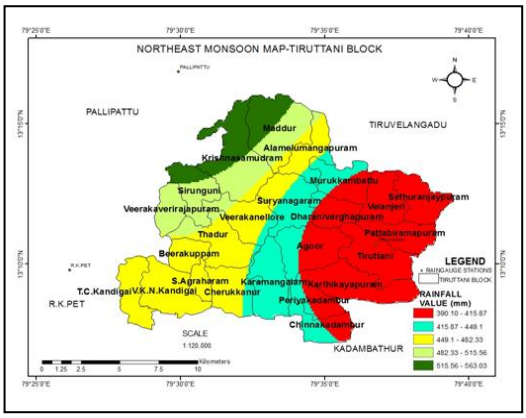


Fig.3 Twenty nine years average northeast monsoon rainfall

The spatial distribution of twenty nine years average southwest monsoon rainfall (Fig.2) shows that the maximum rainfall ranging between 446.91 mm to 464.07 mm experienced in south west parts of the study area. Minimum rainfall in the range of 374.76 mm to 397.63 mm received in the northern parts of the study area. Fig.3 shows the spatial distribution of twenty nine years of average northeast monsoon rainfall. It shows that the maximum rainfall ranging between 515.56 mm to 563.03 mm experienced in northern parts of the study area and minimum rainfall in the range of 390.10 mm to 415.87 mm experienced in the south eastern parts of the study area.

## III. MATERIALS AND METHODS

Monthly rainfall data for 29 years of R.K.Pet, Tiruttani and Pallipattu raingauge stations which located in and around the study area is considered for India Meteorological Department (IMD) method analysis. Standardized Precipitation Index (SPI) method was calculated for 3months, 6months and 12months time scales using a program, SPI_SL_6.exe developed by the WMO (World Meteorological Organization) in 2012 and DrinC software. The meteorological vulnerability maps are generated using Arc-GIS 10.3 software.

### *A. DrinC*

The DrinC version 1.2.19 beta was available in online and it is free downloadable, it is used to find 12-months SPI for each Rain gauge stations. The fig. (4) Shows the image of Drinc.

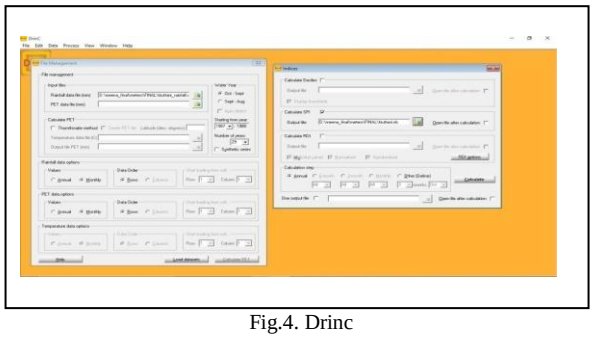

Fig.4. Drinc

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*B. SPI_SL_6*

The software developed by WMO available in National Drought Mitigation Center website. This software is specially developed to find SPI in different time series like 1-month, 3months, 6-months, 9-months and 12-months.The Fig. (5) Shows the image of SPI_SL_6. The output will be in dat file format we have to change that into .txt format.

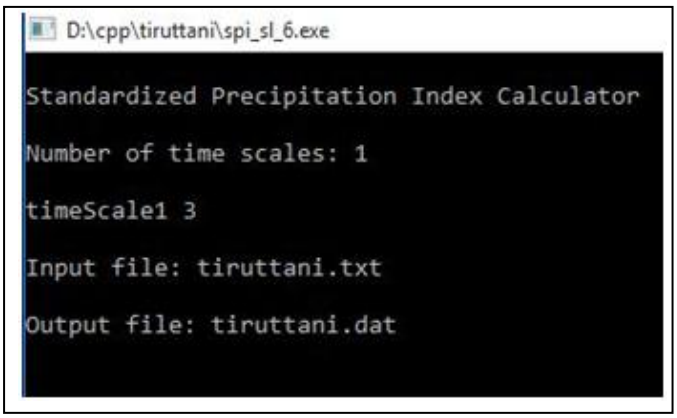


Fig.5. *Spi_sl_6.exe*

*C. SPI*

Precipitation is the main factor which controls the formation and persistence of drought. The SPI is a probability index that is based on precipitation and is designed to quantify the precipitation deficiency for different time scales. A 29 years precipitation records at the three stations are taken for SPI analysis. The DrinC and SPI_SL_6.exe is used to derive 3months, 6months and 12months SPI values. The 3months SPI value gives short term drought, 6months value gives intermediate term drought, 12 months gives long term drought [1]. The drought categories defined by modified SPI values [2] are as follows:

