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# HYDROMETEOROLOGICAL CHARACTERISTICS AND WATER BALANCE OF THE UPPER VAIGAI BASIN, SOUTH INDIA

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ABSTRACT : The study, employing the book keeping procedure of Thornthwaite and Mather, trys to bringout the hydrometeorological characteristics and water balance of the Upper Vaigai basin, South India. At first, the spatial distribution of mean annual rainfall and potential evapotranspiration are analysed. A budgeting estimates, water deficiency and surplus. Finally, the implications of water balance elements are discussed with the view of water resources development.

Water is the most sought resource for human use. It is basically an input in agriculture, which is the primary occupation in India, supporting more than three fourth of the population. It is important to analyse the quantities of water available and the uses to which it is put to, thus facilitating to assess whether at the present rate of exploitation, the surface and subsurface water will be available for future adequately. Water availability depends on the flow in the river which varies seasonally and annually. This temporal variability necessitates the storage by conserving water in years of excess flow so as to some extent mitigate the deficiency. This sort of storage becomes a pressing need especially in areas drained by non-perennial rivers. As such, a thorough understanding of water availability both, surface and subsurface has become quite essential (Hidore, 1970; Rao, 1975; Walton, 1970; De Ridder and Erez, 1977 and UNESCO, 1978). Studies on hydrometeorological characteristics and water balance are gaining increasing importance today and are reported from several parts of the world (Bowden, 1980; Subrahmanyam et al., 1970, 1980, 1982; Subramanian, 1980; Rao et al., 1976; Yoshino, 1971 and Yu, 1976). As in several parts of India, Tamil Nadu suffers from frequent failure of monsoons, water resources of Tamil Nadu have been studied by many (Kumaraswamy, 1974; Government of Tamil Nadu, 1974; CGWB, 1980; World Bank, 1977; and Ram Mohan, 1978). However there is no systematic basin-wise study on the hydrometeorological characteristics and water balance in the state of Tamil Nadu.

An attempt is made in this paper to study the hydrometeorological characteristics and water balance in the Upper Vaigai basin, Tamil Nadu. The basin located in a rainshadow region of the Western Ghats receives on an average 883 mm of rainfall per annum resulting in poor water storage position even in the years of normal rainfall. A portion of the Periyar waters have been divertėd and led into the Suruliar, a tributory of the Vaigai to feed the parched lands of Madurai district (Rao, 1975).

STUDY AREA : PHYSICAL SETTING

The Upper Vaigai basin covering an area of about 3975 $km^2$ lies between $9^{o}$ 31' N and $10^{o}$ 20' N latitudes and $77^{o}$ 10' to $77^{o}$ 51' 15" E longitudes in the Madurai district of Tamil Nadu (Fig. 1). The basin is enclosed by hills of the Western Ghats. The Lower Palanis form the northern and northwestern boundaries of the basin, while to the northeast the axis of the trough is continued by a col leading between the Palanis and the Karundamalai's to Dindigul (Spate et al, 1975). The eastern slopes of the Cardamon hills form the western boundary and the southeastern and eastern parts of the basin are bodered by the Varushanad–Andipatti hills running in a NE to SW direction.

The major tributaries of the Vaigai draining into this basin are Thalai Vaigai, Suruliar, Kottagudi, Varahanathi, Manjalar and Maruthanathi. The basin may be further divided into eleven minor basins such as the Thalai Vaigai, the Suruli, the Thevaram, the Kottagudi, the Vaigai Dam, the Varahanathi, the Manjalar, the Maruthanathi, the Viralipatti, the Viruveedu and the Andipatti.

The Upper Vaigai basin has been classified as having a semi-arid type of climate adopting Thorthwaite's scheme (Subrahmanyam, 1956). Computations made by the authors are also arrived at the same climatic type. The summer is hot with temperature rising to a maximum of 39.6$^{o}$C in April, which is the hottest month. The mean minimum temperature is 15.1$^{o}$C in January. The annual range of temperature is 11.7$^{o}$C.

PRECIPITATION

Precipitation in the Upper Vaigai basin is mainly during the southwest and northeast monsoons, which last from June to September and October to December respectively. The distribution and intensity of rainfall are largely influenced by the physiography. The Upper Vaigai basin lies on the left side of the Cardamom hills and so it receives less rainfall (annual mean 883 mm), although there are stations close to the hills receiving more than 2000 mm of rainfall. The high lands of the Lower Palanis and the extreme southeastern part of the Varushanad hills receive the maximum rainfall (1200 mm). The central part of the basin running southwest to northeast (Fig. 2) is a dry tract receiving less than 700 mm of rainfall per annum. Except the dry central stretch, the rest of the plain areas near the foot hills receive moderately high rainfall ranging from 700 to 800 mm per annum.

