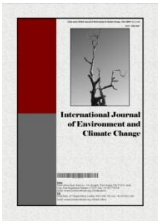

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Evaluation of Drought Characteristics Using the Reconnaissance Drought Index (RDI) over Parambikulam Aliyar Basin of Tamil Nadu

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Drought tends to be a creeping phenomenon occurs gradually with the deficiency in rainfall further extending its impact on sectors which are dependent on water. The drought characteristics were analysed in Parambikulam Aliyar Project (PAP) basin based on the European Centre for Medium range Weather Forecasts Interim Reanalysis (ERA-Interim) gridded data with resolution of 0.125° ×0.125° during 1981-2017. Reconnaissance Drought Index (RDI) was applied for monitoring the drought. The variables used in RDI are rainfall and potential evapotranspiration (ETo), the required meteorological data were taken from the ERA Interim dataset and ETo was calculated using

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Penman-Monteith method. RDI indicated that 41% of the time had drought condition over 37 years. Two years (1982 and 2012) faced severe drought across all the parts of the PAP basin and the highest number of mild drought events were observed than the other drought conditions in PAP basin. Results showed that Plain areas in PAP basin experienced maximum number of drought events compared to the other areas in PAP basin during the investigation period.

Keywords: Drought intensity; drought analysis; PAP basin.

1. INTRODUCTION

Concerns on water resources have become widespread in a global context due to the growing interconnection with other development-related issues and also with social, economic, environmental, legal, and political factors at every scale [1,2,3]. In this scenario, the knowledge of drought phenomena plays an important role for an appropriate planning and management of water resources, such that characterisation of drought has attracted the interest of many researchers in recent years [4]. Drought originates due to deficiency of precipitation over a period of time from long period average [5]. In the study of the drought phenomenon, drought indices that are able to objectively quantify climate conditions are usually required [6]. Several drought indices have been proposed to monitor the various kinds of drought in different areas. Reconnaissance Drought Index (RDI) works based on the ratio between precipitation and potential evapotranspiration (ET), and can be computed for different time scales [7,8]. Parambikulam-Aliyar basin is located in the south western part of the Peninsular India, covering areas in Kerala and Tamil Nadu States and it is considered as one the important basin in Tamil Nadu [9]. Hence drought analysis of PAP basin is gaining more importance for agricultural planning.

2. MATERIALS AND METHODS

2.1 Study Area

Parambikulam-Aliyar basin (PAP) is an inter-state water distribution project collaborating two states namely Kerala and Tamil Nadu. This project is mainly framed to divert the water from the eight west flowing rivers. The PAP basin area situated in coordinates of 10°10'00" N to 10°57'20" N latitude, 76°43'00" E to 77°12'30" E longitudes and distributed over 2388.72 sq.km area (Fig. 1).

2.2 Data

In this study meteorological data for the period of 37 years (1981-2017) was obtained from ERA Interim 0.125° ×0.125°gridded dataset. Rainfall and the required weather parameters such as temperature, relative humidity, solar radiation and wind speed for computing the ET_o were extracted from ERA Interim dataset. The rainfall and ET_o were used as inputs for RDI computation.

2.3 Reconnaissance Drought Index (RDI)

The Reconnaissance Drought Index (RDI) is calculated based on the ratios of precipitation over potential evapotranspiration for different time scales. Drought index calculator Version 1.7 (DrinC) was employed for computing RDI [10]. The potential evapotranspiration is computed through the Penman- Monteith formula. RDI classification is given in the Table 1. Initially, α_k is presented as the coefficient of the i^{th} year in an aggregated form using a monthly time step and can be calculated on a monthly, seasonal or annual basis as following.

$$a_k^{(i)} = \frac{\sum_{j=1}^{k} P_{ij}}{\sum_{j=1}^{k} ET_{ij}}, \text{ i = 1: N and j = 1:K}$$

Where,

P_{ij} is precipitation, ET_{ij} is potential evapotranspiration in j^{th} month of i^{th} year.

