



Water Budget Analysis by Using Thornwaite's TMI Index: A Case Study of India

KEYWORDS

Precipitation, Potential Evapotranspiration, Water Balance, Total Moisture Index

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ABSTRACT *In order to identify the water scarcity or drought situations and its severity, it is very important to understand the water balance process over earth. It is the cyclic process in which the water balance is maintain through continuous processes of evaporation, condensation and precipitation. The atmospheres acquires moisture by evaporation from oceans, lakes, rivers and damp soil or from moisture transpired from plants taken together, this area often referred to as evapotranspiration (Darry and Chorley, 1969, pp-58). And after the process of condensation water vapours are again converted in to solid or liquid state and precipitate on the ground. In this way the hydrological cycle is completed. So, the water surplus areas and deficit areas are identified with the help of total evapotranspiration from the earth to the atmosphere and precipitation over the earth. For the present investigation the water balance of Indian states are mainly determined by potential evapotranspiration from earth to atmosphere and reverse of water to the ground surface is determined by precipitation over the ground surface. With these above mentioned two climatic elements Thornwaite's TMI values are calculated and water deficit and surplus areas are marked.*

Introduction

The primary objective of the study is to find out ground water regime. The ground water availability is totally depends on natural as well as artificial condition of recharge and discharge. The Natural processes like precipitation, evaporation, evapotranspiration, storage, etc are the important in case of determining the ground water availability. While, the artificial processes indicate the pumpage from the ground in the form of well, tube well, etc.

The precipitation amount is easily calculated by using instruments but the determination of Potential evapotranspiration is quite difficult one. The term evapotranspiration is nothing but combined evaporation from the soil surface and transportation from plants. It represents the transfer of water back to the atmosphere on the other hand no instrument has yet been perfected to measure the water movement from the earth to the atmosphere (<http://www.jstor.org>). Evapotranspiration is computed using the method devised by Thornthwaite and Mather (1957).

The present investigation is about an assessment of water surplus and deficit areas of India by using the annual precipitation and potential evapotranspiration (PET) values. But, it is impossible to explain dry or moist climatic condition without knowing TMI index of area. With the help of TMI index water surplus and deficit areas are identified. That helps to mark the drought prone areas and water logged areas in India. This helps us to develop the proper water planning strategies

Objective

- To determine the water surplus and water logged areas in India.
- To identify the drought prone areas in India.

Data Base

The present investigation is based on the secondary sources of data. Secondary data is obtained from Grampanchayat office, Talathi office in the form of maps, documents and brochures. Other relevant data is collected from District census handbook, Socio-economic review of Sangli district, Gazetteers, Website of Municipal Corporation and available published and unpublished material, internet, Books and Maps. In spite of that the numbers of books are also used to clarify the concepts.

Methodology

The present study is mainly based on the analysis of the water balance by using TMI index. TMI index is mainly used for identification of water surplus and water deficit areas of India. For the analysis of water budget numbers of techniques are used by hydrologist, geographers and engineers. Thornthwaite devised an index to take in to account the balance between precipitation and potential evapotranspiration; index is termed as TMI. And it helps to identify the water deficit and water surplus areas; therefore, the total moisture index (TMI) is used for present investigation. According to him total moisture index is as follows-

$$TMI = 100 [P/PE-1]$$

Where,

TMI= Total Moisture Index

P= Precipitation

PE= Potential Evapotranspiration

The values of the index are corresponds to the humidity or aridity of an area. If value of the index is positive then the atmospheric condition is humid and the negative index value represents a dry climate conditions.

Study Area

The present study is concern with water budget of India. The India is located between 8°4' and 37°6' north latitude and 68°7' and 97°25' east longitude. The total area of the India is 3,166,414 square kilometers or 1,222,559 sq miles. As per the total area India is seventh-largest country in the world. India has a coastline of 7,517 km (4,671 mi) and a land frontier of 15,200 km (9,445 mi). India is rich in surface water resources. Average annual precipitation is nearly 4000 cubic km and the water resource in river system is estimated to be 1880 cubic km. Because of concentration of rainfall only in the three monsoon months, the utilizable quantum of water is about 690 cubic km. However, the conditions vary widely from region to region. Some regions are drought affected and at the same time other are experiences flash floods. Due to the increase in population the demand for irrigation, human and industrial consumption of water has increased considerably thereby causing depletion of water resources.

Determination of Water Balance by Using Thornwaite's

TMI Index

Thornthwaite devised an index to take in to account the balance between precipitation and potential evapotranspiration; index is termed as TMI. And it helps to identify the water deficit and water surplus areas; therefore, the total moisture index (TMI) is used for present investigation. According to Thornthwaite's formula the total moisture index for each state in India is-

