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WATER BALANCE AND CLIMATIC CLASSIFICATION OF THE SWARNAMUKHI RIVER BASIN, INDIA

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ABSTRACT

The water balance elements worked out by using Thornthwaits and Mather(1955) show that hardly a few of the stations in the study area has water surplus even on a monthly basis. Contributions to the ground water reservoir from this region are thus normally absent. In certain years, however, when the precipitation during the rainy season is much greater than the normal, local water supplies occur for brief periods only, and these surpluses not only produce enormous surface flow resulting in the inundation but also significantly contribute to the ground water resources. Overall, 60-70 percent of the area in the district suffers from severe water deficit (which ultimately leads to drought) in the bordering taluks. Therefore, this mandal has been rightly identified as 'draught prone area' by the Irrigation Commission (1972).

***Key words**: Precipitation, Potential evapotranspiration, Hydrological Drought*

Introduction:

Water balance is the study of water input in the form of precipitation and water loss in the form of evaporation and evapotranspiration Thornthwaite Mather (1955) have developed a book keeping procedure to work out water balance of elements namely potential evapotranspiration, actual evapotranspiration, water deficit, water surplus, moisture adequacy and Aridity Index. Hemamalini (1979) has studied the eco-climatology of Andhra Pradesh. Subrahmanyam (1982) has published a monograph on water balance and its applications. In order for a land to support a crop, there should be adequate moisture content in the soil. Unless irrigated, the moisture content of soil is dependent upon the available water capacity of soil to hold moisture and a climatological factors such as, monthly mean air temperature (t), in ^{0}c precipitation (p), in mm., and daily sunshine hours. This type of study is particularly needed in a droughtprone area like Chandragiri mandal as most of the cultivated land is unirrigated and depends on rainfall only.

Locational and Spatial Aspects of the Mandal

Chandragiri Mandal in Chittoor District derives it's name from Chandragiri, its head quarters town. It is located 13°20' to 13° 50' N and 79° 5' to 79° 30' E. It is bordered by Rajampeta Revenue Division of Kadapa district in the north and Penumuru mandal of Chittoor district in the south and Tirupati rural and Vedurukuppam mandals of Chittoor district in the East and Pulicherla and Y.V. Palem mandals of Chittoor district in the west. It is situated in the northeastern part of the Chittoor district with a distance of 54 Km. from Chittoor town and 10 km. from Tirupati town. It is one of the smallest mandals of the district covering an area of 1,184.52 Sq.km. or 1,12,572 Hectares and a population of 83,987 (2011 provisional figures). It is included in the Survey of India Topographical sheets of $57\frac{o}{2}$ and $57\frac{o}{6}$ on a scale of 1:50,000.

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This mandal was originally included in the North Arcot district of Madras Presidency. When Chittoor district was newely formed on 1st April 1911, it was divided into 15 Taluks and 65 Firkas. Lateron in the year 1982 the whole Taluks and Firkas were changed and 'Mandals' were emerged in the place of Firkas, and Hamlets. So, 'Chandragiri Mandal' was newly formed by the inclusion or deletion of some of the villages from the neighbouring mandals. Now this mandal is divided into 23 Revenue villages and 29 hamlets.

Objectives

The main objectives of the present study are;

1) To study the mean of monthly, seasonal and annual rainfall and evaluate the surface water resources of the Swarnamukhi basin,

2) To describe the seasonal and annual water balance elements of the Swarnamukhi basin,

3) To examine the precipitation, potential evapotranspiration, water deficit, and water surplus zones through water balance method and see how much water is available for crop culture.

Methodology

The very important parameters of climatic water balance are the precipitation (P) and potential evapotranspiration (PET) for the combined water loss to atmosphere which needs comparison. Evapotranspiration raises difficult problems in water balance studies particularly in the assessment of drought, owing to uncertain knowledge regarding the rate of loss during the drying cycle of the soil. A number of methods for estimating evapotranspiration are available most of which give potential evapotranspiration, those which claim to give actual evapotranspiration are generally more complex and unreliable. These have recently been summarized by Haunam (1971) with particular reference to problems in water balance studies. So it is not surprising to state that a large number of models describing the water balance are available and these vary mainly in the way in which they handle the evapotranspiration and soil water storage terms. The Thornthwaite model of the water balance, which may be used on a daily or long-period basis, has been applied to the solution of numerous soil water problems, including the study of agricultural drought (Mather, 1961). As stated earlier, the model takes the difference between precipitation and evapotranspiration and carries forward a balance of water deficiency or surplus. A first requirement is the water holding capacity of the soil relative to soil type and land use. And these are tabulated by Mather for a wide range of conditions. Water surplus can be readily computed and is considered as drainage and runoff. Water content of the soil and, in the Thornthwaite model, the rate of evapotranspiration is computed from the precipitation with reference to the amount of available water remaining in the soil (Thornthwaite and Mather, 1955). When precipitation is less than the potential evapotranspiration, the actual evapotranspiration equals the precipitation plus an, soil water which is evaporated or transpired. (The latter is the soil water storage change).