Table 1. Drought classification based on the RDI values

RDI values	Classification
>0	No drought
0 to -0.99	Mild drought
-1 to -1.49	Moderately drought
-1.5 to -1.99	Severe drought
-2<	Extremely drought

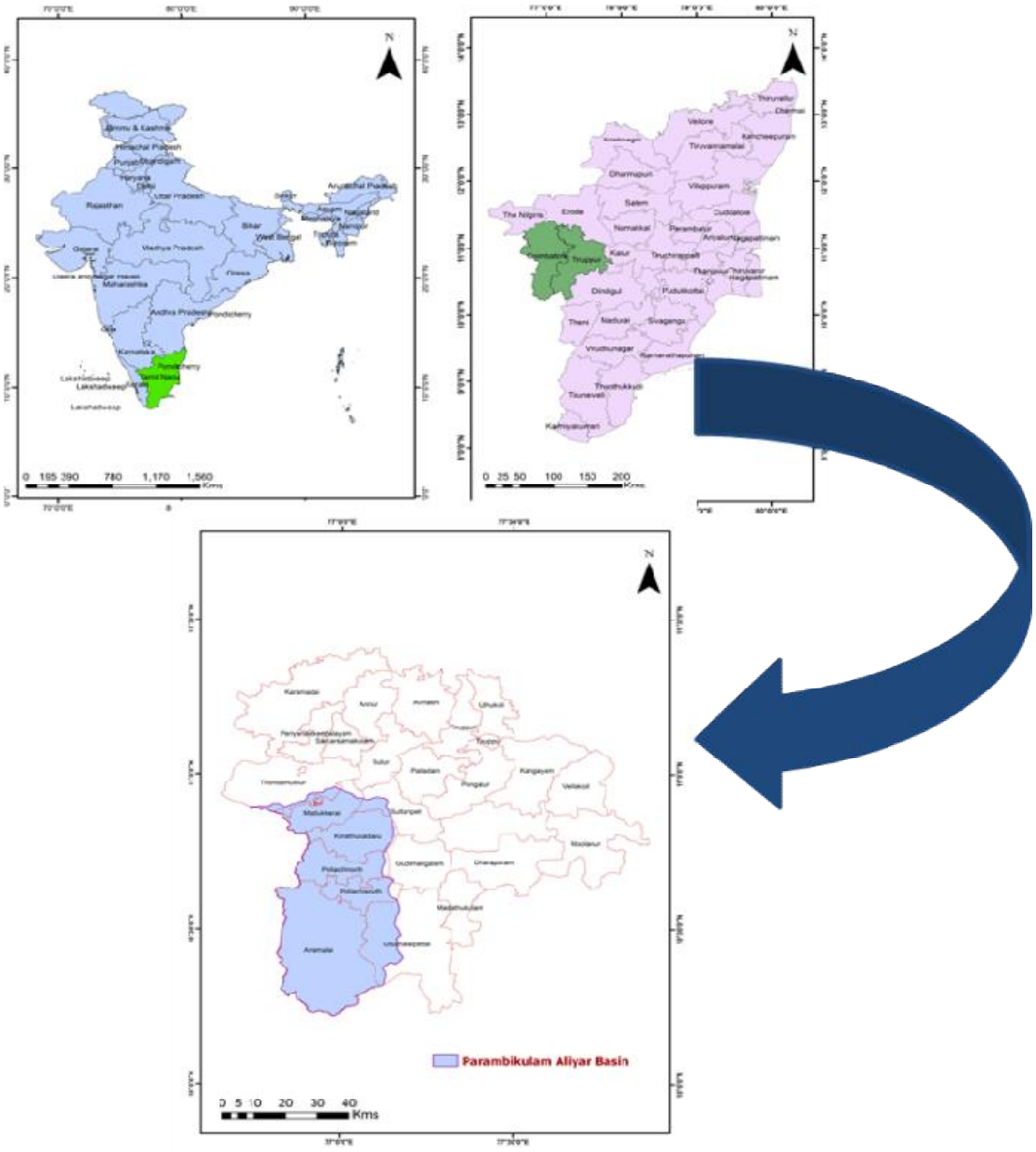

Fig. 1. Study area map of Parambikulam Aliyar basin

2.4 Calculation of Potential Evapotranspiration

The Penman - Monteith equation is used most commonly for computing the ET_o, recommended by the FAO in 1998 as reference ET. Many studies found that the Penman-Monteith is more appropriate for arid and semi-arid regions. In PAP basin, total potential evapotranspiration (ET_0) has been estimated through built in FAO Penman – Monteith equation as shown below using ET_o calculator version 3.2 developed by the FAO [11].

