World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:7, No:7, 2013

Estimation of Reconnaissance Drought Index (RDI) for Bhavnagar District, Gujarat, India

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***Abstract*—**There are two types of drought as conceptual drought and operational drought. The three parameters as the beginning, the end and the degree of severity of the drought can be identifying in operational drought by average precipitation in the whole region. One of the methods classified to measure drought is Reconnaissance Drought Index (RDI). Evapotranspiration is calculated using Penman-Monteith method by analyzing thirty nine years prolong climatic data. The evapotranspiration is then utilized in RDI to classify normalized and standardized RDI. These RDI classifications led to what kind of drought faced in Bhavnagar region on 12 month time scale basis. The comparison between actual drought conditions and RDI method used to find out drought are also illustrated. It can be concluded that the index results of drought in a particular year are same in both methods but having different index values where as severity remain same.

***Keywords*—**Drought, Drought index, Reconnaissance Drought Index (RDI), Precipitation.

I. Introduction

DROUGHTS are the resultant of acute water scarcity due to lack of rains over extended periods of time moving various human activities and lead to problems like widespread crop failure, un-replenished ground water resources, depletion in reservoirs and shortage of drinking water. The drought prone areas in the country classified on annual rainfall departures fall either in arid, semi-arid and dry sub-humid regions where droughts occur frequently.

Drought produces a large number of impacts that affects the social, environmental, and economical standard of living. One of the sectors where the immediate impact of drought is felt is agriculture. With the increased intensity or extended duration of drought prevalence, a significant fall in food production is often noticed. Drought results in crop losses of different magnitude depending on their geographic incidence, intensity and duration. It does not have a sharp ending although sometimes a prolonged spell of drought can come to a sudden end through a fairly long spell of especially heavy rainfall as in case of depression or cyclone. Drought proceeds in sequential behavior. Its impacts are spread across different domains as listed: Meteorological drought is simple deficit of rainfall from the normal, hydrological drought often leads to reduction of natural stream flows or groundwater levels, plus stored water supplies. Main impact is on water resource systems and the agriculture drought occurs when moisture level in soils is insufficient to maintain average crop yields.

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II. Impact, Strategies and Reducing drought Impact for Well-Organized Management of Drought

A. Impact of Droughts

There are many impact of drought such as shortage in ground water recharge, Non-availability of superiority seeds, reduced draught power for agricultural operations due to distress sale of cattle and land degradation.

B. Strategies

As drought is a slow on set disaster, it's monitoring and early warning systems are central to drought management. The Indian Meteorological Department (IMD) is the designated agency for provided that drought early warning and forecasting. IMD predicted the first scientific monsoon in 1886. IMD forecast droughts on: Long-range forecasts of seasonal total rainfall for the entire country, which are done before onset and at the beginning of the monsoon.

- Policy issues, national, regional and district level.
- Rural development infrastructure.
- Input supply, marketing and farm advisory services.
- Rural institutions, local self-governments.
- Philanthropic organizations.

C. Reducing Drought Impacts

The move toward to drought in the past has been generally reactive and response oriented, through disaster management. Developing an inventory of water resources indicators and index. Development of standardized indicators for specific use, including hazards assessments. Development of decision support models for the dissemination of drought related information to end users and appropriate methods for encourage feedback on climate and water supply assessment products. Support development of regional networks for drought preparedness that would enhance regional capacity to share lessons learned in drought monitoring, prediction, preparedness, and policy development