Results and Discussion:

Results of long-term average monthly water balance calculation at Chandragiri station. (Moderately dry year)

Long-term average monthly precipitation, potential evapotranspiration, and actual evapotranspiration (in mm) are calculated for a sandy loam soil with an available water capacity of 200 mm., to estimate runoff, soil moisture utilization, surplus, recharge and deficit by the method of Thornthwaite and Mather (1957). The calculations are given in Mean monthly temperature and precipitation relate to Chandragiri station and mean daily sunshine hours for each month relative to Tirupati.

Subsurface Runoff

Because of moderate to good drainage of soils in the study area with fairly low available water capacity, a fairly high proportion of surface water percolates into the underground to form subsurface runoff. Due to the rugged nature of terrain with fairly steep slopes, precipitation received as tendency to move away very fast primarily as surface runoff and secondarily as groundwater runoff along the valleys, finally joins the Swarnamukhi and its tributaries. But due the presence of a number of tanks across the streams, there has been a greater scope for the surface water to artificially recharge ground water.

Ground water is little or scanty in Bairenkonda quartzites, which occur as flat-topped hills, steep to moderately steep escarpments, except along certain steeply carved valleys filled up with soil, and ground water to support luxuriant vegetation. Although Cumbum formations occurring as denudational hills carry little or no ground water, while the same formation occurring as pediments and pediplains form very good aquifers. Although ground water occurring under water-table condition is scanty, deep bore wells drilled upto 60 m., or more can give discharges, provided they pierce through water bearing fractures. Such water bearing fractures are hardly occur at every place.

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In areas where shales with water bearing fractures occur in the vicinity of shales having intercalations of dolomitic limestones with solution cavities and fractures, bores drilled in the former sites can be dry, while those drilled in the latter sites can give good discharges.

Alluvium occurring along the valley fills, flood plains, and palaeo-channels of Swarnamukhi river and its tributaries has very high potential for ground water development; Alluvium is composed of boulders, gravel, cobbles, sand, silt and clay in varying proportions. Alluvium carrying little or no silt and clay is the best aquifer. The depth of water table in alluvium in the river is almost at bed level, while its thickness ranges from about less than 1 m., to more than 11m. As the entire underground runoff under both unconfined and confined conditions has to ultimately join the rivers, which are available in the study area, there is enormous scope for development of ground water from these water courses.

TABLE – 1

ANNUAL TOTALS OF WATER BALANCE ELEMENTS

(Dry year)

Sl. No.	Station	Annual Water Supply (mm.)	Annual Water need (mm.)	Deficit/ Surplus (mm.)
1	Chinnagottigallu	378	1491	-1113
2	Pakala	568	1615	-1047
3	Chandragiri	456	1489	-1033
4	Chinnagottigallu	391	1615	-1224
5	Vedurukuppam	730	1745	-1015
6	Tirupathi	735	1738	-1003
7	Panapakam	518	1489	-971
8	**Chandragiri Mandal**	**377.6**	**1118.2**	**-740.6**

Source: Computed from the data collected

Water Balance Graphs during Dry Year or Hydrological Drought Year

The monthly water balance graphs during dry year for 7 Raingauge stations (Table 1) reveal that the plain region in the eastern part of the mandal experience water surplus during October, November and December in the form of runoff. On the hilly terrain all the stations except Chinnagottigallu station experience water deficit ranging from 50mm., to 250 mm., per month throughout the year except in November and December, where a little amount of surplus water goes in the form of soil moisture recharge. This is due to low rainfall and high potential evapotranspiration. This deficit is very high from April to September. In Chinnagottigallu station, water surplus occurs in August, which goes in the form of soil moisture recharge. The annual water balance elements during dry year (table - 1) shows that the water need is more in the study area(1118.2 mm.)(table -1) than the water supply (377.6 mm.), thereby showing a deficit of -740.6 mm.(table - 1)

As stated earlier, in Water Balance computations precipitation (p) is compared with Potential Evapotranspiration (PET). On a monthly basis, P-PET can be zero, positive or negative. When P-PET is positive, actual evapotranspiration (AET) is equal to Potential Evaportranspiration (PET) as evapotranspiration can proceed unhindered with no water shortage. Negative P-PET values of mean potential loss of moisture from the soil. The actual loss of moisture from the soil will be at potential rate or at a lesser rate as detailed above. Actual evapotranspiration in this case is equal to precipitation plus moisture actually lost from the soil.

The difference between Potential Evapotranspiration and Actual Evapotranspiration is water deficiency of the month. After the soil has attained the field capacity the difference between precipitation and actual evapotranspiration which equals to PET is the

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water surplus of the month. This surplus is the amount of water that is available for deep drainage as well as surplus only does actually runoff in the month. This has been taken as 50 per cent of the surplus, the value is generally considered to hold good for large water sheds. The rest of the surplus is detained in the water-shed and becomes runoff during the subsequent month.

Conclusion:

The water balance elements worked out by using Thornthwaits and Mather(1955) show that hardly a few of the stations in the study area has water surplus even on a monthly basis. Contributions to the ground water reservoir from this region are thus normally absent. In certain years, however, when the precipitation during the rainy season is much greater than the normal, local water supplies occur for brief periods only, and these surpluses not only produce enormous surface flow resulting in the inundation but also significantly contribute to the ground water resources.

Overall, 60-70 percent of the area in the district suffers from severe water deficit (which ultimately leads to drought) in the bordering taluks. Therefore, this mandal has been rightly identified as 'draught prone area' by the Irrigation Commission (1972).

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