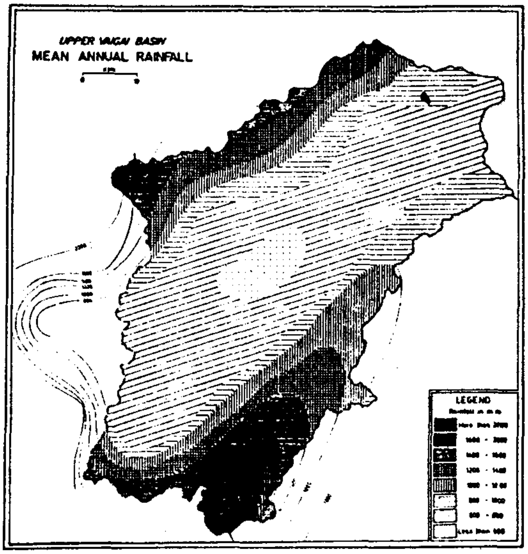
The northeast monsoon accounts for nearly 40 per cent of the total annual rainfall over the basin. In this season too, the hilly tracts such as the Lower Palanis and the Varushanad hills get the maximum rainfall whereas the central stretch of the basin proper receive less rainfall. Thus both the southwest and northeast monsoon seasons are characterised by high rainfall in the hills and poor rainfall in the basin proper. Summing up, climatically we could recognise a dry central tract surrounded by areas with increasing rainfall all around to a maximum along the high land regions of the basin.

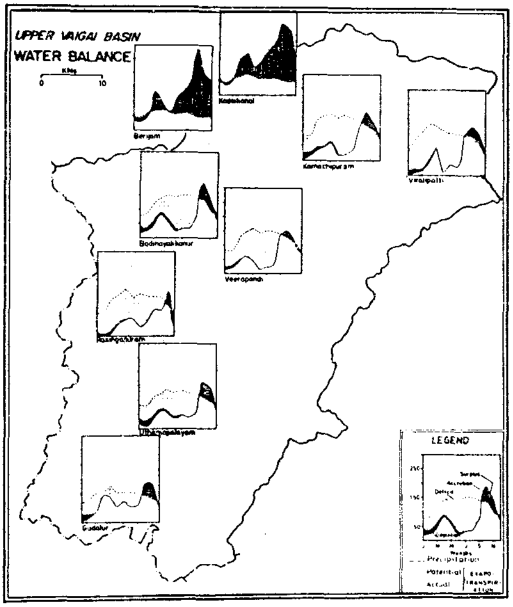
POTENTIAL EVAPOTRANSPIRATION

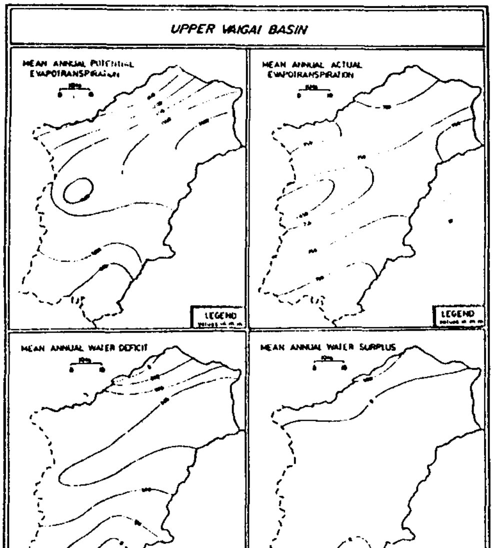
The potential evapotranspiration is estimated using the book keeping procedure of Thornthwaite and Mather (1948, 1955 and 1957). The spatial distribution of mean annual potential evapotranspiration in the basin is depicted in Fig. 3a and Table 1.