III. Literature Review

The climatic fundamentals exercise a very strong and direct influence on the development and allocation of soil, crops and live stock. For the estimation of drought severity, apart from precipitation, the inclusion of evatranspiration gives a more realistic estimate of water deficit [1]. Comparability analyses are performed to investigate differences between standardized precipitation index (SPI) and reconnaissance drought index (RDI), utilizing precipitation and potential evapotranspiration. The results show that the RDI by utilizing the ET0 can be very sensitive to climatic variability. This is rather important, since if the drought analyses are for agricultural applications, utilization of the RDI would seem to serve a better purpose [2]. The monsoon of 1974 proved erratic. Rains were 20-59% below normal over large parts of Gujarat, Rajasthan, Orissa, West Bengal, Bihar, Haryana and Punjab. Consequently, a shortage of 7 million metric tons in the monsoon season crop of food grain was feared [3]. Support development of regional networks for drought preparedness that would enhance regional capacity to share lessons learned in drought monitoring, forecast, preparedness, and policy development [4]. RDI and SPI indices respond in a similar fashion and can be used effectively to analyzed drought conditions and for monitor drought events [5]. Evaluation of the results indicate that SPI and RDI of A2 scenario would have a negative trend along with the projected years, while these indicators tend to have positive trend when resulted from B2 scenario. The latter result demonstrates an increase of vulnerabilities based on upcoming droughts [6].

IV. Study Area and Availability of Data

Bhavnagar is a peninsular district of South-Eastern Gujarat. It covers an area of over 8334 km². There are close to 800 villages in this district. Geographical location of Bhavnagar district is 21° 28′ N (Latitude) and 74° 52′ E (Longitude). The main resources of irrigation in these areas are wells and rivers.

Fig. 1 Location of the study area

V. Methodology

A variety of drought indices have been developed to quantify whether or not a region is experiencing a drought and to categorize the seriousness of the drought. Drought indices are useful for mapping regional water supply trends, both temporal and spatial [10]. Drought indices are also used to define disaster conditions that qualify for government assistance and where and when emergency water restrictions may be required.

This method is based on the ratio between two aggregated quantities of precipitation and potential evapotranspiration. The role of *ET*0 in the detection of drought events has been helpful in the development of a new reconnaissance drought identification and assessment index [1]. αo is calculated as the coefficient of the i^{th} year in aggregated form, using a monthly time step as following.

$$\alpha_0^{(i)} = \frac{\sum_{j=1}^{12} P_{ij}}{\sum_{j=1}^{12} PET_{ij}} \quad (1)$$

where, i = 1(1) N and j = 1(1)12, Pij and PETij are precipitation and potential evapotranspiration of the jth month of the ith year and N is the total number of years of the existing data. Equation (1) may be considered for twelve month of the year. In this research ETo was used to represent PETij, which was estimated using the Penman-Montieth method, explained in Allen et al. [8]. The Normalized *RDI* (*RDIn*) is computed, using α as the arithmetic mean of αo values based on obtainable data.

$$RDI_n^{(i)} = \frac{\alpha_0^{(i)}}{\overline{\alpha_0}} - 1 \quad (2)$$

The Standardized RDI (RDIst) is computed in a manner similar to the twelve month of SPI.

$$RDI_{STk}^{(i)} = \frac{y_k^{(i)} - \overline{y^k}}{\widehat{\sigma_{yk}}} \quad (3)$$

where, yk is the $\ln(\alpha_0^{(i)})$, yk is the arithmetic mean and $\widehat{\sigma_{yk}}$ is the standardized deviation. In the present study *RDI* is used to be *RDIst*.

TABLE I
THE RDI DROUGHT CATEGORY CLASSIFICATION

Sr. No.	*RDI* VALUE	Category
1	2.0 and above	Extreme wet condition
2	1.5 to 1.99	Very wet condition
3	1.0 to 1.49	Moderately wet condition
4	-0.99 to 0.99	Near normal condition
5	-1.0 to -1.49	Moderately dry condition
6	-1.5 to -1.99	Severely dry condition
7	-2.0 and less	Extreme dry condition

VI. DATA COLLECTION AND ANALYSIS

In any Climatological study, data collection has the major role to play for completion of work. There are 25 types of atmospheric monitoring networks that are operated and coordinated by the IMD [7]. The major data required for the analysis are monthly minimum and maximum temperature, rainfall, humidity, wind speed and sun hours. Thirty nine years climatic data was obtained from different government agencies. The same has been utilized to derive RDI. These data are collected from 1971 to 2010 for this study. The average of maximum temperature and average of minimum temperatures ranges from 33.7°C and 21.4°C and average rainfall is 52.1mm where derived from the data. The average humidity and wind speed are 54% and 16 Km/hr of Bhavnagar region. Referred data was gathered from various government agencies, than put to states in formulae to derive the results.