1) Maharashtra

$$P = 64.58$$

$$PE = 155.5 \quad TMI = 100 (P/PE - 1)$$

$$= 100 (64.58 / 155.5 - 1)$$

$$= 100 (0.41 - 1)$$

$$= 100 (-0.59)$$

$$= -59$$

2) Madhya Pradesh

$$P = 74.08$$

$$PE = 140.08 \quad TMI = 100 (74.08 / 140.08 - 1)$$

$$= 100 (0.52 - 1)$$

$$= 100 (-0.48)$$

$$= -48$$

3) Gujarat

$$P = 36.66$$

$$PE = 167.41 \quad TMI = 100 (36.66 / 167.41 - 1)$$

$$= 100 (0.21 - 1)$$

$$= 100 (0.79) = -79$$

Table 1**India: Potential Evapotranspiration, Precipitation and TMI Index**

S.N	State	PET	Precipitation	TMI	Climatic Type
1	Maharashtra	64.58	155.5	-59	Semi-arid
2	Gujarat	36.66	167.41	-79	Dry
3	Madhya Pradesh	74.08	140.08	-48	Semi-arid
4	Orissa	128.33	128	0.25	Sub-humid
5	Karnataka	93.16	136.91	-32	Sub-dry
6	Andhra pradesh	95.08	146.33	-36	Semi-arid
7	Uttarakhand	136.25	85.58	59	Humid
8	Tamilnadu	76.25	112.83	-33	Semi-arid
9	Kerala	227.58	141.66	60	Humid
10	Himachalpradesh	97.08	91.66	5.09	Sub-humid
11	Chattisgarh	119.41	131.58	-9.24	Sub-dry
12	Haryana	49.41	134.91	-64	Semi-arid
13	Rajasthan	37	150.83	-76	Dry
14	Bihar	93.91	120.08	-21.79	Sub-dry
15	Uttar Pradesh	68.66	125.33	46	Humid
16	Panjab	60.41	114	-48	Semi-sarid
17	Zarkhand	118.75	112.08	5.95	Sub-humid
18	West Bangal	125.5	124	1.2	Sub-humid
19	Meghalaya	310.5	90.91	241	Very humid
20	Assam	203.58	95.91	112	Very humid
21	Manipur	175.5	86.91	101	Very humid
22	Jammu & Kashmir	75.08	15.41	387	Very humid
23	Sikkim	179.5	76.91	133	Very humid
24	Nagaland	144.66	72.75	98	Humid
25	Goa	208.08	146.16	42	Humid
26	Tripura	NA	NA	NA	NA
27	Arunachal Pradesh	NA	NA	NA	NA
28	Mizoram	NA	NA	NA	NA

Data Source: www.waterportal.org (2010).

Very Humid States in India (according to TMI)

Meghalaya, Assam, Manipur, Sikkim and Jammu & Kashmir states of India represents very humid climatic conditions. From that Jammu & Kashmir state having very high humid index value (TMI=387). Jammu & Kashmir state is followed by Meghalaya with 241 TMI value. While Manipur state represents comparatively low humidity. On an average above mentioned states in India having very high humidity. So, these states do not experience the water scarcity problems in current and near future days as per our calculation.

The Uttarakhand, Nagaland, Uttar Pradesh, Goa, Kerala and Uttarakhand states of India are represent the humid climatic conditions. Among all humid states Nagaland is stand at first rank with 98 TMI value. Whereas, Goa state is represent the lowest humidity among the remaining humid states with 42 TMI value.

Sub-Humid States in India

As per the Thornthwaite TMI index about four states are come under the sub humid climatic zone. These states are Orissa (0.25), Himachal Pradesh, Zarkhand (5.95) and West

Humid States in India

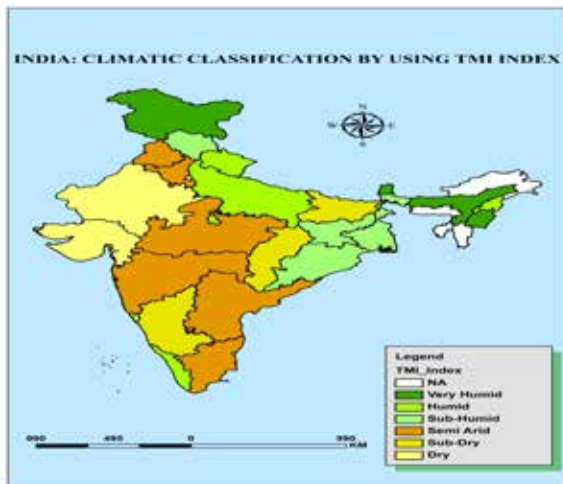


Fig. 1. Climatic Classification of India by Using TMI values.

Bengal. Among these above mentioned states Zarkhand state (5.95) has highest TMI value, while Orissa state (0.25) is denote to very low TMI index which represents the lowest humidity.

Sub-Dry States in India

The Karnataka (-32), Chhattisgarh (-9.36) and Bihar states are comes under the sub dry climatic zone. The Karnataka state with (-32) TMI value denotes the comparatively more dry climatic condition than that of Chhattisgarh (-9.36) state.

Semi-Arid States in India

In India about six states represents semi-arid climatic conditions as per the TMI values. Therefore, these states some time experience the drought like situations. The states of Maharashtra, Madhya Pradesh, Andra Pradesh, Tamil Nadu, Haryana and Punjab are very seriously faces the problem of water scarcity.

Dry States in India

The Gujarat (-79) and Rajasthan (-76) are the two very dry states in India. And if there is a lack of irrigation facilities then these state experiences drought like situations in near future.

Conclusion

The climatic conditions of India are varies from very humid to the dry; this climatic conditions are interpreted by using the Thornthwaite's TMI formula. According to the values obtained, about five states in India are having very humid climatic conditions. Very specifically the Jammu & Kashmir state is having very high humid index value (TMI=387). On the contrary, around eight states in India represent the semi-arid and dry climatic conditions. These eight states are easily vulnerable to the drought, vulnerability of these states to the droughts is totally depends on the availability of modern irrigation facilities, development of other related water sources and awareness about the watershed management. As per calculations, the Maharashtra state is included in to semi-arid area. Due to the lack of irrigation facilities in Maharashtra state most of the districts in south-eastern Maharashtra are vulnerable to drought.

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