TABLE III.CLASSIFICATION OF DROUGHT BASED ON SPI

| S.No | Drought Classes | SPI |
|---|---|---|
| 1 | Extreme drought | <-2.0 |
| 2 | Severe drought | <-1.5 |
| 3 | Moderate drought | <-1.0 |
| 4 | Mild drought | <0.0 |
| 5 | No drought | >0.0 |

## IV. SPI-BASED TIME SERIES DROUGHT CHARACTERISTICS

29 years precipitation records at the three stations were taken for SPI analysis The SPI_SL_6.exe and DrinC software were used to derive 3months, 6months and 12months SPI values. The 3months SPI value gives short term drought, 6months value gives intermediate term drought and 12 months gives long term drought.

*A. Tiruttani-rain gauge station*

The drought characteristics based on 3-months SPI time series, it is observed that the maximum drought severity of -10.19 occurred for a continuous duration of 6months, between August 2014 to January 2015 (TABLE IV). Based on 6-month SPI time series, the maximum drought severity is -16.79 occurred for a continuous duration of 25months from April 2002 to April 2004 (TABLE V) and finally based on 12-month SPI time series, the maximum drought severity is -25.31 occurred for a continuous duration of 25 months, between December 2013 to December 2015 (TABLE VI). From the result obtained from the different SPI time scales, it is observed that if the SPI time series increases then the severity also increases. Compared with these three scales 12-month SPI shows the highest severity.

TABLE IV. 3-MONTHS SPI IN TIRUTTANI

| S.No | Onset – Termination of Drought | Duration >3 (in Months) | Severity |
|---|---|---|---|
| 1. | May 1987-Sep 1987 | 5 | -7.26 |
| 2. | March 1988-May 1988 | 3 | -0.53 |
| 3. | Oct 1988 - Aug 1989 | 10 | -4.11 |
| 4. | Jan 1991-Aug 1991 | 8 | -6.54 |
| 5. | Dec 1992 - Feb 1993 | 3 | -1.6 |
| 6. | Apr 1993-Oct 1993 | 7 | -7.94 |
| 7. | Mar 1994- June 1994 | 4 | -2.26 |
| 8. | Nov 1995 - Mar 1996 | 5 | -5.17 |
| 9. | Mar 1997-May 1997 | 3 | -1.43 |
| 10. | May 1998 - Aug 1998 | 4 | -3.1 |
| 11. | Mar 1999- Dec 1999 | 10 | -6.48 |
| 12. | May 2000-July 2000 | 3 | -1.95 |
| 13. | Nov 2000- Jan 2001 | 3 | -0.64 |
| 14. | Mar 2002 - Sept 2002 | 7 | -2.6 |
| 15. | Dec 2002 - Feb 2003 | 3 | -1.77 |
| 16. | June 2003 - Apr 2004 | 11 | -7.53 |
| 17. | Dec 2004 - Feb 2005 | 3 | -2.97 |
| 18. | Mar 2006-July 2006 | 5 | -3.12 |
| 19. | Jan 2007 - May 2007 | 5 | -1.59 |
| 20. | Feb 2009 - Nov 2009 | 10 | -6.7 |
| 21. | Nov 2011-Jan 2012 | 3 | -3.23 |
| 22. | Sep 2012-Jan 2013 | 5 | -6.34 |
| 23. | Sep 2013-Feb 2014 | 6 | -7.92 |
| 24. | Aug 2014 - Jan 2015 | 6 | -10.19 |
| 25. | Sept 2015-Dec 2015 | 4 | -6.29 |

