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RESEARCH ARTICLE

Examining Drought Behaviour Using Departure Index and Rainfall Anomaly Index for Nambiyar River Basin, Tamil Nadu

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Abstract

Drought is caused by a lack of long-term rainfall. The humans as well as environment are greatly affected due to drought. It is not related to particular climate regions but it causes similar effect in all climatic regions of the world. There are a number of drought prone areas in India so the Government of India has developed a Drought Affected Area Plan which is being implemented in drought prone areas. An attempt has been made in this paper studying two drought indices such as Departure Index (DI) and Rainfall Anomaly Index (RAI) in Nambiyar River Basin of Tamil Nadu to assess the drought condition. Only 3 classifications (moderate, mild and no droughts) are observed in Departure Index. Mild drought years are highly found in Nambiyar River basin followed by moderate and no droughts. Chidambarapuram, Nainaputhoor station had maximum drought of 24 years and 6 years of moderate drought is observed in Vallioor station. The frequency of drought years for RAI index are repeatedly noted high during the year 2003, 2016 and Keeriparai station had the highest negative anomaly value of -10.67 in the year 2017.

Keywords: Rainfall; RAI; DI; Nambiyar river basin; Drought

Intorudction

Drought is one of the complex natural phenomena. In extreme cases, drought causes great damage to the economy and human life. The economic loss caused by drought is high compared to all other weather disasters. (Wilhite, 2000). Globally, drought causes an economic loss at an average of 6 to 8 billion USD (Yagci et al., 2013). Drought is one of the least mention natural calamity (Kao and Govindaraju, 2010). Droughts can be classified as agricultural, hydrological, meteorological and socio-economic droughts (Shiau et al., 2012). The climatic parameters such as rainfall and temperature play a crucial role in defining drought. Among the climatic parameters rainfall is an important factor and is a readily available weather measurement. Using rainfall data from thirty or more years is better for effective growth planning than using short-term ones (Dennett et al., 1985). It also affects agriculture, drainage, human settlements and politically and its impact varies from place to place.

The main factor leading to the impact of drought depends on the size, frequency, duration of the drought and their extent. (Degefu and Bewket, 2015; Zargar et al., 2011; Surendran et al., 2017).Many drought indices have been developed for drought forecasting such as Palmer Drought Severity Index, Rainfall Anomaly Index, Departure Index, Drought area Index, Drought Severity Index, Gumbel Recurrence Interval and Standardized Precipitation Index etc. There is drought indices use rainfall alone to define drought. Consecutively, there are indices combine other parameters such as potential evapotranspiration (PET), temperature and soil moisture along with rainfall for to understand drought. Here, an attempt has been made in this study considering rainfall as a prime factor to understand the drought characteristics of the study area using Rainfall anomaly index (RAI) and departure index.

Study Area

The Nambiyar basin covers a part of Tirunelveli, Thoothukudi and Kanyakumari districts of Tamil Nadu. Geographically,the basin extends between 08° 08'00"N to 08° 33' 00"N latitude and 77° 28'00"E to 78° 15' 00"E longitude. The basin is surrounded by Tamiraparani basin on and Kodaiyar basin on north and southern side respectively. Eastern part of the basin is covered by Gulf of Mannar and the western part is by Kerala state. The total area of the basin is 2018.4 sq.km. Karamaniyar river in northern side, Hanumanadhi river in the southern part and the Nambiyar river lies in between these two rivers are the major rivers draining this basin. The maximum and minimum temperature of the basin is 33°C and 28°C respectively. The Nambiyar river originates in the eastern slopes of Western Ghats exactly over Nalikkal Mottai located 9.6 km west of Thirukkarangudi village. Millets, pulses, oil seeds, coconut and fewer area is under paddy cultivation are some of the major cops of the basin (Figure 1).

Data and Methodology

The base map of Nambiyar river basin was digitized from river basin map of Tamil Nadu. The in and around rainfall data for Nambiyar basin from the year 1981 to 2017 were used in this study to understand the drought. The basin covers 13 gridded points collected from ECMWF reanalysis Interim (ERA-1) data set having horizontal resolution of 0.75^0. This gridded data were downscaled to 17X17 km resolutions using WRF re-initialization method were adopted. The gridded points are considered as rainfall location such as, Valliure, Elankulam, Sirappur, Chidambarapuram, Vadakankulam, Nainaputhoor, Boothapandi, Keeriparai, Manjolai, Venkatarngapuram, Nellaiyappapuram, Veppenkulam and Ammanpuram. The graphs were prepared using Excel software and spatial maps were prepared using Arc GIS platform.

