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Climatological assessment of water harvesting technology through dug-out ponds in arid regions

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सार — सन् 1930 ई० से 1981 ई० तक की अवधि के लिए बीजापुर की दैनिक वर्षा का अध्ययन इस ध्येय से किया गया है कि खुदे हुए तालाबों द्वारा पैदावार की सम्भावयता का मूल्यांकन किया जा सके। नम दौरों की निरन्तरता को समझने के लिए प्रति सप्ताह 10 से 30 मिलीमीटर वर्षा मात्रा प्राप्त करने के लिए प्रारम्भिक और प्रतिबन्धित प्रायिकता विश्लेशण किया गया है। बीजापुर की गहरी काली मिट्टी के दैनिक मृदा जल अवशेष का अध्ययन अपवाह संग्रहण के लिए अतिरिक्त जल की उपलब्धता के परीक्षण के लिए किया गया है। यह अध्ययन जल पैदावार प्रौद्योगिकी के विकास करते समय शुष्क प्रदेशों के वर्षा चालढाल को पूर्ण रूप से समझने की महत्ता को प्रदर्शित करता है।

ABSTRACT. The daily rainfall data of Bijapur for the period from 1930 to 1981 is studied to assess the feasibility of water harvesting through dug-out ponds. The initial and conditional probability analysis is done for receiving rainfall amounts of 10 to 30 mm per week to understand the continuity of wet spells. Daily soil water balance of deep black soils of Bijapur is studied to work out the availability of excess water for runoff collection. The study brings out the importance of thorough understanding of rainfall behaviour of arid regions while developing water harvesting technology.

1. Introduction

Collection of runoff water and its recycling, for stabilizing crop production under rainfed agriculture in semi-arid and arid climates, has been advocated in the recent past; and much work on its feasibility on scientific lines is under way. Availability of water through runoff at a locality depends primarily on rainfall amount, its intensity, soil type, its slope etc. The water harvesting is more feasible under heavy rainfall tracts as evidenced by the presence of number of ponds and pools due to prolonged rainy season and heavy rainfall. But these arid climates are characterised by low, erratic and uncertain rainfall, due to which the availability of excess rain water may be at low probability. Added to this, the climatic water demand and other losses, limit the scope of impounding runoff, as water may not be available after all the losses, at needy occasions. Further, the mechanism (construction of farm pond, its maintenance, cost of irrigation etc) for water harvesting from a considerable catchment area needs huge investment. This warrants proper assessment of natural resources like rainfall and soil of the region. This study is taken up to understand the rainfall behaviour with respect to water harvesting in and around Bijapur area.

As per the climatic classification of Thornthwaite (1948), Subramaniam (1964) has classified *Bijapur under arid climates. This* region is characterised by low and uncertain rainfall, with high climatic demand for water. Soils of this region are derived from Deccan trap. They are black soils of the order of vertisols with varying depths and moisture holding capacities.

2. Data

The daily rainfall data from 1930 to 1981 for Bijapur is considered for the study. Data on maximum and minimum air temperature, relative humidity of both morning and evening hours, average wind speed and total cloud amount on daily basis was used for the period 1965-81 in the computation of daily potential evaporation following modified Penmann method (Doorenbos and Pruitt 1975). This estimate was used in working out daily moisture balance of the medium to deep black soils of Bijapur area (available water holding capacity is 250 mm/100 cm) following Thornthwaite and Mather (1955) water balance procedure.

3. Results and discussion

The monthly rainfall statistics of Bijapur comprising total rainfall for each month, standard deviation and coefficient of variation, were presented (Table 2). The rainfall of Bijapur follows bimodal distribution with a negligible peak in the month of June followed by a pronounced maximum during September. The individual monthly rainfall distribution is highly variable as indicated by the coefficient of variation (CV) and range of variation. The year to year variation in rainfall of the

TABLE 1

Initial and conditional probabilities of rainfall for selected amount during rainy season (1930-81)—Bijapur

Week No.	10 mm		20 mm		30 mm	
	W	W/W	W	W/W	W	W/W
18	19	20	12	17	4	0
19	17	44	8	0	0	0
20	25	62	15	38	8	75
21	48	56	37	37	29	27
22	40	76	23	50	15	25
23	58	53	44	43	33	29
24	48	32	27	29	15	25
25	44	52	31	25	23	27
26	42	50	25	23	15	13
27	50	35	29	20	15	13
28	33	47	15	50	12	17
29	44	61	29	40	19	40
30	46	46	33	47	25	31
31	42	45	38	45	25	31
32	31	50	25	38	15	25
33	37	47	25	31	13	14
34	40	38	35	39	27	36
35	38	60	35	39	27	43
36	42	59	35	67	29	60
37	58	73	42	50	35	39
38	63	76	52	63	50	50
39	77	70	65	50	52	52
40	65	56	46	50	40	43
41	56	38	48	24	37	32
42	35	61	19	60	17	56
43	37	42	31	31	21	18
44	37	21	23	8	17	11
45	19	20	15	0	12	0
46	13	0	8	0	6	0

area was more. From the point of rain water harvesting and recycling, the rainfall received in the months of June to October is important during which CV varied from 66 to 83 indicating their uncertain nature.

