WATER BALANCE IN DROUGHT YEARS AT MASULIPATAM

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The present paper is concerned with the analytical study of droughts and water balances at Masulipatam, a semiarid coastal station in Andhra Pradesh in years of extreme climatic shifts. The book-keeping procedure for water balance originally developed by Thornthwaite and Mather (1955) is employed for the purpose.

Proneness of Masulipatam to droughts is initially investigated by plotting the yearly indices of aridity against the years of record (1901–1964) and categorizing the drought years as suggested by Subrahmanyam and Sastri (1969). Decennial frequency of drought years is then calculated and graphically plotted to understand the characteristics of drought occurrence at the station.

For studying the yearly variations in the moisture regime of the above station, moisture indices are computed every year and plotted against the respective years. In the years of extreme climatic shifts as indicated by the graph water balances are studied. For purpose of comparative study the monthly marches of water balance of Masulipatam both in the normal year, the arid year as well as an extremely humid year are presented and discussed.

INTRODUCTION

The present paper is concerned with the analytical study of droughts and water balances at Masulipatam, a semiarid coastal station in Andhra Pradesh, in years of extreme climatic shifts. Proneness of Masulipatam to droughts is initially investigated by plotting the yearly indices of aridity against the years of record (1901–1964) and categorising the drought years as suggested by Subrahmanyam and Sastri (1969) (Fig. 1).

CLASSIFICATION OF DROUGHTS

During the 64 years under study, Masulipatam experienced a total of thirty-one drought years, one being disastrous, six severe, thirteen large and eleven moderate. In Fig. 2 is presented the decennial frequency of drought years at the station. It is observed that the decade 1901–1910 was the severest with one disastrous, three severe, two large, and one moderate drought years while 1931–1940 was the least droughty decade with only one moderate and two large drought years.

But conditions responsible for aridity are produced by pronounced fluctuations in the moisture regime of climate. To study this aspect in greater detail, yearly moisture indices of Masulipatam were plotted as shown in Fig. 3. Though during this period there were occasional migrations of its regime into the extreme types, the climate of Masulipatam appears to be rather conservative being most of the time close to normal climatic regime. A knowledge of water balances in such extreme

