Trans. Inst. Indian Geographers
Vol. 5, No. 1, January 1983

SOME ASPECTS OF HYDROCLIMATOLOGY AND WATER BALANCE OF THE CHANDRAMPALEM BASIN

V. P. SUBRAHMANYAM, Waltair

ABSTRACT : The study is an attempt at understanding the hydroclimatological features and water balance characteristics of a small watershed located in the midst of a hilly tract in the vast semiarid region in South India. Investigations carried out over a period of about four years (1969–1972) revealed the strong combined influence of orography and wind circulation on the spatial distribution of rainfall over the basin in different seasons. Water balance computations involving measurements of evapotranspiration and soil moisture have led to the conclusion that the stream flow as well as ground water fluctuations are explainable through rainfall–infiltration considerations rather than in terms of water balance modelling.

Chandrampalem basin (about 25 sq. miles in area) is a natural ground water basin (Fig.1) enclosed on all sides by the Kambalakonda hills of the Eastern Ghats range in the State of Andhra Pradesh in south India. The hills though of varying elevation are continuous around the basin excepting for an opening on the northern side through which an ephemeral stream issues out. The hills and the slopes are sparesely vegetated with scattered stunted trees and hardy semi-arid scrub.

The general sequence of soil formations in the basin is loamy soil on the top followed by tallus formation resting on a highly weathered and kaolinized zone down below. This merges into a fissured formation which in turn gradually tends into the hardy-rock region. Ground water occurs typically in veins and fractures both in the tallus formation and in the fissured zone. The intervening weathered zone, being a semi-permeable layer, holds water in pockets here and there

Lying as it does on the eastern littoral zone of peninsular India, the Chandrampalem basin is under the influence of the Bay of Bengal branch of the south-west monsoon circulation. Consequently, the main rain season here is from June to September (Fig.4-a) which provides an average amount of about 51.4 cm. of rainfall. On monthly basis, however, October is the rainiest month registering 19.9 cm. of rainfall on account of cyclonic activity in the Bay of Bengal during the post-monsoon season. From then onwards there occurs a steep fall in rainfall with a slight rise again in the month of February due to the secondary effect of the so-called " Western ' Disturbances " movfrom west to east across north India. The slight rise in rainfall from April until June is the result of local thunderstorm activity in the premonsoon season.

The standard form of the water balance equation employed for purposes of the present study is

