Analysis of Water Balance to Study Aridity Index and to Define Months of Water Deficit/Surplus in Relation to Crop Planning for Kharif and Rabi Seasons

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Abstract-Water an essential component of all life forms, is being depleted due to overexploitation of water resources. As demand of water is increasing day by day, due to increasing urbanization and industrialization. Hence the information about the spatial and temporal availability of water would be helpful for optimum utilization of water resources. The study of water balance is useful for computing seasonal and geographical pattern of water availability to facilitate better management of available water resources. In this study water balance of the Jharkhand region has been calculated, using thirty four (1977-2005) years climatic data, and with the help of estimated water balance components we have also tried to find out climatic and drought patterns for the selected study area. The result of the study indicates that during the SW monsoon period, the region has sufficient amount of water i.e. from mid June to mid October and these months become months of water surplus for this region, and it undergoes a period of water deficit from February to mid June.

Computation of the aridity index shows that this area is moderate drought prone and according to The Thornthwaite Climate classification which is being used here to define climate of this region [based on moisture indices (I_m)] climate of the region is- Humid-climate. With the help of water balance components we were able to know months of water deficit and surplus which has helped us to identify crop patterns of this region in different seasons. Through this we found that crop grown during Rabi season don't favor more water while crop grown during Kharif season suggest successful cropping with rainfall. The present study also indicates that this station has not undergone a period of water deficit during Kharif season.

Key: words*;* -Water balance, water deficit, water surplus.

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"1. **Introduction", -**Water is vital for all known forms of life as well as plays an important role in the world economy. In spite of this we use water every day in farming, agricultural, transportation and power generation too. Water also plays many essential roles in plant growth and function. Water supply is one of the important factors for rapid development and urbanization. But overexploitation of water resources has resulted in a condition of unsutainbility and environment degradations. As demand of water is increasing day by day due to increasing urbanization and industrialization, the need for spatial and temporal availability of water is also increasing which is helpful for the optimum utilization of water resources. And hence the computed water balance is useful for computing seasonal and geographical patterns of water availability to facilitate better management of water resources. The water balance study is a useful tool to understand the hydrological behavior of any area **[5].** The estimates of soil water balance and water balance indices (humidity index, aridity index and moisture index) at a given location provides useful information on soil moisture storage, period of water deficit and water surplus.Knowledge of moisture deficit facilitates the understanding of economic feasibility of irrigation and that of the water surplus provides information on the scope of recharge and conservation for future utilization. The estimated soil water balance can be used as guides for estimating the probable length of growing season, irrigation needs, leaching of soils for salts, fluctuations in the water table, drought hazards, soil water availability in different regions and judging the agricultural potential of the region. The quantitative results obtained may also be utilized for

Agromet Advisory Service bulletins **[8].** Water engineers and scientists are confronted with challenges of sustainable development and have the responsibility to meet these challenges, both at the macro-level of overall demand and supply and at the micro-level, by designing, operating and maintaining water resources and water projects in a manner consistent with the objective of local sustainability. The future availability of water for human use depends on how water resources are managed **[5].** Through most of the study we found that water shortage is one of the important reasons behind the increased migration from upland areas to the plains.

1.1. **Objective-**

- ✓ The purpose of this research is to analyze water balance and the aridity index with reference to drought.
- ✓ To define months of water deficit/surplus in relation to crop planning for both seasons Monsoon or Kharif (June to September) and Rabi (October to February).
- ✓ To define climate of this region according to Thorntwait climate classification.

***"2.* Study Area and Data Used,"-**The study area Ranchi is the capital of Jharkhand also referred to as the "City of Waterfalls", due to the presence of numerous large and small falls around the close vicinity of the city. Having latitude 23.3500° and longitude 85.3300° .The total area of Ranchi is 5,321 km^2 (2,054 sq m^2), having humid subtropical climate. Temperature ranges from a maximum 42 to 20 °C during summer and from 25 to 0 °C during winter. In this study last thirty four years needed input climatic parameters (1997-2005) has been used for WATER balance and Aridity Index computation and to define drought & Climatic pattern of this region. The $ET_\circ$ used in computation of water balance has been calculated by using Pan Evaporator data. Pan provides a measurement of the integrated effect of radiation, wind, temperature and humidity on the evaporation from an open-water surface **[1],** and to convert class A pan evaporation into $ET_\circ$ a coefficient Kp is used which depend upon the fetch distance around the Pan (F), wind speed (WS), and relative humidity (RH). To determine Kp, charted value or equation can be employed, where Kp is a function of F, WS, and RH (Doorenbos & Pruit, 1997), **[4].**

2.1. Pan Evaporation Method (Doorenboss And Pruitt 1977)-

$$ET_\circ = Epan * Kp$$

Where, Pan=Pan evaporation in mm day^{-1} K_p=Pan coefficient., For the class a evaporation Pan, the K_P varies between 0.35 and 0.85, **[4].**

"3. Materials And Methods,"-

3.1. Water Balance computation method-

The moisture balance is expressed by the so-called "storage equation" of the hydrologist where

$$P = PE + R + \Delta S,$$

P = water supply to the region as precipitation in all its forms or from other sources, PE = total water loss by evaporation and transpiration (Potential evapotranspiration), R = runoff from the area by sub-surface or overload flow and ΔS = change in the moisture status of the soil (Soil moisture Storage).