TABLE I : WATER BALANCE IN UPPER VAIGAI BASIN

| Months / Item | J | F | M | A | M | J | J | A | S | O | N | D | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kodaikanal | | | | | | | | | | | | | |
| P | 61 | 33 | 52 | 137 | 147 | 99 | 120 | 158 | 183 | 256 | 238 | 132 | 1616 |
| PE | 48 | 46 | 59 | 68 | 75 | 67 | 62 | 61 | 58 | 55 | 50 | 48 | 697 |
| AE | 48 | 46 | 59 | 68 | 75 | 67 | 62 | 61 | 58 | 55 | 50 | 48 | 697 |
| WD | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WS | 13 | 0 | 0 | 49 | 72 | 32 | 58 | 97 | 125 | 201 | 188 | 84 | 919 |
| Berijam | | | | | | | | | | | | | |
| P | 37 | 29 | 53 | 134 | 102 | 61 | 112 | 137 | 167 | 289 | 197 | 124 | 1442 |
| PE | 48 | 46 | 65 | 68 | 75 | 67 | 62 | 64 | 61 | 49 | 50 | 48 | 703 |
| AE | 48 | 45 | 64 | 68 | 75 | 67 | 62 | 64 | 61 | 49 | 50 | 48 | 701 |
| WD | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| WS | 0 | 0 | 0 | 28 | 27 | 0 | 44 | 73 | 106 | 240 | 147 | 76 | 741 |
| Kamatchipuram | | | | | | | | | | | | | |
| P | 5 | 16 | 37 | 44 | 66 | 21 | 19 | 34 | 122 | 168 | 141 | 66 | 739 |
| PE | 84 | 85 | 142 | 155 | 165 | 149 | 159 | 151 | 141 | 125 | 109 | 89 | 1551 |
| AE | 32 | 30 | 49 | 50 | 69 | 23 | 19 | 34 | 122 | 125 | 109 | 77 | 739 |
| WD | 52 | 55 | 93 | 105 | 96 | 126 | 137 | 117 | 19 | 0 | 0 | 12 | 812 |
| WS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Viralipatti | | | | | | | | | | | | | |
| P | 1 | 12 | 14 | 49 | 95 | 12 | 34 | 32 | 142 | 169 | 155 | 41 | 756 |
| PE | 80 | 123 | 152 | 174 | 173 | 161 | 152 | 147 | 142 | 145 | 123 | 72 | 1644 |
| AE | 20 | 26 | 22 | 52 | 96 | 12 | 34 | 32 | 142 | 145 | 123 | 52 | 756 |
| WD | 60 | 97 | 130 | 122 | 77 | 149 | 118 | 115 | 0 | 0 | 0 | 20 | 888 |
| WS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bodinayakkanur | | | | | | | | | | | | | |
| P | 22 | 23 | 46 | 83 | 62 | 25 | 33 | 34 | 76 | 192 | 151 | 48 | 759 |
| PE | 78 | 85 | 127 | 139 | 152 | 143 | 149 | 148 | 141 | 132 | 97 | 92 | 1483 |
| AE | 45 | 42 | 63 | 91 | 72 | 32 | 37 | 36 | 77 | 132 | 97 | 71 | 795 |
| WD | 33 | 43 | 64 | 48 | 80 | 111 | 112 | 112 | 64 | 0 | 0 | 21 | 688 |
| WS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Veerapandi | | | | | | | | | | | | | |
| P | 16 | 19 | 40 | 59 | 44 | 16 | 21 | 23 | 142 | 148 | 95 | 69 | 692 |
| PE | 84 | 82 | 117 | 148 | 159 | 146 | 152 | 148 | 138 | 129 | 103 | 89 | 1495 |
| AE | 22 | 23 | 44 | 61 | 46 | 17 | 22 | 23 | 138 | 129 | 96 | 71 | 692 |
| WD | 62 | 59 | 73 | 87 | 113 | 129 | 130 | 125 | 0 | 0 | 7 | 18 | 803 |
| WS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rasingapuram | | | | | | | | | | | | | |
| P | 5 | 2 | 9 | 38 | 54 | 66 | 35 | 46 | 95 | 90 | 160 | 17 | 617 |
| PE | 78 | 85 | 130 | 145 | 165 | 137 | 149 | 144 | 141 | 138 | 106 | 89 | 1507 |
| AE | 17 | 11 | 17 | 41 | 57 | 67 | 36 | 46 | 95 | 90 | 106 | 34 | 617 |
| WD | 61 | 74 | 113 | 104 | 108 | 70 | 113 | 98 | 46 | 48 | 0 | 55 | 890 |
| WS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Uthamapalayam | | | | | | | | | | | | | |
| P | 21 | 12 | 25 | 64 | 57 | 34 | 49 | 38 | 52 | 159 | 146 | 53 | 710 |
| PE | 87 | 82 | 108 | 121 | 136 | 127 | 136 | 125 | 119 | 116 | 97 | 95 | 1349 |
| AE | 34 | 28 | 39 | 70 | 63 | 39 | 52 | 39 | 53 | 116 | 97 | 80 | 710 |
| WS | 53 | 54 | 69 | 51 | 73 | 88 | 84 | 86 | 66 | 0 | 0 | 15 | 639 |
| Gudalur | | | | | | | | | | | | | |
| P | 8 | 16 | 32 | 79 | 79 | 54 | 77 | 55 | 59 | 133 | 129 | 42 | 763 |
| PE | 72 | 79 | 99 | 105 | 123 | 102 | 107 | 103 | 101 | 95 | 85 | 74 | 1145 |
| AE | 30 | 31 | 44 | 83 | 84 | 58 | 79 | 58 | 61 | 95 | 85 | 55 | 763 |
| WD | 42 | 48 | 55 | 22 | 39 | 44 | 28 | 45 | 40 | 0 | 0 | 19 | 382 |
| WS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |