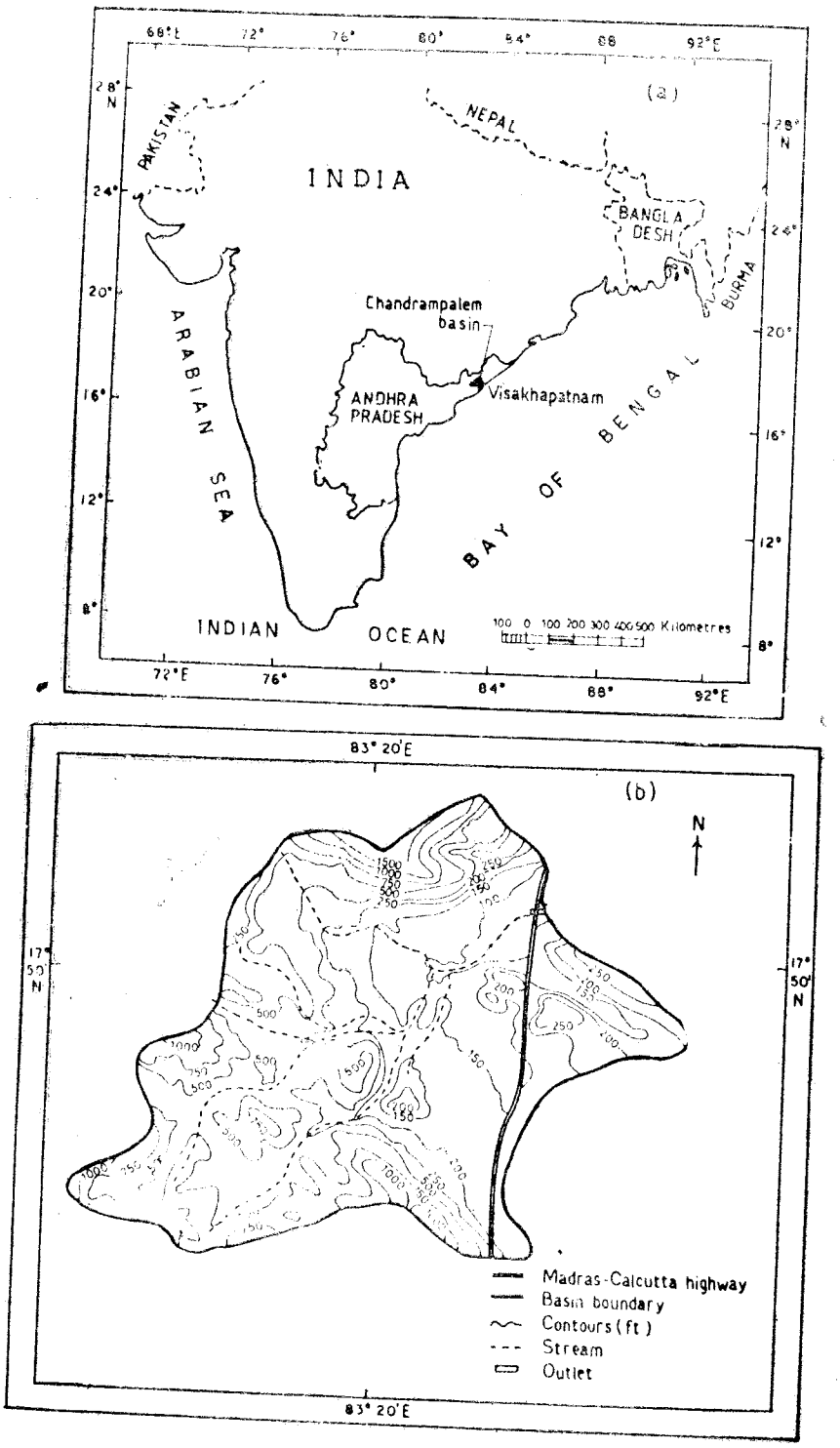

Figure 1. (a) Index map showing location of Chandrampalem basin;(b) Chandrampalem basin.

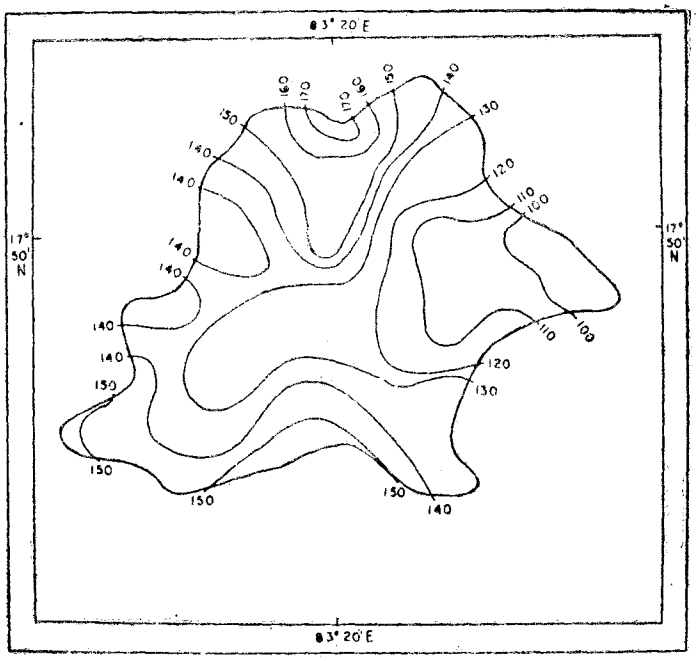

Figure 2. Chandrampalem basin : Rainfall during August 1971, mm.