3.2. Climatic Classification based on Moisture Indices -Studies of the water balance (which is the principle of mass conservation applied to exchanges of water) ensure the magnitudes of the various water exchange processes, and allow investigation of the interaction between the Elements of the hydrological cycles. The purpose of water balance studies is to investigate climate shifts and to classify the region into climatic categories based on availability of moisture surplus (WS) and deficit (WD) by computing moisture indices through water balance analysis. Moisture indices determine the moisture status and climatic type of a Region.

Computation of moisture index (I'm), humidity index (I_h) and aridity index I_a are as follows-

$$I_h = \sum_{i-1}^{12} \left(\frac{WS}{PE}\right) \times 100$$

$$I_a = \sum_{i=1}^{12} \left(\frac{WD}{PE}\right) \times 100$$

and

$$I_m = (I_h - I_a)$$ (Carter and mother, 1955).

3.3. Climate classification based on Moisture Indices –

In this study climate of the city is classified following the scheme of Thorntwaite and Mather (1995) which follows the limits of I'm.

Table 1 : Moisture Indices and Climate Classification

Classification	Type	Limits of I_m%
Per-humid	A	100 and Above
Humid	B	20 to 100
Moist sub humid	C2	20to20
Dry sub humid	C1	−33. 3to0
Semiarid	D	−66. 7to−33.3
Arid	E	−100 to −66. 7

Table 2 : Aridity Index Categories

Aridity Index (%)	Criteria
< 16,7	Draught does not occur
16,7 - 33,3	Medium draught
> 33,3	Heavy draught

Ref: Sudibyakto, et al (1999)

"4. Result and Discussion,"-

The water balance study is shown to be very useful in finding out the periods of moisture deficit and surplus of this region. Variation of spatial and temporal variability of each component for last thirty four years has shown in Figure -1. The weekly average annual water deficit for the last thirty four years is about 102 mm and the average annual water surplus is 302 mm.

The Ranchi city undergoes for a period of moisture deficit during the month of February to mid of June; and from June to October the region has a water-surplus condition. The weekly average annual rainfall of the city is 360 mm while weekly average $ET_{\circ}$ is 324 mm day^{-1}. And with the help of water balance component aridity index has also been calculated to delineate drought patterns of the city, on computation of aridity index we find its value 21.22, through this A. I value we found Ranchi to be a moderate drought prone area, when we classify it according to table-2. A pictorial representation of Aridity index has shown in Figure-2.

By finding out months of water deficit and surplus we were able to know crop patter of this region in major two crop growing seasons,where we found that crop grown during Rabi season has RF/PET value less than 1, which suggest that crop grown during this time don't favor crop requiring more water, while RF/PET value during Kharif season varies between 1 to 4 suggesting successful cropping with rainfall which also shows that this station has not undergone a period of water deficit during kharif season from last thirty four years. Which is shown in Figure-3.

To delineate climate type of the study area, we have used Thortwait climate classification which is based on the Moisture indices, in the computation of moisture indices with the help of water balance component we found its value-55.1, which show type B climate for the city i.e., Humid according to Thorntwait climate classification.

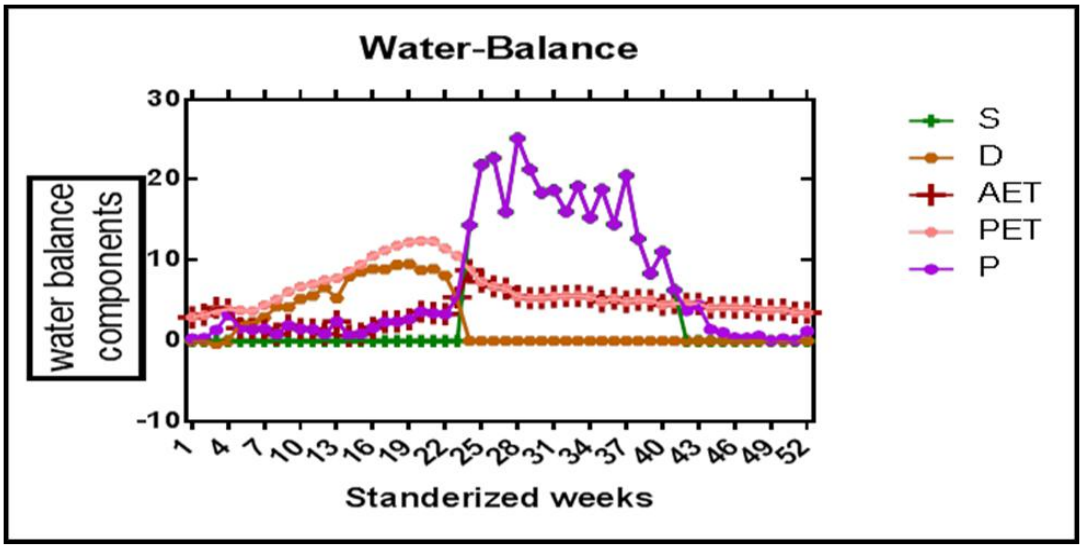

Figure 1: Water-balance and their components

Where S=Surplus,D=Deficit,AET=Actual evapotranspiration,PET=Potential evapotranspiration,P=Precipitation