TABLE V. 6-MONTHS SPI IN TIRUTTANI

| S.No | Onset – Termination of Drought | Duration >3 (in Months) | Severity |
|---|---|---|---|
| 1. | June 1987 - Nov 1987 | 6 | -1.24 |
| 2. | July 1988 - Nov 1989 | 17 | -0.60 |
| 3. | Mar 1991 - Sept 1991 | 7 | -1.03 |
| 4. | Dec 1992 - Nov 1993 | 12 | -1.17 |
| 5. | May 1994-Sep 1994 | 5 | -0.39 |
| 6. | Nov 1995- May 1996 | 7 | -1.06 |
| 7. | June 1998-Sept 1998 | 4 | -0.52 |
| 8. | May 1999-Jan 2000 | 9 | -1.07 |
| 9. | June 2000 - March 2001 | 10 | -0.33 |
| 10. | Apr 2002- Apr 2004 | 25 | -0.67 |
| 11. | Feb 2005- June 2005 | 5 | -0.22 |
| 12. | June 2006-Aug 2006 | 3 | -0.78 |
| 13. | May 2009- Apr 2010 | 12 | -0.85 |
| 14. | July 2010-Oct 2010 | 4 | -0.17 |
| 15. | Dec 2011- Feb 2012 | 3 | -0.47 |
| 16. | Oct 2012 - Mar 2013 | 6 | -1.20 |
| 17. | Oct2013-Apr2014 | 7 | -1.67 |
| 18. | Sept 2014 - Mar 2015 | 7 | -1.63 |
| 19. | Sept 2015-Dec 2015 | 4 | -1.40 |

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TABLE VI. 12-MONTHS SPI IN TIRUTTANI

| S.No | Onset – Termination of Drought | Duration > 3 (in Months) | Severity |
|---|---|---|---|
| 1. | Dec 1987-May 1988 | 6 | -1.64 |
| 2. | Oct 1988 - May 1990 | 20 | -19.96 |
| 3. | May 1991 - Sept 1991 | 5 | -3.57 |
| 4. | Nov 1992 - Aug 1994 | 22 | -21.5 |
| 5. | Jan 1996 - Mar 1996 | 3 | -0.47 |
| 6. | May 1996 - Nov 1996 | 7 | -5.61 |
| 7. | Sept 1999- Sept 2001 | 25 | -17.9 |
| 8. | Aug 2002- July 2004 | 24 | -24.72 |
| 9. | July 2005 - Sept 2005 | 3 | -0.95 |
| 10. | Aug 2009- Oct 2010 | 15 | -16.47 |
| 11. | Nov 2011 - Feb 2012 | 4 | -2.07 |
| 12. | July 2013- Sept 2013 | 3 | -0.51 |
| 13. | Dec 2013- Dec 2015 | 25 | -25.31 |

### *B. R.K.Pet-rain gauge station:*

The drought characteristics based on 3-months SPI time series, it is observed that the maximum drought severity of -17.11 occurred for a continuous duration of 6months, between May 2015 to October 2015 (TABLE VII). Based on 6-month SPI time series, the maximum drought severity is -17.11 occurred for a continuous duration of 15months from August 2014 to October 2015 (TABLE VIII) and finally based on 12-month SPI time series, the maximum drought severity is -35.12 occurred for a continuous duration of 28 months, between august 2013 to November 2015 (TABLE IX). From the result obtained from the different SPI time scales, it is observed that the duration may 2015 to October 2015 is more severe drought months when compared with all other months because it lies in all 3 SPI time series .

TABLE VII. 3-MONTHS SPI IN R.KPET

| S.No | Onset – Termination of Drought | Duration > 3 (in Months) | Severity |
|---|---|---|---|
| 1. | May 1987-Nov 1987 | 7 | -10.34 |
| 2. | July 1988-Feb 1989 | 8 | -10.41 |
| 3. | May 1991-July 1991 | 3 | -2.15 |
| 4. | May 1993-Aug 1993 | 4 | -2.13 |
| 5. | May 1994-Aug 1994 | 4 | -1.69 |
| 6. | Sept 1995-Feb 1996 | 6 | -11.72 |
| 7. | Sept 1997-Jan 1998 | 5 | -1.06 |
| 8. | May 1998-Sept 1998 | 5 | -3.81 |
| 9. | Sept 1999-Nov 1999 | 3 | -1.15 |
| 10. | Aug 2000-Jan 2001 | 6 | -3.42 |
| 11. | July 2001-Sept2001 | 3 | -1.15 |
| 12. | Nov 2001-Jan 2002 | 3 | -1.14 |
| 13. | Oct 2002-Feb 2003 | 5 | -2.64 |
| 14. | June 2003-Feb 2004 | 9 | -7.93 |
| 15. | Oct 2004-Feb 2005 | 5 | -3.32 |
| 16. | July 2005-Sept 2005 | 3 | -3.59 |
| 17. | May 2006-Aug 2006 | 4 | -0.4 |
| 18. | July 2007-Sept 2007 | 3 | -0.42 |
| 19. | June 2009-Oct 2009 | 5 | -4.37 |
| 20. | Aug 2010-Oct 2010 | 3 | -1.73 |
| 21. | Nov 2012-Feb 2013 | 4 | -1.6 |
| 22. | Oct 2013-Feb 2014 | 5 | -3.52 |
| 23. | Aug 2014-Feb 2015 | 7 | -5.54 |
| 24. | May 2015-Oct 2015 | 6 | -4.96 |