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} U_2(es - ea)}{\Delta + \gamma(1 + 0.34U_2)}$$

Where,

ET_0 is the potential evapotranspiration rate ($mm.d^{-1}$), G is the soil heat flux density ($MJ.m^{-}$

^{2}.day^{-1}) ; T is the mean daily air temperature at 2 m height (^{o}C); U_2 is the wind speed at 2 m height (m.s^{-1}); ed is the saturation vapour pressure (KPa); ea is the actual vapour pressure (KPa); Δ is slope of vapour pressure curve (KPa.°C^{-1}); γ is the psychrometric constant (KPa, °C^{-1}); Rn is the net radiation at the crop surface (MJ.m^{-2}.day^{-1}).

3. RESULTS AND DISCUSSION

Drought characteristics determined by the RDI from 1981 to 2017 period are presented in Table 2. It can be observed that six years exposed to mild drought (1987, 1994, 1995, 1998, 1999 and 2006) condition in hilly areas of PAP basin. The mild drought events in two consecutive years happened two times (1994, 1995, 1998 and 1999) over 37 years. Moderate drought phenomenon was also noticed in six years (1986, 1988, 2001, 2002, 2003 and 2016) and consecutive three years had moderate drought (2001, 2002 and 2003). Severe drought occurred in two years 1982 and 2012 (Fig. 2).

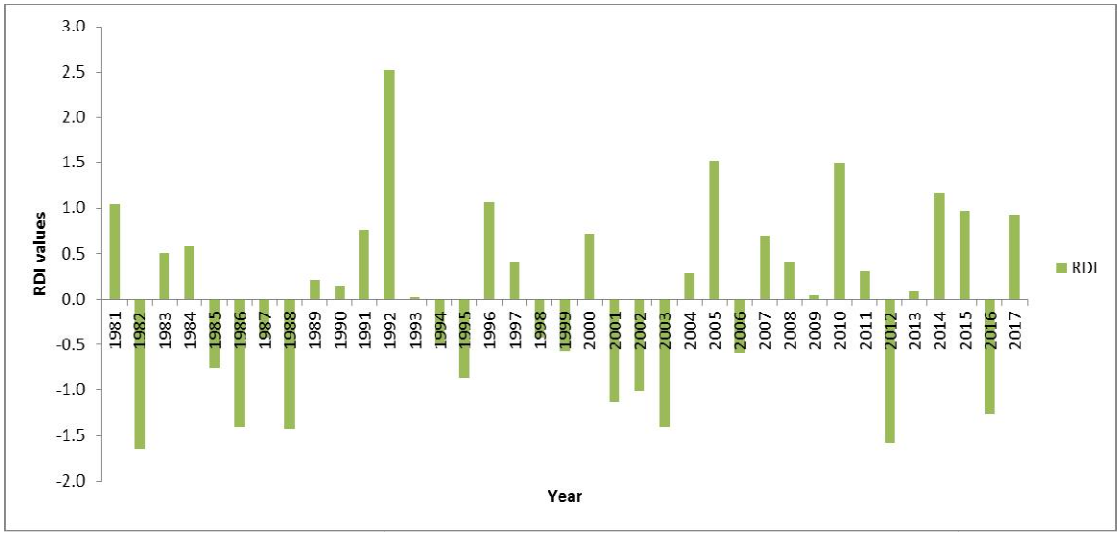

Fig. 2. 12-month time scale basis drought results using RDI method in PAP hilly area