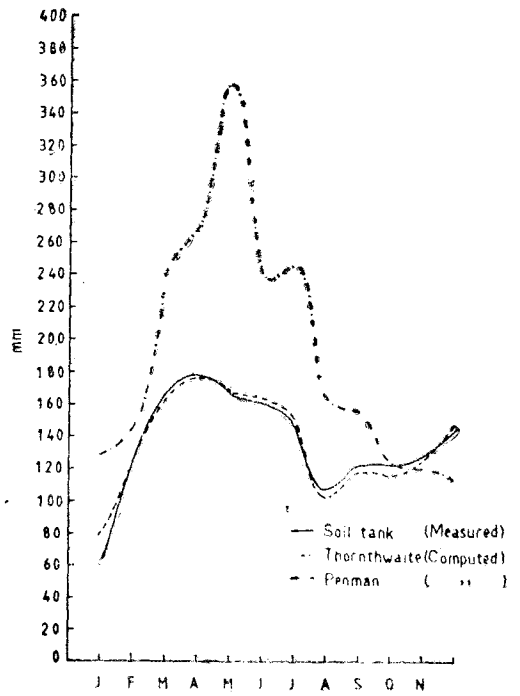

Figure 3. Chandrampalem basin : Monthly march of evapotranspiration, 1971

$$P = E + R + \Delta S$$

where P = Rainfall
E = Evapotranspiration
R = Runoff and
ΔS = Chage in soil moisture storage

For measuring the amount of rainfall over the basin, six ordinary rain-gauges of the Symon type and two self recording raingauges of the Casella (Natural Syphon) pattern installed at representative spots were employed. For obtaining a general idea about evoporation losses from the basin, a small soil evaporimeter of the Thornthwaite-Mather pattern (Mather 1954) was used. Though the entire outflow from the basin has been known to occr through the ingle ephemeral stream on the nosr thern end of the basin, no measurement of the actual stream – flow could be made on account of the non-amenability of the stream for flow measurement. Moisture content of the soil from representative locations in the basin was measured every week by the drying-and-weighing method. Fluctuations in groundwater level were

measured by regular free water-table observations in 120 selected unpumped open water wells.

From the water balance angle the physiographic characteristics of the basin are perhaps of some relevance here. The hills are the lowest on the eastern siderising to the west both through north and south. Thus though the convective activity during the pre-monsoon months is essenti-ally confined to the basin proper, the rainfalt distribution itself within the basin is not uniform, depending upon the prevailing windcirculation either the northern or the southern flanks receive heavy rainfall (Fig. 2) though ultimately the entire basin ts benefitted by the rainfall to some exten or the other.

March of soil evaporation through the year (Fig . 3) shows lower values in winter on account of low temperatures (in spite of lower humidities). Higher air temperatures and low relative humidities are responsible for high rates of evaporation in the summer months. It is of interest to note that the $oil evaporation figures have close agreement with the potential evapotranspiration values computed from Thornthwaite's formula (Thornthwaite 1948) rather than from the Penman (1956) equation.

Table I-a Climatic Water Balance of Chandrampalem basin

Item	J	F	M	A	M	J	J	A	S	O	N	D	Year
PE	74	94	144	161	184	179	174	169	155	147	109	76	1666
P	11	24	12	18	51	105	112	131	166	199	119	14	962
△S	-12	-11	-15	-10	-6	-2	-1	-1	+11	+52	+10	-15	
S	52	41	26	16	10	8	7	6	17	69	79	64	
AE	23	35	27	28	57	107	113	132	155	147	109	29	962
WD	51	59	117	133	127	72	61	37	0	0	0	47	704
WS	0	0	0	0	0	0	0	0	0	0	0	0	0

