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A TREND SURFACE ANALYSIS OF RAINFALL DISTRIBUTION : A CASE OF UPPER VAIGAI BASIN, TAMIL NADU

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ABSTRACT : An attempt is made in the present paper to study the rainfall distribution in Upper Vaigai basin of Tamil Nadu using Trend Surface analysis. The data points employed in the construction of the trend surface model are the location of rainfall stations. Trend Surface analysis defines the general pattern of mean annual rainfall distribution. Linear trend surface and associated residuals are defined for the distribution of rainfall in the Upper Vagai basin. Covering an area of 3945 km^2 in the Madurai and Anna Districts of Tamil Nadu, the Upper Vaigai basin has been facing a critical situation in respect of water use in the last few years. The basin is located in a rain-shadow region between the Lower Palanis, the Cardamom hills and the Varushanad - Andipatti hills of the Western Ghats. The mean annual rainfall of the basin is 883mm. However, the great dependence of agriculture on irrigation is mainly due to the uneven distribution of rainfall with respect to time. In the present paper, an attempt is made to study the rainfall distribution in Upper Vaigai basin using trend surface analysis. Rainfall data for twenty four rain gauging stations in and around the Upper Vaigai basin have been collected for 35 to 82 years according to the availability of data.

SPATIAL DISTRIBUTION OF MEAN ANNUAL RAINFALL

The Upper Vaigai basin is characterised by sharp areal differences in the quantum of rainfall (Fig. 1). It is bordered by highlands all around except in the northeast. The central stretch of the basin has a south 0west to northeast alignment and the distribution of rainfall very closely follows this alignment. The southwest and northeast monsoons are the two main seasons of rainfall; however, the northeast monsoon accounts for larger share in the total annual rainfall.

The Lower Palanis in the north and northwest and the Varushanad hills in the southeastern corner of the basin receive maximum rainfall (Fig. 1). In fact, these highlands virtually shelter the central stretch of the basin from the full vehemence of the southwest monsoon winds thereby depriving the region from the heavy rains of this season. Rainfall sharply decreases from over 2000 mm along the slopes of these hills to about 700 to 900 mm along of foot-hills zones of the lee side of these hills Gudalur, (762 mm), Bodinayakanur (793 mm) and Periyakulam (842 mm), and then to the central stretch of the basin. The rainfall in the central stretch of the basin is less than 700 mm (Kambam, 677mm, Veerapandi, 592 mm, Vaigai Dam, 640 mm, and Devadanapatti, 685 mm). Thus, the Central stretch of the basin forms a dry belt extending from Kambam and Gudalur in the southwest to Devadanapatti in the northeast (Fig. 1).

TREND SURFACE ANALYSIS OF MEAN ANNUAL RAINFALL

Trend surface analysis is adopted to indicate the general distributional pattern of mean an-

nual rainfall. The potential application of trend surface analysis in determining mean annual rainfall is investigated by the Institute of Hydrology (1971) and Chidley and Keys (1970). It attempts to decompose each observation on a spatially distributed variable into a component associated with a regional trend present in the data and a component associated with purely local effects (Unwin, 1975 and Robinson and Bryson, 1957). The computation of best [illegible] the mapping of residuals from it ma[illegible] enable to distinguish between the broad pattern in which rainfall changes with distance and the more local changes.

Linear trend surface and associated residuals are defined for the distribution of rainfall in the Upper Vaigai basin; taking the station-wise data (17 stations). The trend surfaces are presented in the form of isopleths of 100mm interval and graphic portrayal of three dimensional representation fitted to rainfall in the