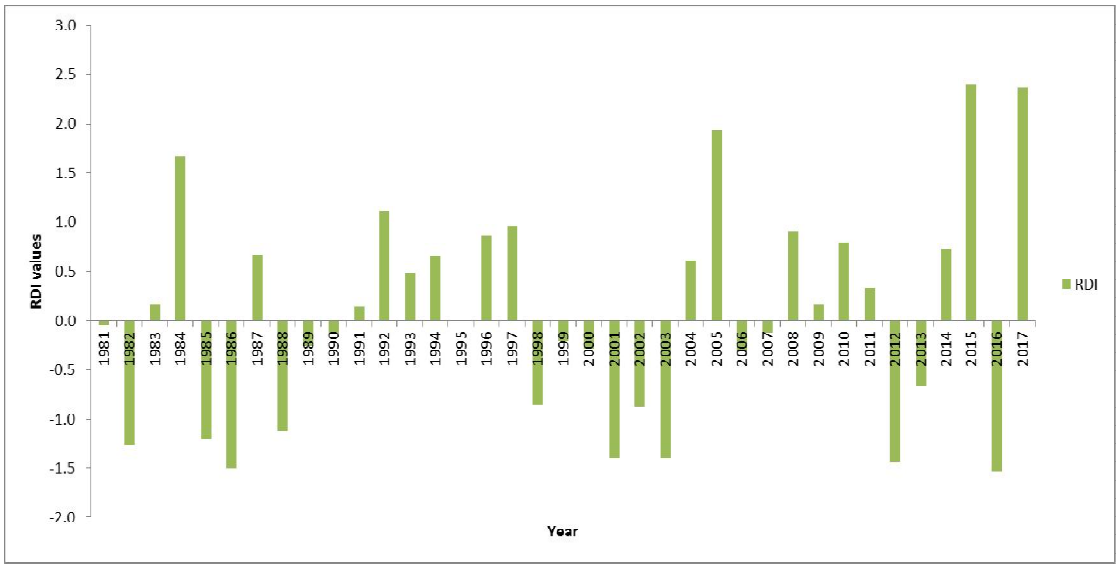

Fig. 3. 12-month time scale basis drought results using RDI method in PAP Plain area

Table 2. Drought characteristics for the RDI from 1981 to 2017 of PAP hilly area, PAP Plain area and Total PAP basin

Years	PAP Hilly areas		PAP Plain areas		Total PAP basin	
	RDI values	Classification	RDI values	Classification	RDI values	Classification
1981	1.1	No drought	0.0	No drought	0.7	No drought
1982	-1.6	Severe drought	-1.3	Moderately drought	-1.6	Severe drought
1983	0.5	No drought	0.2	No drought	0.4	No drought
1984	0.6	No drought	1.7	No drought	1.0	No drought
1985	-0.8	Mild drought	-1.2	Moderately drought	-1.0	Moderately drought
1986	-1.4	Moderately drought	-1.5	Severe drought	-1.5	Severe drought
1987	-0.4	Mild drought	0.7	No drought	0.0	No drought
1988	-1.4	Moderately drought	-1.1	Moderately drought	-1.4	Moderately drought
1989	0.2	No drought	-0.3	Mild drought	0.0	No drought
1990	0.2	No drought	-0.1	Mild drought	0.0	No drought
1991	0.8	No drought	0.1	No drought	0.6	No drought
1992	2.5	No drought	1.1	No drought	2.1	No drought
1993	0.0	No drought	0.5	No drought	0.2	No drought
1994	-0.5	Mild drought	0.7	No drought	-0.1	Mild drought
1995	-0.9	Mild drought	0.0	No drought	-0.6	Mild drought
1996	1.1	No drought	0.9	No drought	1.0	No drought
1997	0.4	No drought	1.0	No drought	0.6	No drought
1998	-0.4	Mild drought	-0.9	Mild drought	-0.6	Mild drought
1999	-0.6	Mild drought	-0.2	Mild drought	-0.5	Mild drought
2000	0.7	No drought	-0.3	Mild drought	0.4	No drought
2001	-1.1	Moderately drought	-1.4	Moderately drought	-1.3	Moderately drought
2002	-1.0	Moderately drought	-0.9	Mild drought	-1.0	Moderately drought
2003	-1.4	Moderately drought	-1.4	Moderately drought	-1.5	Severe drought
2004	0.3	No drought	0.6	No drought	0.4	No drought
2005	1.5	No drought	1.9	No drought	1.7	No drought
2006	-0.6	Mild drought	-0.3	Mild drought	-0.5	Mild drought
2007	0.7	No drought	-0.1	Mild drought	0.4	No drought
2008	0.4	No drought	0.9	No drought	0.6	No drought
2009	0.0	No drought	0.2	No drought	0.1	No drought
2010	1.5	No drought	0.8	No drought	1.3	No drought
2011	0.3	No drought	0.3	No drought	0.3	No drought