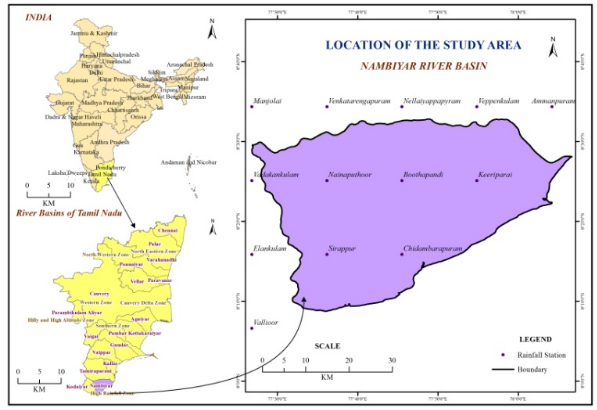

Fig. 1. Location of the Study Area

Departure Index

Based on the annual precipitation deficiency the droughts are classified by Nation commission on Agriculture and Indian Meteorological Depatment (IMD and National Commission on Agriculture). Departure Index is based on long-term averages of precipitation value.

DI = Percentage of departure from long term average precipitation

RF= the annual precipitation particular year

M_{RF}= the long term average of annual precipitation

$$DI = \left(\frac{RF - M_{RF}}{M_{RF}} \right) \times 100$$

Rainfall Anomaly Index

Rainfall Anomaly Index assesses the frequency and intensity of the dry and rainy years. .RAI had two anomalies; there is positive and negative anomaly. The rainfall data were arranged descending and ascending order based on rainfall intensity. The mean values of maximum 10 values $(M_{H10})$and minimum 10 values (M_{L10}) were considered for calculations. Based on the average ten rainfall values stand for positive and negative anomalies respectively. The following equations were used to calculate RAI for the annual.

$$RAI = +3 \left(\frac{RF - M_{RF}}{M_{H10} - M_{RF}} \right)$$

$$RAI = -3 \left(\frac{RF - M_{RF}}{M_{L10} - M_{RF}} \right)$$

RF= Sum of annual rainfall receiving particular year

MRF= the average rainfall receiving over the study period

M_{H10} and M_{L10} = the average value of 10 highest and 10 least values respectively.

Result and Discussion

The Meteorological Department of India and the National Agriculture Authority provide the percentage of normal rainfall and associated weather drought intensity rainfall departures (Table 1). During this study period, the study area is comes under two categories such as moderate and mild drought. Most of the location in this study area is under mild drought. The stations which having maximum number of years fall under moderate drought is Vallioor, followed by the stations are Veppankulam, Elankulam, Sirappur, Vadakkankulam, Venkatarengapuram, Nellaiyappapuram, Manjolai and Ammanpuram. Minimum drought years are noted in Chidambarapuram, Nainaputhoor and Boothapandi stations during the study period (Figure 2). Chidambarapuram and Nainaputhoor are the location have high number of years with mild droughts and minimum year are found in Elankulam station followed by Boothapandi, Keeriparai, Manjolai, Venkatarengapuram and Nellaiyappapuram station (Table 2).

Table 1. Departure Index

Departure Index	Intenity of Meterological drought
0.00 <	No Drought
00.0 to -25.00	Mild Drought
-25.00 to -50.00	Moderate Drought

Table 2. tation Wise Departure Index in Nambiyar River Basin

Sl. No	Station	No drought	Mild drought	Moderate drought
1	Vallioor	15	16	6
2	Elankulam	19	15	3
3	Sirappur	15	18	3
4	Chidambarapuram	12	24	1
5	Vadakkankulam	17	17	3
6	Nainaputhoor	12	24	1
7	Boothapandi	14	22	1
8	Keeriparai	15	22	0
9	Manjolai	13	21	3
10	Venkatarengapuram	15	20	2
11	Nellaiyappapuram	14	21	2
12	Veppenkulam	17	16	4
13	Ammanpuram	16	19	2

Spatially, the moderate droughts years found above three years are noted in western part, north eastern part of the study area and below 3 drought years found in central

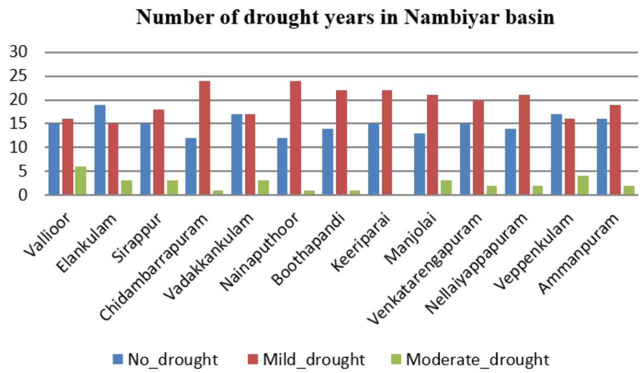

Fig. 2. Number of drought years

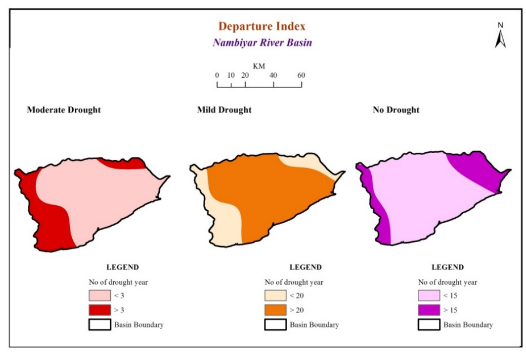

Fig. 3. Departure Index

and southeastern part of the basin. Northern, central and southeastern part of the study area have maximum number of mild drought category ie., above 20 years and below 20 years were found in western and northeastern part. The years which having greater than 15 years of no droughts was observed in western and eastern part of the study area. Below 15 drought years found in central part of study period (Figure 3)

Rainfall Anomaly Index

Rainfall Anomaly Index mainly used for maximum and minimum rainfall which is compared the long term mean of a particular study period. Rainfall Anomaly Index value differ from station to station, its show the how many years comes under the positive anomaly as well as negative anomaly. If the values of RAI are generally less than minus three it is associated with drought (Tilahun, K. 2006).