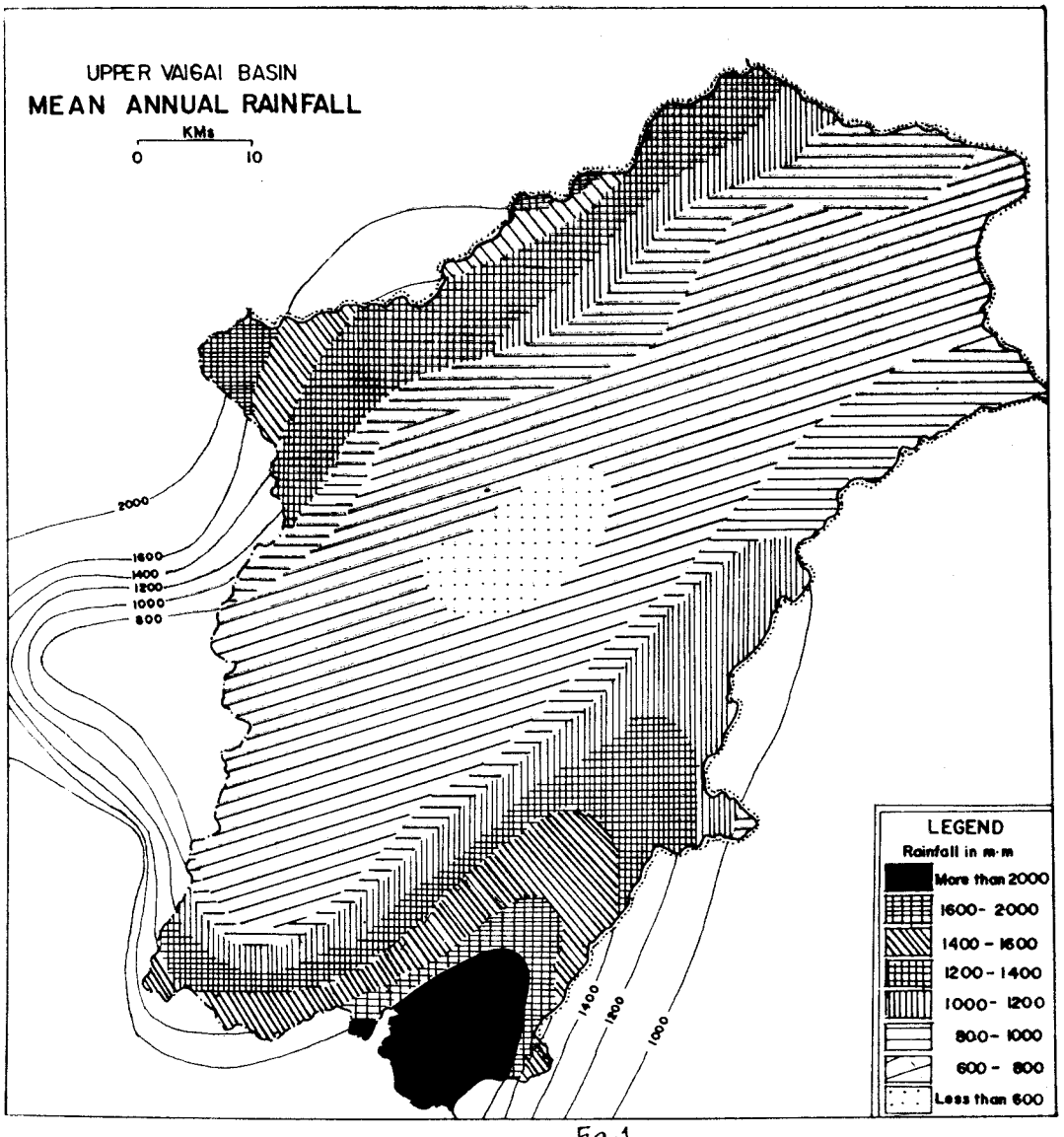


Fig.1

Upper Vaigai basin. The linear trend surface model used in this study is

$$Z = 9.762 - 0.145x + 0.03\ Y$$

The derivation of values required for the calculation of plane surface and calculation of predicted Z values and residuals from a linear trend surface are presented in Table 1 and 2.

The regional trend of the annual rainfall is found to be a surface sloping down from the west-northwest to east southeast of the basin (Fig. 2 and 3). In the west-northwest about 1025 mm of rainfall are expected each year and this declines to 700 mm in the east-southeast.