The probability of receiving different amounts of rainfall (10 to 30 mm) during each week (W) and conditional probability of wet week followed by another wet week (W/W) was worked out and presented in Table 1, to understand the rainfall behaviour of Bijapur. The analysis indicate that the chances of receiving a rainfall of 10 mm or more at more than 50 per cent probability level occur only from 37th week to 41st week. Further, the conditional probabilities indicate less chances of receiving 10 mm or more rainfall in a week being followed by another wet week under Bijapur conditions, except for the period from 35th week, during which the probabilities of 50 per cent are observed for a wet week to follow another rainy week. For higher rainfall amounts, which may be considered for water harvesting the probabilities are still low.

TABLE 2

Monthly rainfall statistics, 1930-81

Month	Mean rainfall	Standard deviation	C.V. (%)
January	2.4	7.0	289
February	2.6	8.1	309
March	7.3	11.8	163
April	26.3	24.4	92
May	42.0	35.7	85
June	85.1	56.8	67
July	81.7	67.4	83
August	84.7	61.1	72
September	155.6	102.1	66
October	108.3	81.7	75
November	28.7	45.7	159
December	5.4	10.4	191
Annual	630.2	190.0	30

TABLE 3

Probability of occurrence of high amounts of rainfall in a single day during different months (1930-81)

	Rainfall amount (mm)				Rainy days		
	15	20	30	40	Total	Lowest	Highest
May	27	20	10	5	3	0	9
Jun	35	24	14	8	5	0	14
Jul	23	16	10	8	6	0	14
Aug	34	23	13	10	5	0	12
Sep	46	35	22	12	8	0	16
Oct	41	27	15	10	6	0	18

TABLE 4

Climatically excess water during 1975

Date (1975)	Rainfall (mm)	Climatically excess water (mm)	Percentage
27 Sep	19.2	16.0	83
28 ,,	8.8	5.8	66
29 ,,	7.0	4.0	57
05 Oct	20.4	11.4	56
06 ,,	7.2	0.0	0
08 ,,	32.4	28.6	88
09 ,,	7.6	4.2	55
10 ,,	10.8	7.9	73
11 ,,	15.8	13.0	82
12 ,,	21.8	18.5	85
18 ,,	10.8	2.5	23
19 ,,	82.3	79.0	96
28 ,,	21.4	9.9	46
29 ,,	5.2	2.6	50
30 ,,	26.8	24.3	91
Total	296.5	227.7	76

Added to these, the rainy season of these dry areas which are situated in rain shadow region for both the monsoon currents, is of short in nature (35 days o 2.5 mm rainfall or more) of low amount and hence, o low intensities. In order to assess the extent of runof *which may be* considered for water harvesting and recy cling, the probability of occurrence of high amounts c rainfall (15 mm to 40 mm) in a single day during differer months of the rainy season was worked out (Table 3). I the initial stages of the monsoon season (May to August) the probability of receiving a rainfall amount of 15 mm or more in a single day is of the order of 25 to 35 per cent of the total rainy days. The probabilities exceeded 40 per cent during September and October months only. The probabilities will further go down (of the order 10 per cent of the total rainy days) if occurrence of higher amounts of rainfall were considered, indicating low probabilities of excess water being harvested in these dry areas. Further, an analysis of rainfall intensities at Bijapur indicates that occurrence of high intense storms coupled with heavy rainfall amount are very low. Added to this, the farmers of this locality keep the land fallow during kharif season so as to allow maximum rain water to infiltrate, thereby runoff is minimised. However, it is presumed that the impounding of water into a dug-out pond will be a continuous phenomenon from the initiation of monsoon rains and one or two heavy showers may be sufficient to harvest considerable quantity of water. The rainy season of these dry regions is characterised by frequent dry spells of considerable length. High wind speeds coupled with high day time temperatures enhancing evaporation and transpiration, limit the scope of harvesting runoff water from the one or two heavy showers and its retention. Added to this, the standing kharif crop in the later monsoon season (July, August etc) will further reduce rain water runoff.

From the above, it can be understood that the occasions for water harvesting are low in this tract. All these considerations will add up to the cost of construction of the pond, its maintenance and further for utility. Instead, in these dry areas, if reduction of runoff from rains is considered by following suitable moisture conservation methods, *in situ* moisture conservation and reduction in soil loss could be achieved, while avoiding farm pond construction and irrigation cost. To have an insight into the effectiveness, daily soil moisture budgeting was done following Thornthwaite and Mather (1955) procedure. The procedure presumes that all the pre-requisites for maximum water conservation are met with. The daily water balance considering

daily rainfall as inputs to the soil moisture storage and estimated potential evapotranspiration as withdrawals was carried out for the period from 1965 to 1983 and climatically excess water was arrived at, at the end of each day, after the soils are saturated. Percentage estimated runoff to the total rainfall of each storm for an exceptionally good rainfall year (1975, R/F 953 mm) is presented (Table 4). This type of rainfall distribution did provide climatically excess water in the months of September and October after the soils are recharged. However, this type of rainfall situation is observed at one year out of 20 years. But during normal and low rainfall situation, most of the rain water will be utilized in recharging the soils without yielding excess water for harvesting.

4. Conclusions

The above analysis indicate that in the seasonally dry regions, the rainfall which is low and erratic, intermingled with prolonged dry spells, set a limitation on the scope of water harvesting and recycling. As the adoption of this technology involved high investments, in this era of agricultural development on watershed basis needs a thorough assessment of climate.

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