TABLE VIII. 6-MONTHS SPI IN R.KPET

| S.No | Onset – Termination of Drought | Duration (in Months) | Severity |
|---|---|---|---|
| 1. | Jun 1987-Jan 1988 | 8 | -12.04 |
| 2. | Aug 1988-Jun 1989 | 11 | -16.24 |
| 3. | May 1991-July 1991 | 3 | -3.32 |
| 4. | May 1993-Oct 1993 | 6 | -4.49 |
| 5. | May 1994-Aug 1994 | 4 | -2.33 |
| 6. | Oct 1995-May 1996 | 8 | -15.11 |
| 7. | Dec-97-Dec 1998 | 13 | -8.11 |
| 8. | Nov 1999-Feb 2000 | 4 | -1.18 |
| 9. | Aug 2000-Mar 2001 | 8 | -5.53 |
| 10. | Nov 2001-May 2002 | 7 | -2.92 |
| 11. | July 2002-May 2003 | 11 | -5.45 |
| 12. | Aug 2003-April2004 | 9 | -11.82 |
| 13. | Jan 2005-May 2005 | 5 | -3.45 |
| 14. | July 2005-Dec 2005 | 6 | -3.28 |
| 15. | June 2006-Sept 2006 | 4 | -0.94 |
| 16. | July 2007-Sept 2007 | 3 | -0.72 |
| 17. | Apr2009-Oct 2009 | 7 | -8.1 |
| 18. | July 2010-Oct 2010 | 4 | -1.05 |
| 19. | Feb 2013-July 2013 | 6 | -3.04 |
| 20. | Sept 2013-May 2014 | 9 | -5.9 |
| 21. | Aug 2014-Oct 2015 | 15 | -17.11 |

TABLE IX. 12-MONTHS SPI IN RKPET

| S.No | Onset – Termination of Drought | Duration (in Months) | Severity |
|---|---|---|---|
| 1. | Dec1987-Aug 1989 | 21 | -23.16 |
| 2. | Oct 1995-Nov 1996 | 14 | -17.42 |
| 3. | Dec 1997 - June 1999 | 19 | -8.72 |
| 4. | Sept 1999- June 2004 | 58 | -40.87 |
| 5. | July2005-June 2006 | 12 | -6.67 |
| 6. | July 2009-Nov 2009 | 5 | -2.49 |
| 7. | Aug 2013 - Nov 2015 | 28 | -35.12 |

### *C. Pallipattu -rain gauge station:*

The drought characteristics based on 3-month SPI time series, it is observed that the maximum drought severity of -18.86 occurred for a continuous duration of 11 months, between May 1990 to March 1991(TABLE XII). Based on 6-month SPI time series, the maximum drought severity is -47.8 occurred for a continuous duration of 33 months from october1988 to June 1991(TABLE XI) and finally based on 12-month SPI time series, the maximum drought severity is -74.41 occurred for a continuous duration of 59 months, between December 1987 to October 1992 (TABLE X). From the result obtained from the different SPI time scales, it is observed that compared with recent years the past years from 1987 to 1992 the severity of drought is high.

TABLE X. 12-MONTHS SPI IN PALLIPATTU

| S.No | Onset – Termination of Drought | Duration (in Months) | Severity |
|---|---|---|---|
| 1. | Dec 1987 - Oct 1992 | 59 | -74.41 |
| 2. | May 1996 - July 1996 | 3 | -0.48 |
| 3. | Oct 2000- Sept 2002 | 24 | -13.22 |
| 4. | Oct2003- Oct2004 | 13 | -9.73 |
| 5. | May2005-Sep 2005 | 5 | -0.43 |
| 6. | Oct 2009-Oct 2010 | 13 | -5.08 |
| 7. | Oct2012-July2013 | 10 | -5.52 |
| 8. | Oct 2013-Oct2015 | 25 | -25.42 |