Table I-b Water Balance of Chandrmpalem basin for 1971

Item	J	F	M	A	M	J	J	A	S	O	N	D	Year
PE	80	128	165	177	167	164	150	104	118	117	126	148	1644
P	8	34	11	238	169	76	142	130	103	209	0	0	1120
△S	-18	-14	-10	+61	+2	-31	-2	+26	-6	+92	-85	-40	
S	30	16	6	67	69	38	36	62	56	148	63	23	
AE	26	48	21	177	167	107	144	104	109	117	85	40	1145
WD	54	80	144	0	0	57	6	0	9	0	41	108	499
WS	0	0	0	0	0	0	0	0	0	0	0	0	0

Where PE = Potential Evapotranspiration
P = Precipitation
△ S = Soil moisture tsornge change
S = Soil moisture storage
AE = Actual Evapotranspiration
WD = Water Deficiency
WS = Water Surplus, all values being in mm.
Field capacity value 150 mm.

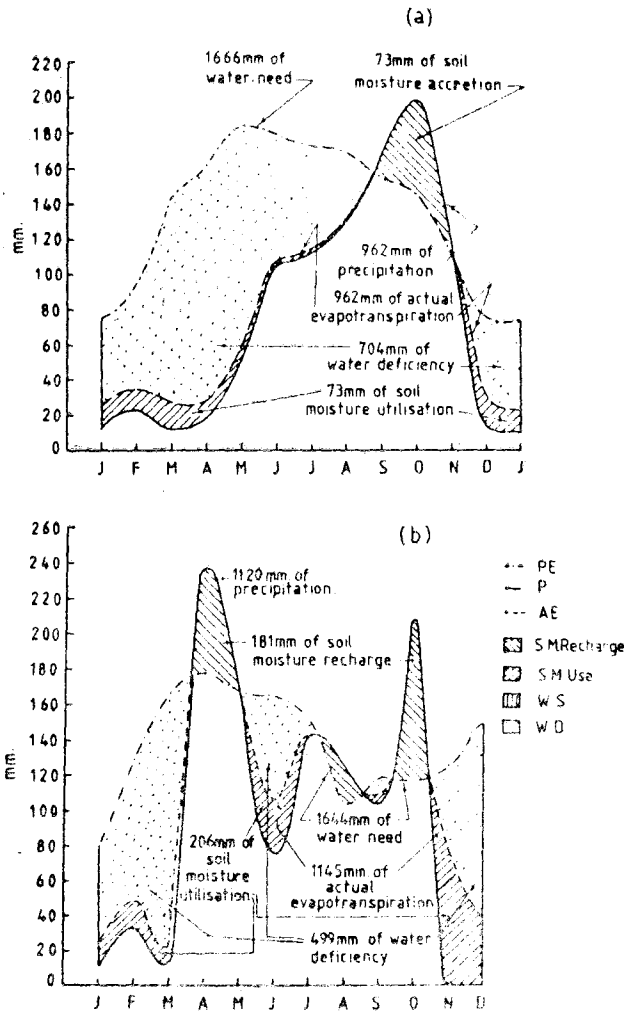

Figure 4. Water balance of Chandrampalem basin
(a) Climatic; (b) 1971

It is generally known that on small hydrological basins, especially of the hilly catchment type, the water balance considerations as embodied in the hydrylogical equation will not be strictly applicable. One of the main aims of the present study was to examine if the conventional water balance concepts could be adopted to the Chandrampalem basin and the fluctuations in soil moisture and ground water table could be satisfactorily explained according to the water balance procedure.

Tables I-a and I-b give the water balance computations for the basin for the average (climatic) year and for the year 1971 and in Figs - 4 - a and 4 – b are shown the graphical representations of the respective water balances. Even climatically, Chandrampalem basin receives 962 mm. of annual rainfall which is slightly more than half the total annual water-need of 1666 mm. The slight excess of 73 mm. of rainfall in the months o‹

September, October and November over the potential evapotranspiration goes into soil storage and is used up so fast later for evapotranspirational purposes that an overall water deficiency of 704 mm. accumulates for the year as a whole.