The map of residuals from the trend surface (Fig. 4) shows that the highlands of the Lower Palanis and the Varushanad hills standout as areas with positive residuals whereas the central stretch of the basin are the areas of negative residuals. From the residuals of trend surface it is inferred that in the areas of the Lower Palanis and the Varushanad hills the predicted rainfall surface almost tally with actual surface of annual rainfall distribution. However, in the central stretch the predicted surface has a deviation of 1.5 cm from the actual. The isopleths in Fig. 4B suggest that the residuals follow a distinct pattern with a ridge of positive residuals towards the Lower Palanis and the Varushanad hills and the maximum negative residuals around Rasingapuram and Periyakulam.

CONCLUSION

Using the trend surface analysis the general pattern of mean annual rainfall distribution of

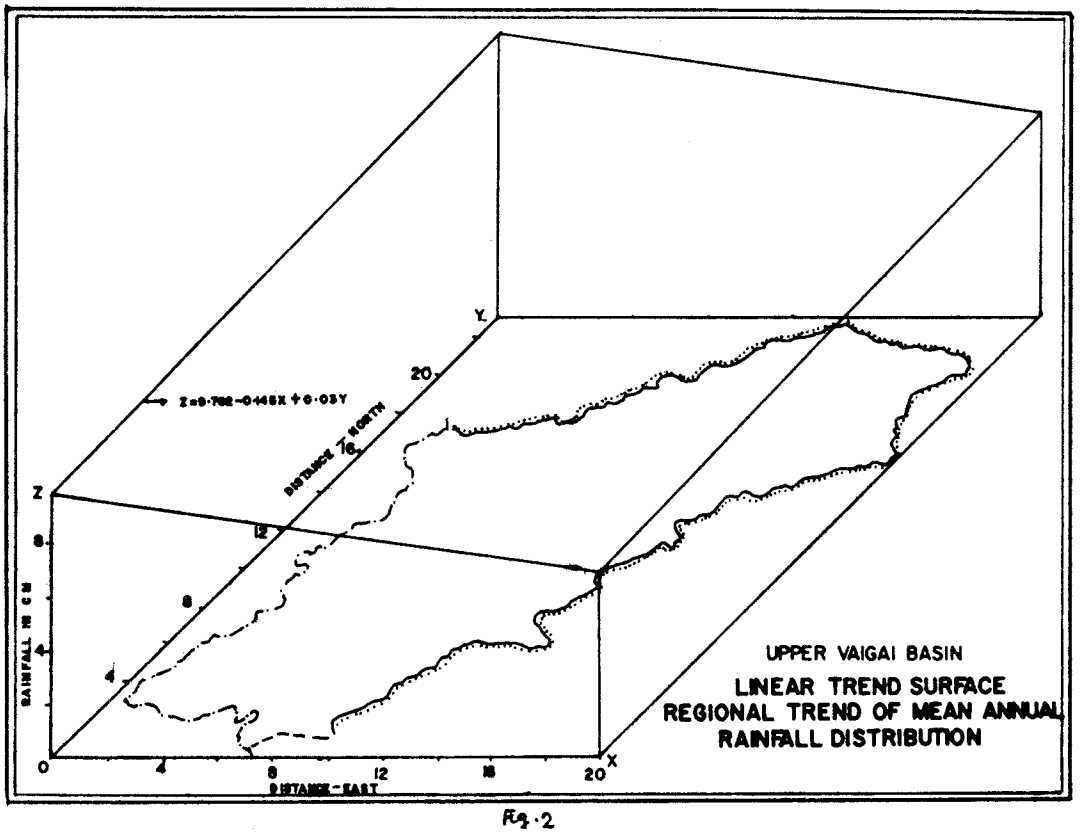


Fig. 2

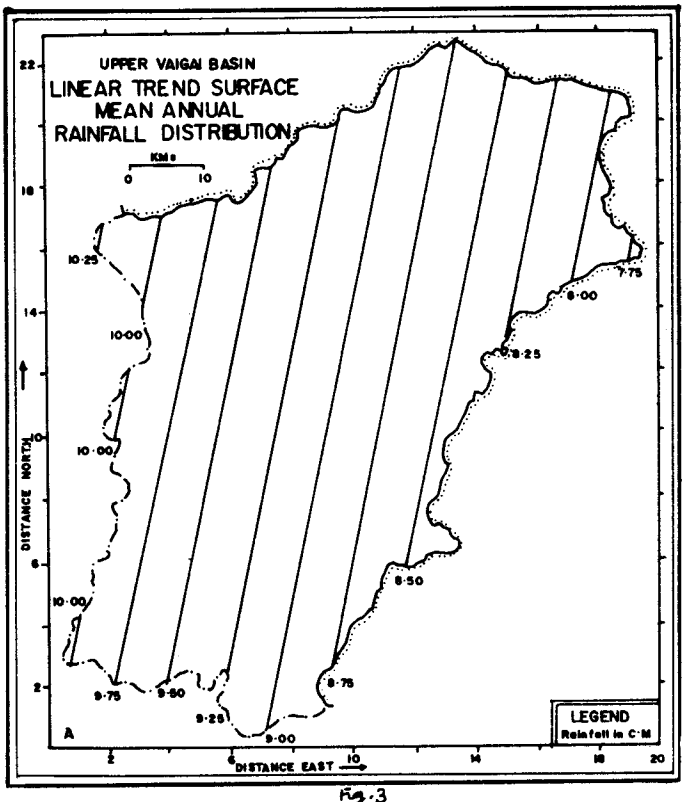
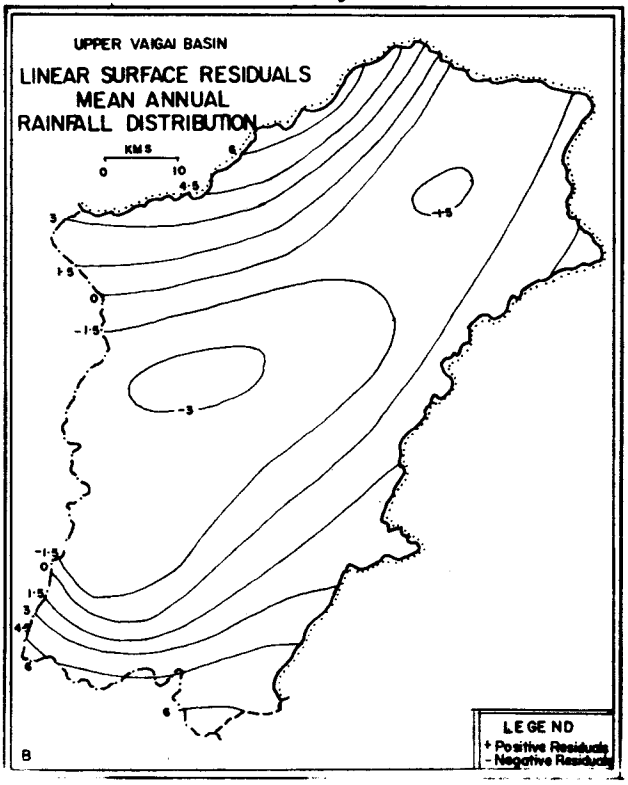

UPPER VAIGAI BASIN
LINEAR TREND SURFACE
MEAN ANNUAL
RAINFALL DISTRIBUTION
KMs
0
10
10·25
10·00
10·00
10·00
9·75
9·50
9·25
9·00
8·75
8·50
8·00
7·75
8·25
DISTANCE NORTH
DISTANCE EAST
LEGEND
Rainfall in C·M
A

Fig.3


UPPER VAIGAI BASIN
LINEAR SURFACE RESIDUALS
MEAN ANNUAL
RAINFALL DISTRIBUTION
KMS
0
10
6
4·5
3
1·5
0
-1·5
-3
+5
-1·5
0
1·5
3
4·5
6
6
LEGEND
+ Positive Residuals
- Negative Residuals
B

the Upper Vaigai basin is analysed. Linear trend surface and associated residuals are defined for the distribution of rainfall. The regional trend of mean annual rainfall is found to be a surface sloping down from the west northwest to the east southeast. It is seen that in the west-northwest about 1000 mm of rainfall is annually expected and this declines to about 800 mm in the east - southeast. The map of residuals from the trend surface shows that the highlands of the Lower Palanis and the Varushanad hills stand out as areas with positive residuals, which denotes high amount of rainfall whereas the central stretch running from the Thevaram sub-basin towards the northeastern part of the basin are the areas of negative residuals which indicates low amount of rainfall.