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TABLE XI. 6-MONTHS SPI IN PALLIPATTU

| S.No | Onset – Termination of Drought | Duration (in Months) | Severity |
|---|---|---|---|
| 1. | Oct 1987-Dec 1987 | 3 | -1.1 |
| 2. | Oct 1988-June 1991 | 33 | -47.8 |
| 3. | Aug 1991-Sept 1992 | 14 | -14.93 |
| 4. | Nov 1995-Jan 1996 | 3 | -0.82 |
| 5. | Aug 2000-Dec 2001 | 17 | -12.41 |
| 6. | June 2002-Sept 2002 | 4 | -3.86 |
| 7. | May 2003-April 2004 | 12 | -9.37 |
| 8. | July 2005-Sept 2005 | 3 | -1.77 |
| 9. | May 2006-Sept 2006 | 5 | -4.23 |
| 10. | July2007-Sept 2007 | 3 | -0.52 |
| 11. | May 2009-April 2010 | 12 | -5.96 |
| 12. | July 2012-June 2013 | 12 | -6.9 |
| 13. | Nov 2013-May 2014 | 7 | -7.62 |
| 14. | Dec 2014-Oct 2015 | 13 | -16.14 |

TABLE XII 3-MONTHS SPI IN PALLIPATTU

| S.No | Onset – Termination of Drought | Duration (in Months) | Severity |
|---|---|---|---|
| 1. | May 1988-July 1988 | 3 | -1.83 |
| 2. | Oct 1988-March 1989 | 6 | -5.19 |
| 3. | July 1989-March 1990 | 9 | -10.45 |
| 4. | May 1990-March 1991 | 11 | -18.86 |
| 5. | Aug 1991-Mar 1992 | 8 | -9.89 |
| 6. | June 1992-Sept 1992 | 4 | -3.3 |
| 7. | May 1998-Aug 1998 | 4 | -0.65 |
| 8. | May 2000-March 2001 | 11 | -7.84 |
| 9. | May 2001-Nov 2001 | 7 | -1.87 |
| 10. | May 2002-Sept 2002 | 5 | -3.69 |
| 11. | May 2003-Jan 2004 | 9 | -5.23 |
| 12. | June 2005-Aug 2005 | 3 | -2.55 |
| 13. | May 2006-Sept 2006 | 5 | -4.11 |
| 14. | May-Aug 2009 | 4 | -1.31 |
| 15. | Oct 2009-Jan 2010 | 4 | -2.06 |
| 16. | July 2012-March 2013 | 9 | -4.64 |
| 17. | Oct 2013-March 2014 | 6 | -7.29 |
| 18. | Sept 2014-March 2015 | 7 | -7.97 |
| 19. | May 2015-Sept 2015 | 5 | -3.16 |

### *D. Drought Severity Index*

The result obtained from the DrinC software 12months SPI is tabulated in TABLE XIII. Occurrence and frequency of drought severity classes based on SPI TABLE XIV, shows that the stations Pallipattu and R.K.Pet experienced extreme drought in one year while there is no extreme drought in Tiruttani station. Two times severe drought has occurred in Tiruttani and R.K.Pet stations. Number of occurrence of moderate drought is maximum at R.K.Pet station followed by Pallipattu and Tiruttani. The frequency of mild drought is maximum in Tiruttani followed by Pallipattu and R.K.Pet.

TABLE XIII..DROUGHT SEVERITY CLASSES BASED ON SPI

| Year | Drought Classes | | |
|---|---|---|---|
| | *Tiruttani* | *Pallipattu* | *R.K.Pet* |
| 1987 | Mild drought | Mild drought | Mild drought |
| 1988 | Moderate drought | Mild drought | Extreme drought |
| 1989 | Mild drought | Moderate drought | No drought |
| 1990 | No drought | Extreme drought | No drought |
| 1991 | No drought | Moderate drought | No drought |
| 1992 | Mild drought | No drought | No drought |
| 1993 | Mild drought | No drought | No drought |
| 1994 | Mild drought | No drought | No drought |
| 1995 | No drought | Mild drought | Mild drought |
| 1996 | No drought | No drought | No drought |
| 1997 | No drought | No drought | Mild drought |
| 1998 | No drought | No drought | Mild drought |
| 1999 | Severe drought | No drought | No drought |
| 2000 | Mild drought | Mild drought | Moderate drought |
| 2001 | No drought | Mild drought | Mild drought |
| 2002 | Mild drought | No drought | Moderate drought |
| 2003 | Severe drought | Moderate drought | Severe drought |
| 2004 | No drought | No drought | No drought |
| 2005 | No drought | No drought | Mild drought |
| 2006 | No drought | Mild drought | No drought |
| 2007 | No drought | No drought | No drought |
| 2008 | No drought | No drought | No drought |
| 2009 | Moderate drought | Mild drought | No drought |
| 2010 | No drought | No drought | No drought |
| 2011 | Mild drought | No drought | No drought |
| 2012 | No drought | Mild drought | Mild drought |
| 2013 | Mild drought | Mild drought | Moderate drought |
| 2014 | Moderate drought | Moderate drought | Severe drought |
| 2015 | Mild drought | No drought | No drought |