VII. RESULTS AND DISCUSSION

A drought index value is normally a single number, far more valuable than raw numbers for result making. Large historical datasets are required in order to study drought which involves complex inter-relationship between the climatological and meteorological data. First of all calculated potential evapotranspiration by Penman –Monteith equation for forty years. The maximum and minimum yearly potential evapotranspiration of the region are 52.17 mm/year and 56.42 mm/year. Thus it can be establish during the year of 1974 there as severe drought with -0.718 RDI value and during the year of 1976, there were plenty wet conditions with 0.87 RDI value in normalized RDI. Similarly result shows for standardized RDI, during the year of 1974 there as severe drought with -2.42 RDI value and during the year of 1976, there were plenty wet conditions with 1.52 RDI value. Actual data gathered from collectorate Bhavnagar it is revealed that there was 75.80% drought was reported as pre scarcity manual in the year of 1974[9]. Similarly there was no scarcity during the wet year of 1976. All these results, comparison graphs and table are appended. Thus it can be concluded that the index results of drought in a particular year are same in both methods but having different index values where as severity remain same.

APPENDIX

TABLE II
THE RDI VALUES CLASSIFICATION

Year	Standardized RDI	Normalized RDI
1971	0.096	-0.054
1972	-2.162	-0.680
1973	0.819	0.338
1974	-2.424	-0.718
1975	0.083	-0.60
1976	1.525	0.878
1977	0.302	0.044
1978	-0.319	-0.225
1979	0.930	0.412
1980	-0.418	-0.261
1981	0.412	0.101
1982	-1.752	-0.611
1983	0.821	0.339
1984	-0.108	-0.143
1985	0.344	0.065
1986	-1.207	-0.494
1987	-2.393	-0.714
1988	0.327	0.057
1989	0.009	-0.093
1990	0.857	0.363
1991	-0.464	-0.277
1992	0.465	0.129
1993	-0.570	-0.313
1994	0.635	0.225
1995	-0.097	-0.136
1996	0.378	0.083
1997	0.173	-0.018
1998	0.800	0.326
1999	-0.427	-0.264
2000	-1.803	-0.620
2001	0.496	0.146
2002	1.136	0.558
2004	0.228	0.008
2005	1.193	0.601
2006	0.529	0.164
2007	1.313	0.696
2008	0.627	0.220
2009	-0.676	-0.347
2010	0.725	0.279