During this study period RAI value less then minus 3 are noted in Vallioor during the years 1986, 2001, 2002, 2003, 2004, 2012, in Elankulam location during 2001, 2003,2004 and 2012, Sirappur (1982, 1990, 2003 and 2013) Chidambara-

Table 3. Mean values of RAI and DI

Sl. No	Year	RAI	DI
1	1981	0.03	3.22
2	1982	-2.65	-17.62
3	1983	-0.38	-1.46
4	1984	2.76	29.55
5	1985	-0.35	-1.69
6	1986	-1.42	-9.91
7	1987	0.63	6.69
8	1988	0.66	9.03
9	1989	-1.42	-9.86
10	1990	-1.31	-7.75
11	1991	1.79	18.56
12	1992	-0.22	0.04
13	1993	-0.28	0.14
14	1994	-0.72	-4.35
15	1995	-1.55	-7.54
16	1996	-1.42	-8.90
17	1997	0.45	4.57
18	1998	-0.50	-2.21
19	1999	-1.91	-12.56
20	2000	-0.72	-4.18
21	2001	-3.46	-22.66
22	2002	-2.65	-17.33
23	2003	-2.45	-17.06
24	2004	-2.29	-15.79
25	2005	0.52	8.34
26	2006	0.50	5.38
27	2007	-0.81	-5.76
28	2008	4.80	51.21
29	2009	-0.60	-2.90
30	2010	-0.59	-2.75
31	2011	-1.66	-11.14
32	2012	-3.08	-20.51
33	2013	-2.62	-16.67
34	2014	1.65	16.91
35	2015	2.79	30.20
36	2016	-3.83	-24.86
37	2017	5.98	64.89

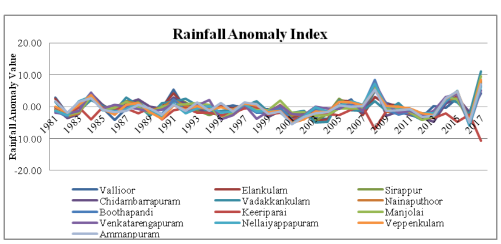

Fig. 4. Rainfall Anomaly Index

puram (1982, 1999, 2003, 2012 and 2013) Vadakkankulam (2003, 2004, 2012. 2012, 2013 and 2016) Nainaputhoor and Boothapandi (2001, 2002, 2013 and 2016) Keeriparai (1984, 1990, 2002, 2008, 2012, 2013, 2015 and 2017) Manjolai (1995, 2012, 2013, 2016) Venkatarengapuram (1995, 1998 and 2016) Nellaiyappapuram and Veppenkulam (1990, 2001, 2002 and 2016) Ammanpuram (2001, 2002, 2012 and 2016) (Figure 4).

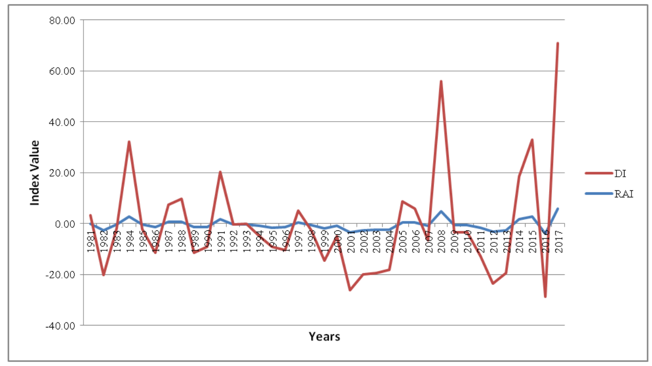

Fig. 5. Comparison of two drought indices

Keeriparai location in the basin is noted as highest drought index value of -10.67 during the study period. The graphical representation of average values of two drought indices is plotted in Figure 5. Both indices are almost similar in character (Table 3).

Conclusion

The main aim of the study is to analyze the drought character using DI and RAI index. The results obtained in this study give almost identical results while comparing the drought years. The two drought index reveals more or less similar results in the drought years. The common drought years between two indexes are notes as 1986, 2003, 2013 and 2016 during the study period. So, both the index is useful for to identify the drought condition in the study area. Even though, the study area is not affected by severe and extreme drought but the recent years indicates most of the stations are under moderate drought conditions. It shows that the basin slowly experiencing drought conditions. So, proper drought management plan is required to mitigate before it goes extreme conditions.

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