Years	PAP Hilly areas		PAP Plain areas		Total PAP basin	
	RDI values	Classification	RDI values	Classification	RDI values	Classification
2012	-1.6	Severe drought	-1.4	Moderately drought	-1.6	Severe drought
2013	0.1	No drought	-0.7	Mild drought	-0.2	Mild drought
2014	1.2	No drought	0.7	No drought	1.0	No drought
2015	1.0	No drought	2.4	No drought	1.6	No drought
2016	-1.3	Moderately drought	-1.5	Moderately drought	-1.4	Moderately drought
2017	0.9	No drought	2.4	No drought	1.5	No drought

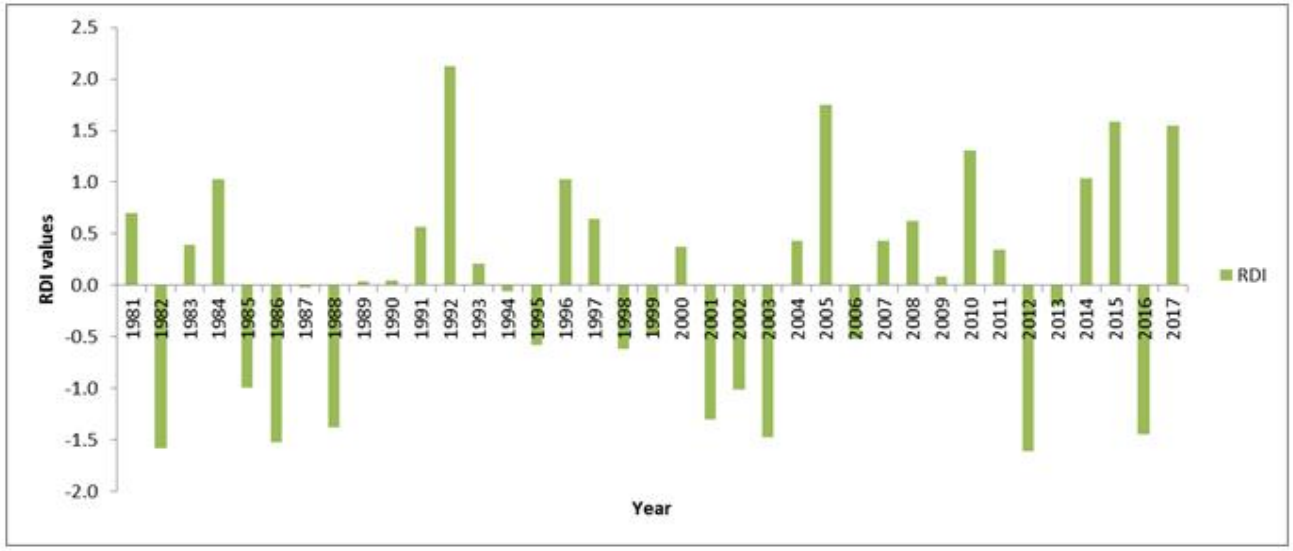

Fig. 4. 12-month time scale basis drought results using RDI method in Total PAP basin

Plain areas of PAP basin found to have mild drought in eight years (1989, 1990, 1998, 1999, 2000, 2006, 2007 and 2013) and moderate drought in seven years (1982, 1985, 1988, 2001, 2003, 2012 and 2016) severe drought was observed in 1986 (Fig. 3).

The entire basin imperilled with the six mild drought years (1994,1995,1998,1999,2006 and 2013) and five moderately drought (1985,1988,2001,2002 and 2016) years (Fig. 4). Four severe drought events (1982, 1986, 2003 and 2012) put the basin at the risk over the 37 years. In most parts of India also affected by below-average rainfall that caused the all-India drought during 1982,2002 and 2016 The monsoon season of 2002 was 19% drier compared to normal [12] and also the monsoon season of 2012 was above 50% drier compared to normal in Tamilnadu [13].

4. CONCLUSION

The Reconnaissance Drought Index (RDI) indicated that in hilly region, 16 per cent of the time experienced drought under mild as well as moderate category. In plain area, 21 per cent of time exposed to mild drought while 18 per cent of the time faced moderate drought. The whole basin was exposed to 16 per cent of the times with mild drought and 13 per cent of time under moderate drought. Four severe drought events jeopardised the agricultural activities in PAP basin.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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