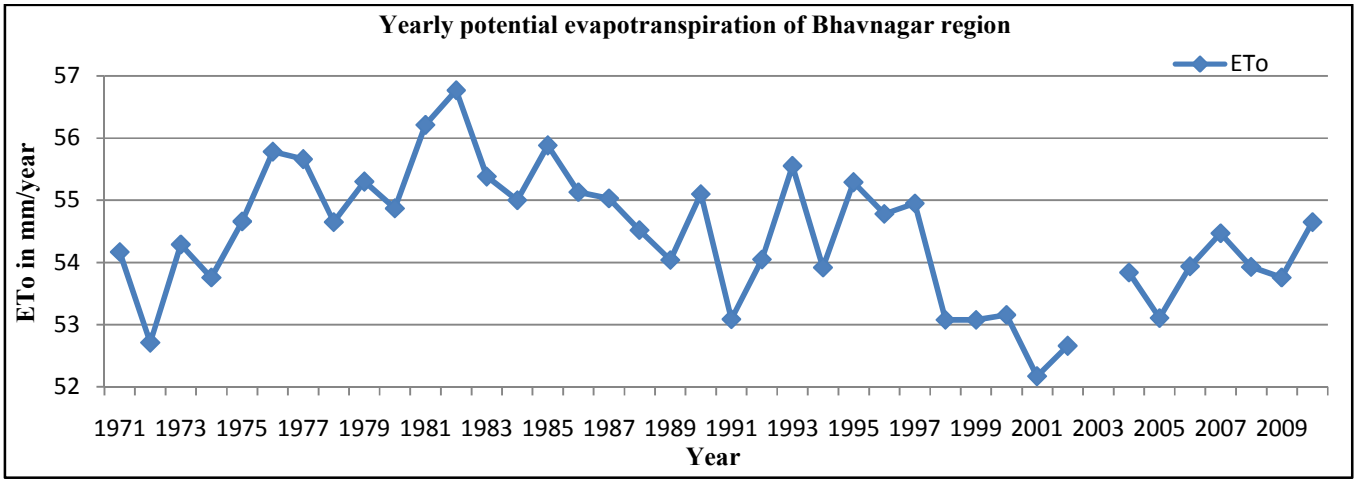

Fig. 2 Yearly evapotranspiration of Bhavnagar region in mm/year

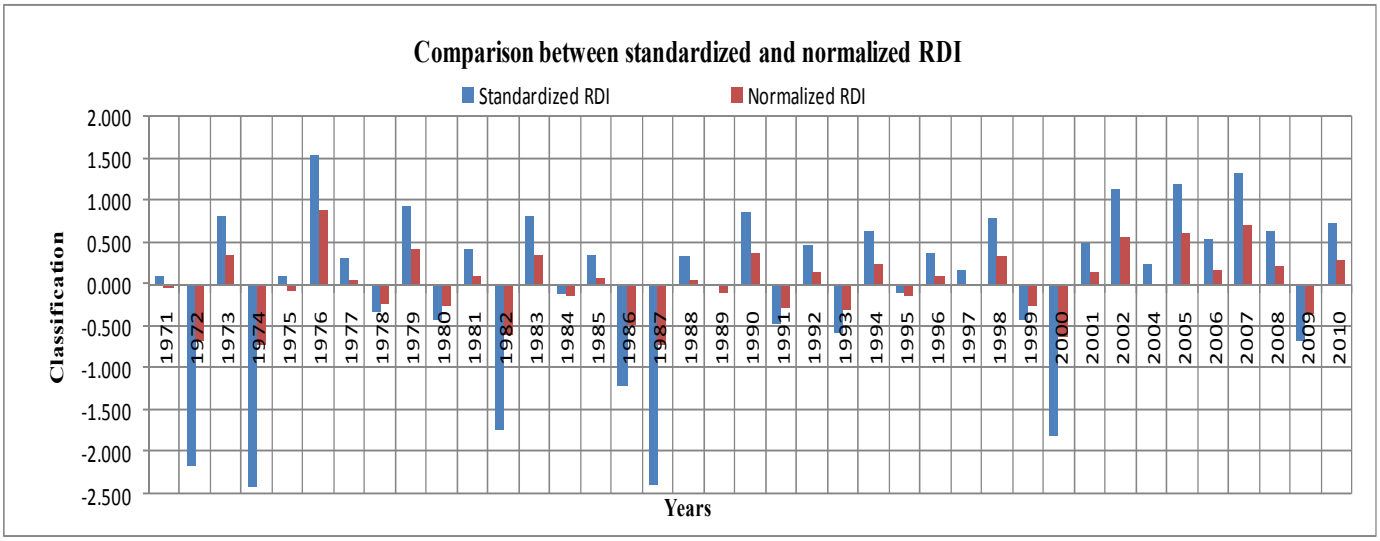

Fig. 3 Comparison between standardized and normalized RDI

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