The year 1971 (Fig.4-b) was not different from the climatic picture (Fig. 4-a) not only because the overall yearly rain fall (1120 mm.) was lower than the water need (1644 mm) but also since there was no water surplus even during the peak period of the rainy season. The water deficits are seen to be regular feature and even in those months when the rainfall was higher than the water need (as in April, May, August and October) the excess water was hardly sufficient to raise the soil moisture content to its field capacity value. Consequently, there was no question of water surplus or runoff either through surface means or through subsurface or underground routes. Thus it should be expected that the monthly computation of water balance elements either on a climatic basis or for individual years (like 1971) yields no contribution to stream flow or ground water replenishment.

Computations on a weekly or even on a daily basis would be of no use in this respect as far as the water balance model is concerned since the priorities taken account of in the procedure will not hold good on such small basins and especially for such short periods of time. The water balance approach requires that the first and the foremost demand on rainfall is for evapotranspiration after satisfying which alone the remaining rainwater goes to replenish the soil reservior. It is only after the soil is raised to its field capacity value that the excess rain water constitutes water surplus which is disposed off as surface, subsurface or underground runof, thus contributing to streamflow or ground water storage.

While these priorities and processes may well be realized in the case of large basins and over prolonged periods of time, their validity appears to be in doubt in the present case. But the solitary stream itself is an ephemeral rain drain which swells up and shrinks down in a matter of hours according to the nature and magnitude of rainfall from local storms.

Regarding the fluctuations in the ground water table in the Chandrampalem basin, while the actual monthly rainfall amounts

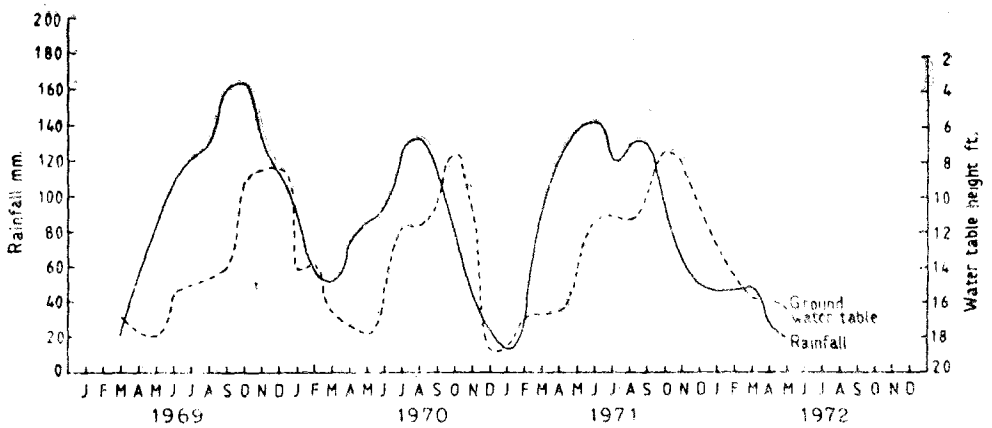

Figure 5. Chandrampalem basin : Rainfall variations and ground water fluctuations, 1969–1972 (based upon 4-month moving averages of rainfall).