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Table 1

Upper Vaigai Basin : Derivation of values required for the calculation of plane surface of mean annual rainfall distribution

i	Z	X	Y	X^2	XY	XZ	Y^2	YZ	Z^2
1	15.74	0.5	2.8	0.25	1.40	7.87	7.84	44.07	247.75
2	7.62	2.9	4.9	8.41	14.21	22.10	24.01	37.34	58.06
3	6.77	3.5	6.2	12.25	21.70	23.70	38.44	41.97	48.53
4	7.09	5.1	8.4	26.01	42.84	36.16	70.56	59.56	50.27
5	6.17	5.3	12.1	28.09	64.13	32.70	146.41	74.66	38.07
6	7.93	5.7	14.1	32.49	80.37	45.20	198.81	111.81	62.88
7	5.92	8.4	12.7	70.56	106.68	49.73	161.29	75.18	35.05
8	14.37	6.8	18.6	46.24	126.48	97.72	345.96	267.28	206.50
9	16.15	8.9	19.9	79.21	177.11	143.74	396.01	321.39	260.82
10	6.40	11.8	14.5	139.24	171.10	75.52	210.25	92.80	40.96
11	8.42	10.8	16.8	116.64	181.44	90.94	282.24	141.46	70.90
12	7.39	12.3	17.1	151.29	210.33	90.90	292.41	126.37	54.61
13	6.85	13.6	17.7	184.96	240.72	93.16	313.29	121.24	46.92
14	7.34	13.2	19.1	174.24	252.12	96.89	364.81	140.19	53.88
15	9.17	15.3	20.7	234.09	316.71	140.30	428.49	189.82	84.09
16	7.58	15.8	16.7	249.64	263.86	119.76	278.89	126.59	57.46
17	9.11	19.2	16.0	368.64	307.20	174.91	256.00	145.76	82.99
	150.02	159.1	238.30	1922.25	2578.40	1341.30	3815.71	2117.49	1497.04
Mean	8.825	9.359	14.018						
Adjusted				$N(X)^2$	NXY	NX2	$N(Y)^2$	NYZ	$N(Z)^2$
items (A)				1489.05	2230.31	1404.08	3340.57	2103.05	1323.97
Adjusted				X^2	XY	XZ	Y^2	YZ	Z^2
sums				433.2	348.09	62.78	475.14	14.44	173.07

Table 2

CALCULATION OF PREDICTED Z VALUES AND RESIDUALS FROM LINEAR TREND SURFACE ESTIMATION EQUATION

$$Z = 9.762 (- 0.145 X + 0.03 Y)$$

15.74	0.5	2.8	9.762	-0.073	-0.084	15.74	9.773	5.967
7.62	2.9	4.9	9.762	-0.421	0.147	7.62	9.488	-1.868
6.77	3.5	6.2	9.762	-0.508	0.186	6.77	9.400	-2.630
7.09	5.1	8.4	9.762	-0.734	0.252	7.09	9.280	-2.190
6.17	5.3	12.1	9.762	-0.769	0.363	6.17	9.356	-3.186
7.93	5.7	14.1	9.762	-0.827	0.423	7.93	9.358	-1.428
5.92	8.4	12.7	9.762	-1.218	0.381	5.92	8.925	-3.005
14.37	6.8	18.6	9.762	-0.986	0.558	14.37	9.334	5.036
16.15	8.9	19.9	9.762	-1.291	0.597	16.15	0.068	7.082
6.40	11.8	14.5	9.762	-1.711	0.435	6.40	8.486	-2.086
8.42	10.8	16.8	9.762	-1.566	0.504	8.42	8.700	-0.280
7.39	12.3	17.1	9.762	-1.734	0.513	7.39	8.541	-1.151
6.85	13.6	17.7	9.762	-1.972	0.531	6.85	8.321	-1.471
7.34	13.2	19.1	9.762	-1.914	0.573	7.34	8.421	-1.081
9.17	15.3	20.7	9.762	-2.219	0.621	9.17	8.164	1.006
7.58	15.8	16.7	9.762	-2.291	0.501	7.58	7.972	-0.392
9.11	19.2	16.0	9.762	-2.784	0.480	9.11	7.458	1.652

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