Ironically enougn it is only this central dry tract covering 32 per cent of the total area of the basin, that is fit for human settlement and the varied activities of man while the foot hills and hills shun settlement due to the hostile physical characteristics such as steep slopes, rugged relief and thick forest cover. It is, therefore, this central tract which has the maximum water need in this region. The computed potential evapotranspiration is more than 1600 mm in this central stretch while in the hilly areas of the Lower Palanis and the Varushanad hills the potential evapotranspiration or water need is 800 mm and 1200 mm respectively. In general, the potential evapotranspiration gradually decreases towards the northwestern and southeastern sections of the Upper Vaigai basin. Potential evapotranspiration is the amount of water evaporated and transpired when the water is unlimited. When water is unlimited evaporation and transpiration takes place to the maximum possible extent and the water left out as balance is in excess of the water needed and is the surplus. But in the case of Upper Vaigai basin proper rainfall is limited to about 700 mm per annum and all of it gets evaporated and transpired, thus leading to no surplus at all. According to the calculations, the mean potential evapotranspiration of the basin is 1286 mm. This clearly indicates that the basin faces a very serious problem of water deficiency.

## WATER BALANCE

Based on the precipitation and potential evapotranspiration the water balance has been calculated for nine stations such as Kodaikanal, Berijam, Kamatchipuram, Viralipatti, Bodinayakkanur, Veerapandi, Rasingapuram, Uthamapalayam and Gudalur (Fig. 3). The moisture holding capacity of the soils are taken depending upon the soil and vegetation types of the stations (soil survey and Land Use Organisation, 1980; 1981). The derived elements of the water balance namely the actual evapotranspiration and water deficiency or surplus are obtained for these stations.

The mean annual actual evapotranspiration is presented in Fig. 3b and Table 1. The central stretch of the basin proper have recorded very low actual evapotranspiration, which is equal to the actual rainfall (less than 700 mm). As one moves from the basin towards the foot hills and the highlands the gap between actual evapotranspiration and potential evapotranspiration decreases due to the rainfall increases as a consequence of which there is a surplus.

Water surplus is considered as the water potential of a region. It is generally held in the underground formation. It is partly responsible for the perennial flow of water in a river system and it is to be tapped when required. Thus a detailed knowledge of water surplus and deficit has become a prerequisite for the design and operation of hydrological systems. It is seen that the Lower Palanis and the Varushanad hills are virtually important in providing the Upper Vaigai basin with enormous amount of water surplus mainly on account of heavy rainfall in this region coupled with low water need (Fig. 3c) excepting these regions of surplus the rest of the basin records a water deficiency.

The water deficiency is quite acute in the central stretch of the basin proper (Fig. 3d). It exceeds 850 mm in this region and ranges between 700 and 800 mm in the surrounding plain areas. The water deficiency is very low in the south and southeastern part of the basin. In the lower Palanis water deficiency is negligible. The elements of water balance of a station when plotted graphically against the months of the year give a comprehensive picture not only of water surplus and deficiency but also of soil moisture accretion and depletion through the year. Figure 4 shows the located water balance graphs of different stations of the basin. Climatically Kodaikanal and Berijam have surplus of 919 and 744 mm accumulated from April to December. The soil moisture is adequate to meet the water need fully in February and March when rainfall is below the potential evapotranspiration. All other stations have no surplus water during the months from January to August or September. The soil moisture is replenished during October and November to be utilised in other months; but this replenishment is not sufficient to avoid water deficiency or shortage.

Summing up one could say that the Upper Vaigai basin proper is an area of least rainfall and maximum water need but the rainfall increases with distance from the basin towards the foot hills and the rim of highlands, where water need decreases rapidly. It, therefore, seems practical to conserve water of these highlands and the foot hill zones in order to make it available to the thirsty lands of the basin.

## CONCLUSION

The spatial distribution of mean annual rainfall, potential evapotranspiration, actual evapotranspiration, water deficit, and water surplus in the Upper Vaigai Basin are analysed. The Lower Palanis and the Varushanad hills have very high amounts of rainfall whereas in the central stretch of the basin proper it is very low. The potential evapotranspiration is in turn inversely distributed. The actual evapotranspiration is more in the northeastern part of the basin and in most of the plain areas. The region of water surplus is restricted to the hilly tracts of the Lower Palanis and the Varushanad hills and water deficiency is quite high in rest of the region demanding serious attention for a careful agricultural planning.

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