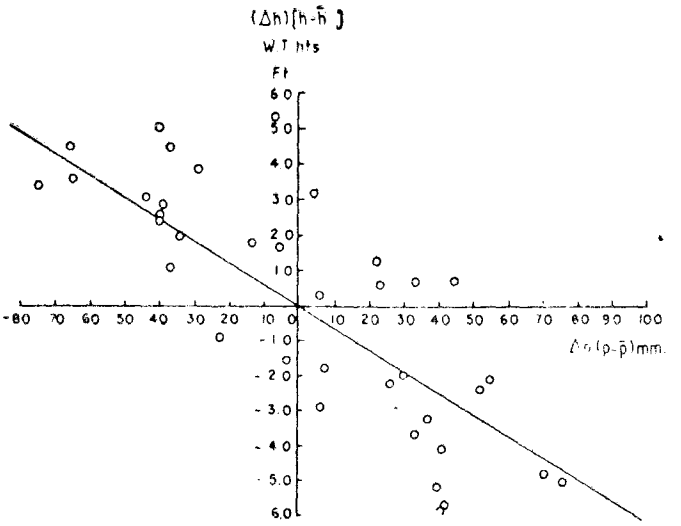

Figure 6. Chandrampalem basin : Relation between rainfall variations and water table fluctuations (based upon 4 month moving averages of rainfall)

(1969–1972) showed no relation to the water table variations, a four - month moving average as shown in Fig. 5 yielded an excellent correlation, the peak and troughs in the curve of water table fluctuations occuring about two months after the occurrence of maxima and minima in the rainfall curve. This is thus a clear indtication that there is definite contribution to ground water reservoir from rainfall, not on an individual monthly basis but through accumulated storage over a four - mouth period; other combinations for obtaining moving averages gave poor responses.

The fluctuations in water-table from the normal level in open water wells and rainfall fluctuations as computed from the four-month moving averages were plotted in order to obtain a liner regression line (Fig. 6) in spite of some usual scatter.

And this had revealed that about 17mm. of rainfall fluctuation from the average produces one foot of corresponding variation in the water table depth.

Such a situation in basin hydrology can be explained only through infiltration percolation processes rather than through the conventional water budget criteria. Particularly on account of the geomorphological nature of the basin, the soil which has originated from the weathered Khondalitic formations has secondary permeability excepting in the surficial layers with the result that attainment of saturation is not essential for deep percolation to occur. This is evident from Fig. 7 which shows the vague relation between rainfall and soil moisture but no saturation of the soil at any time for stream discharges to issue according to water balance concepts. The water table depth fluctuations (Fig. 5) again may be taken as an evidence of the peculiar hydrologic process operating over the basin; the ground water table on an average reaches its minimal level during the hot summer months of May and June, just before the onset of the monsoon and attains the highest. level during November and December, two to three months after the peak of the rainy season.

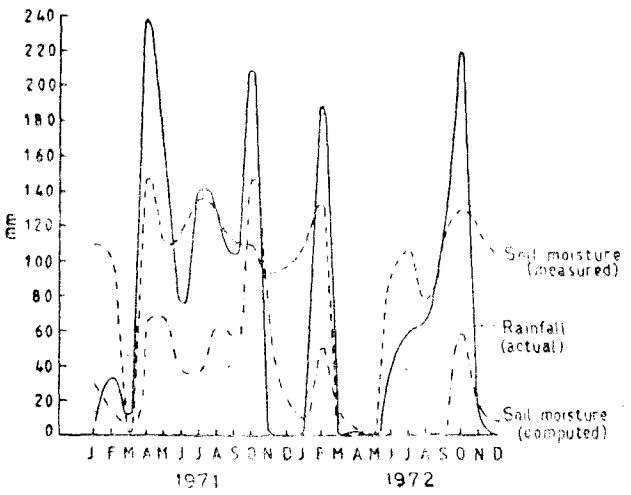

Figure 7. Chandrampalem basin : Rainfall and soil moisture.

Refernces

Mather, J. R. (Ed.) (1954) : The Mesurement of Potential Evapotranspiration. *Publn in clim.*, Vol. 7, No. 1.

Penman, H. L (1956) : Estimating Evaporation, *Trans. Amer. Geophys. Union*, Vol. 37, No. 1, pp. 43-46.

Thornthwaite, C. W. (1948) : An Approach toward a rational Classification of Climate, *Geogr. Rev.*, Vol. 38, No. 1, pp. 55–94.

Address of the author

Prof. V. P. Subrahmanyam, Department of Meteorology and Oceanography Andhra University, Waltair 530 003 (A. P.) South India.