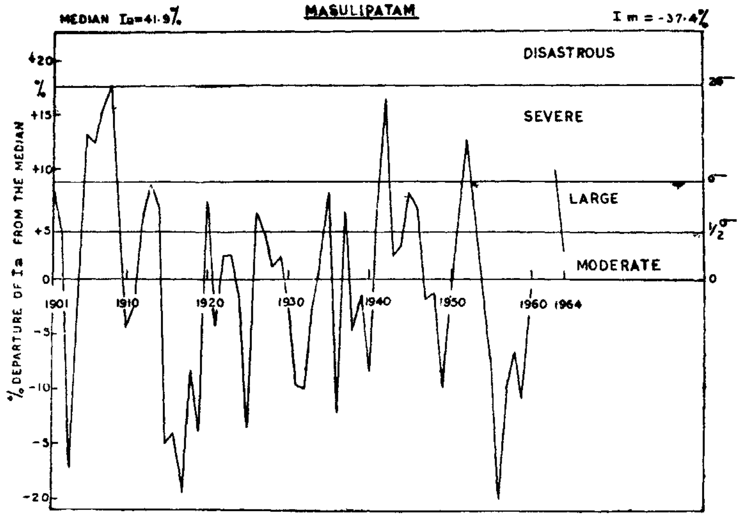

FIG. 1 Yearly March of Aridity Index

MASULIPATAM

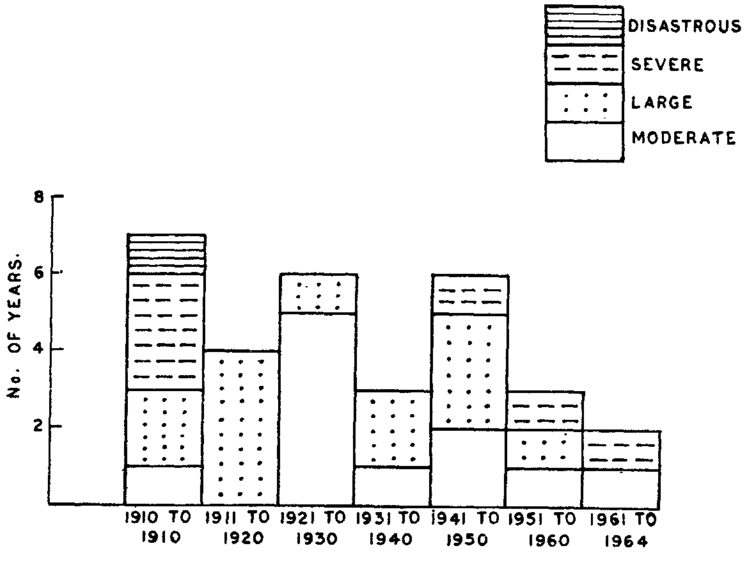

FIG. 2. Decennial Frequency of Drought-Years

years of climatic shifts is of immense value in "Drought Climatology". In all during the study period, there were 39 such shifts on to the more dry-side and 23 shifts in the more humid direction. Table I shows such shifts into different climatic types.

Contributions to the ground water reservoir from the semiarid zone are normally absent. In certain years, however, due to active monsoon the precipitation may be much greater than the normal; local water surpluses then occur for brief periods

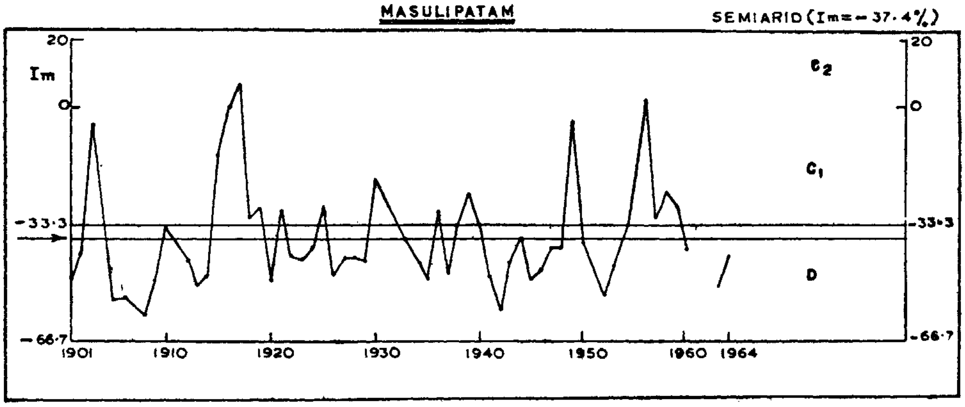

FIG. 3. Climatic Shifts

TABLE I

Shift into Climatic Type		Number of Occasions
Moist subhumid	(C_2)	3
Dry subhumid	(C_1)	16
Semiarid	(D)	43

which not only produce enormous surface flow resulting in flood but also significantly contribute to the ground water resources. Fig. 4*b* illustrates such a situation for Masulipatam for the year 1917. Climatically Masulipatam (Fig. 4*a*) like many

Water Balances of Masulipatam

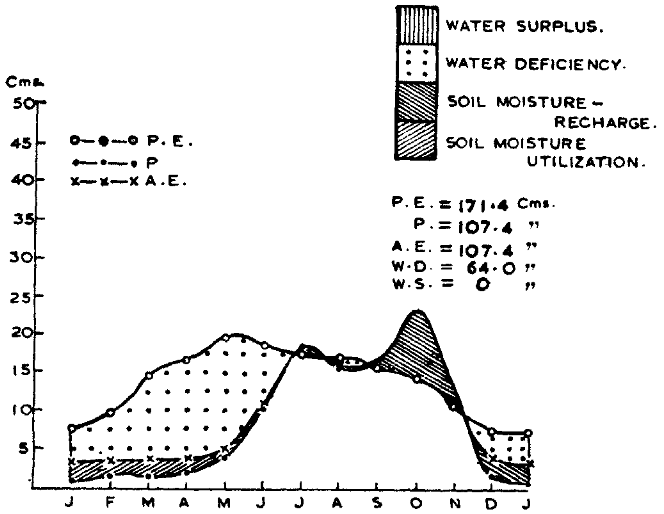

FIG. 4*a*. Climatic

stations in the semiarid region, does not possess any watersurplus. Normal annual rainfall here is 107.4 cm while the waterneed is 171.4 cms (*vide* Table II) and therefore deficiency is 64.0 cm for the year. The excess of 69.2 cm, of precipitation over the normal in the year 1917 resulted in a watersurplus of 49.7 cm. (Fig. 4*b*). In the diagrams Fig. 4*a*, 4*b*, and 4*c* the notation used is P.E. = Potential Evapotranspiration; P = Rainfall; A.E. = Actual Evapotranspiration; W.D. = Water deficit and W.S. = Water surplus.