In all stations, nearly 50% of the years in 29 years span period, no drought had occurred. 34% of the years in Tiruttani had seen mild drought followed by Pallipattu 31% of the years as mild drought. In Pallipattu, 14% of the years recorded moderate drought and the other two stations have 10% of frequency. Severe drought is noticed in R.K.Pet and Tiruttani in 2 years. Extreme drought is noticed in Pallipattu and R.K Pet.

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TABLE XIV OCCURRENCE AND FREQUENCY OF DROUGHT SEVERITY CLASS USING SPI

| S. No. | Name of Station | Occurrence of Drought Severity Class | | | | |
|---|---|---|---|---|---|---|
| | | No | Mild | Moderate | Severe | Extreme |
| | | No. of Occurrences | | | | |
| 1 | Tiruttani | 14 | 10 | 3 | 2 | 0 |
| 2 | Pallipattu | 15 | 9 | 4 | 0 | 1 |
| 3 | R.K pet | 16 | 7 | 3 | 2 | 1 |
| S. No. | Name of Station | Frequency of Drought Severity Class | | | | |
| | | Frequency | | | | |
| 1 | Tiruttani | 0.48 | 0.34 | 0.1 | 0.07 | 0 |
| 2 | Pallipattu | 0.52 | 0.31 | 0.14 | 0 | 0.03 |
| 3 | R.K pet | 0.55 | 0.24 | 0.1 | 0.07 | 0.03 |

Considering the occurrence and frequency of drought in each station (TABLE XIV), weightage 1, 2, 3,4 and 5 are assigned to drought severity classes of no, mild, moderate, severe and extreme droughts respectively. The probability of drought severity class was calculated. The MDSI of each station is found out by multiplying the frequency of each class of drought severity by the corresponding weightage (TABLE XV). Five drought severity classes no drought, mild, moderate, severe and extreme were delineated based on the range of drought severity index (TABLE XVI). Using the MDSI value meteorological drought vulnerability map is generated in GIS platform.

TABLE XV. DROUGHT SEVERITY INDEX

| S. No. | Name of Station | Probability of drought severity class | | | | | Drought Severity Index | Drought Severity Class |
|---|---|---|---|---|---|---|---|---|
| | | No | Mild | Mod. | Sev. | Ext. | | |
| 1 | Tiruttani | 0.48 | 0.34 | 0.1 | 0.07 | 0 | 1.74 | Severe |
| 2 | Pallipattu | 0.52 | 0.31 | 0.14 | 0 | 0.03 | 1.71 | No |
| 3 | R.K pet | 0.55 | 0.24 | 0.1 | 0.07 | 0.03 | 1.76 | Extreme |

TABLE XVI DROUGHT SEVERITY CLASS

| Sl. No. | Range | Drought Severity |
|---|---|---|
| 1 | 1.71 -1.72 | No drought |
| 2 | 1.72 - 1.73 | Mild |
| 3 | 1.73 - 1.74 | Moderate |
| 4 | 1.74 – 1.75 | Severe |
| 5 | 1.75-1.76 | Extreme |

### *E. Percentage Deviation ($D_i$)*

Twenty nine years of precipitation data are taken, for India Meteorological Department (IMD) drought assessment on the basis of percentage deviation of rainfall and is given by

$$D_i = P_i - \bar{P}/\bar{P}$$

Where, $P_i$ is the annual rainfall in the year i and is the long-term annual mean rainfall. The classification of Drought Category based on IMD is mentioned in Table XVII.