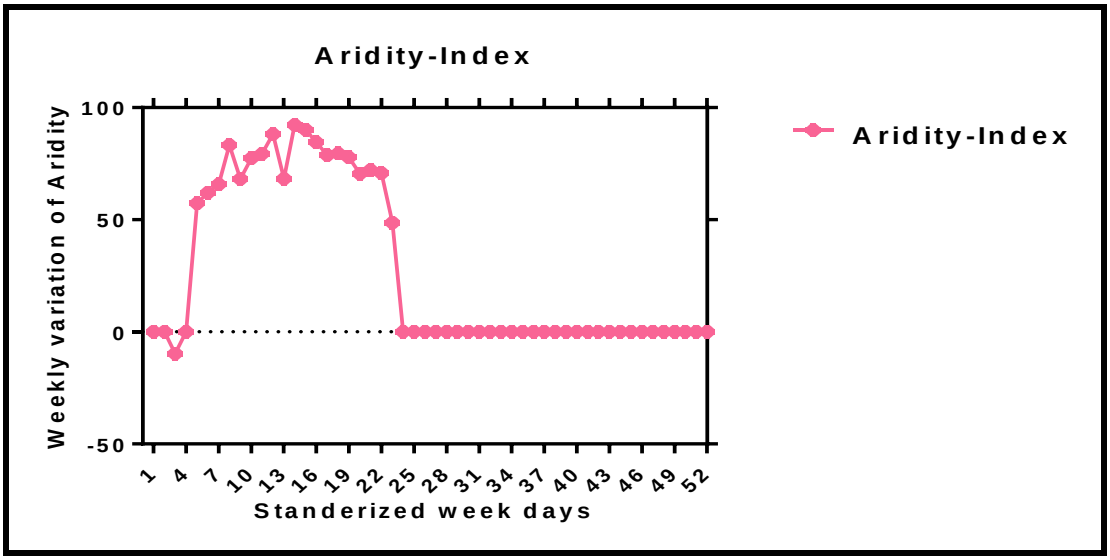

Figure 2: Weekly average aridity-index

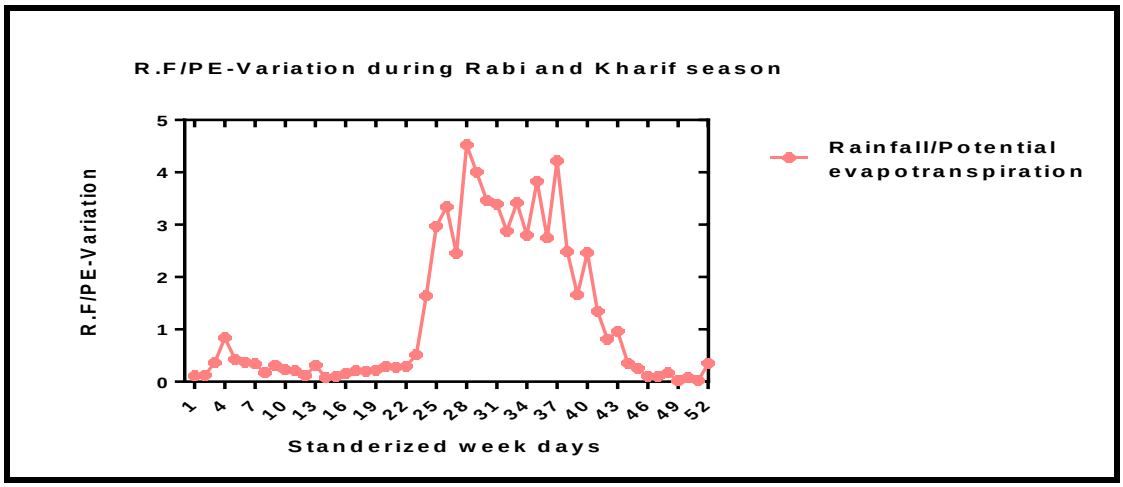

Figure 3: Rainfall/potential evapotranspiration variation during Rabi and kharif seasons

"5. Conclusion,'-The result of the study draws a conclusion that Ranchi undergoes for an annual water deficit from February to June and water surplus in the month of June to October. And less water requiring crop can be grown during Rabi season and more water requiring crop can be grown during the Kharif season. The climatic patter of this region is humid as well as this is, the moderate drought prone area. All this study can be very beneficial for the local population, who can decide their crop calendar and irrigation requirements based upon the period of water deficit or surplus. Water conservation measures can also be planned well in advance based upon the water deficit and surplus period. In spite of all this water balance data have also multiple uses like; consistency checks and quality control of the data; planning, design an and management of projects etc.

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"7. References,"-

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