TABLE II

The moisture parameters of Masulipatam in the years of extreme climatic shifts as compared with the normal year

Category of the year	Water need	Rainfall	Water deficit	$I_m\%$	$I_h\%$	$I_a\%$	Moisture regime
Normal year	171 4 cms	107.4 cms	64.0 cms	—37.4	0	—37.4	Dd
Severe drought year (1907)	174.8 cms	62.2 cms	100.2 cms	—57.3	0	—57.3	Dd
Extremely dry year (1908)	169.2 cms	69.6 cms	101.0 cms	—59.7	0	—59.7	Dd
Humid year (1917)	164.2 cms	176.6 cms	37.4 cms	7.4	30.2	22.8	C_2W_2

Water balance of Masulipatam for the extremely dry year of 1908 is presented in Fig. 4*c*. The moisture index for this year was —59.7 per cent mainly on acount of very low amount of precipitation (69.6 cm) in spite of the water-need being somewhat lower too (169.2 cm.) The water balance diagram is strongly similar to that of a normally arid station. The data more than amply prove that drought intensities cannot be assessed purely on the basis of rainfall records but

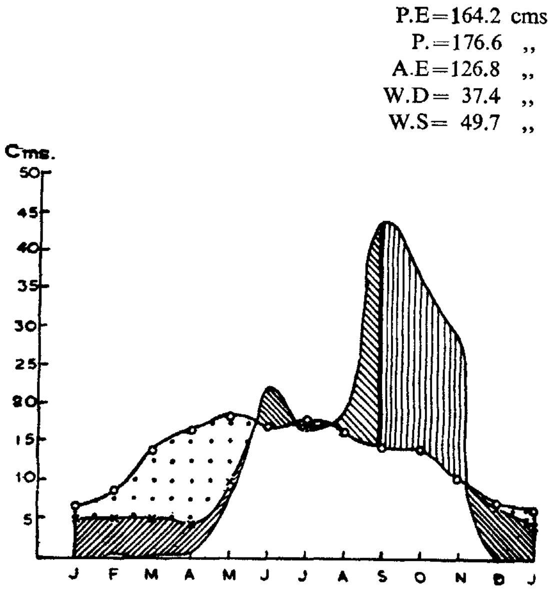

FIG. 4*b*. Humid Year (1917)

P.E=169.2 cms.
P= 69.6 „
A.E= 68.2 „
W.D=101.0 „
W.S=0

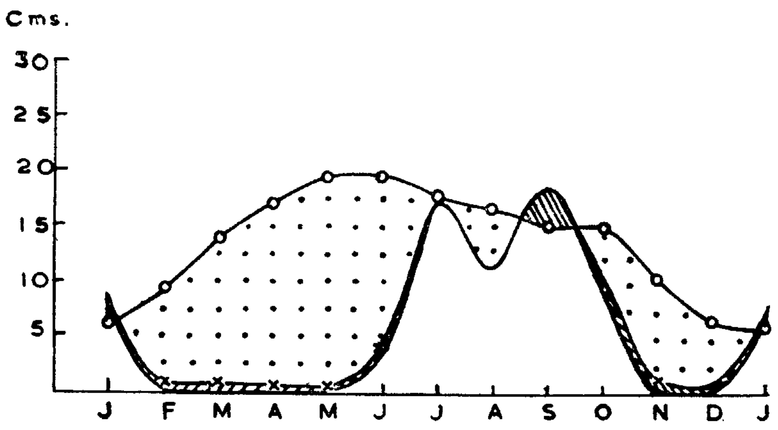

FIG. 4c. Extremely Dry Year (1908)

water balance approach alone is the most rational and realistic. For example, on the basis of rainfall data 1907 must be considered to be the severest drought year while the largest water deficit occurred in 1908 which not only received more rainfall than in 1907 but its water need too was somewhat lower. In fact, the year of minimum rainfall namely 1907 (62.2 cm) had also the lower water deficit (100.2 cm) while the year 1908 with minimum waterneed (169.2 cm) and higher rainfall (69.6 cm) registered the highest water deficit of 101.0 cms. It is thus clear that the rainfall basis of drought analysis will not only yield incorrect information but very often leads also to wrong assessment of drought intensities.

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REFERENCES

Subrahmanyam, V.P., and Sastri, C.V.S.(1969). A study of aridity and droughts at Visakhapatnam. *Ann. arid Zone*, **8**, No. 1, pp. 18–22.

Thornthwaite, C.W., and Mather, J.R.(1955). The water balance. *Clim. Drexel. Inst. Tech.*, **8**, No. 1, pp. 1–104.