TABLE XVII.CLASSIFICATION OF DROUGHT BASED ON IMD

| S.No | Range of $D_i$ | Classification of drought | Category |
|---|---|---|---|
| 1. | > 0 | M0 | No drought |
| 2. | 0 to -25 | M1 | Mild drought |
| 3. | -26 to – 50 | M2 | Moderate drought |
| 4. | < -50 | M3 | Severe drought |

Based on percentage deviation method, the twenty nine years of rainfall data were analyzed and tabulated in TABLE XVIII. This analysis result was compared with SPI result. The SPI is reliable method when compared with IMD method because there are five severity class in SPI method and only four severity classes in IMD.

TABLE XVIII. CLASSIFICATION OF METEOROLOGICAL DROUGHT

| Year/Station | Tiruttani | Pallipattu | R.K.Pet |
|---|---|---|---|
| 1987 | M1 | M1 | M2 |
| 1988 | M2 | M2 | M3 |
| 1989 | M1 | M3 | M0 |
| 1990 | M0 | M3 | M0 |
| 1991 | M0 | M3 | M0 |
| 1992 | M1 | M0 | M0 |
| 1993 | M1 | M0 | M0 |
| 1994 | M1 | M0 | M0 |
| 1995 | M1 | M1 | M2 |
| 1996 | M0 | M0 | M0 |
| 1997 | M0 | M0 | M1 |
| 1998 | M0 | M0 | M1 |
| 1999 | M2 | M0 | M1 |
| 2000 | M1 | M2 | M2 |
| 2001 | M0 | M1 | M1 |
| 2002 | M1 | M0 | M2 |
| 2003 | M2 | M3 | M2 |
| 2004 | M0 | M1 | M0 |
| 2005 | M0 | M0 | M1 |
| 2006 | M0 | M1 | M1 |
| 2007 | M0 | M0 | M0 |
| 2008 | M0 | M0 | M0 |
| 2009 | M2 | M2 | M0 |
| 2010 | M1 | M0 | M0 |
| 2011 | M1 | M0 | M0 |
| 2012 | M0 | M2 | M1 |
| 2013 | M1 | M2 | M2 |
| 2014 | M2 | M3 | M2 |
| 2015 | M1 | M0 | M1 |

## V. RESULTS AND DISCUSSION

The meteorological drought vulnerability map (Fig.6) was created based on the value obtained in the Drought severity index and it shows that the meteorological vulnerability is extreme to moderate from western to eastern side. The north western side is safe. Nearly five villages are severely affected. Rainwater is the main source of water. Rainfall fails in that particular location leads to meteorological drought. The indices show only the value but the spatial distribution maps shows visually which area was vulnerable. So, the affected area can be easily identified.

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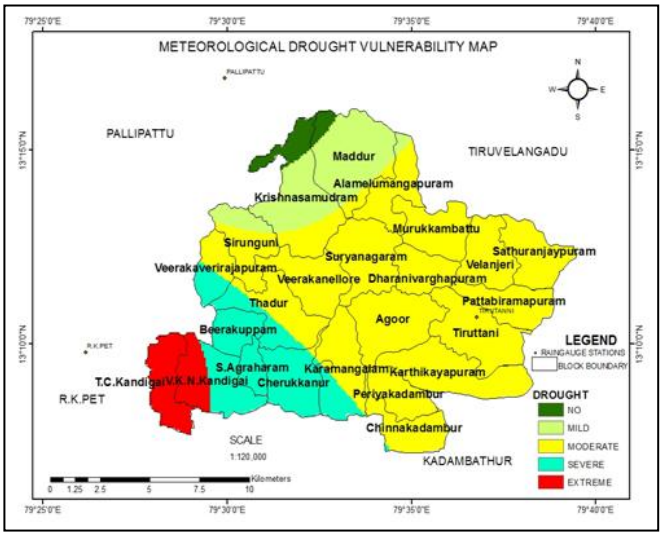


Fig.6. Meteorological drought vulnerability map

## VI. CONCLUSION

SPI method was more reliable compared with IMD method because in SPI method the drought are classified into five in SPI method instead of four as in IMD method. The spatial distribution map is useful to understand which location is vulnerable and the path of meteorological drought. During drought situation where the more concentration is needed is easily identified using this map. Followed by meteorological drought the hydrological drought, agricultural drought and socio-economic drought will occur. All droughts are inter-related. Based on meteorological vulnerability if necessary steps are taken to that particular location then the other drought cab be easily avoidable..

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