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Weather and Crop Instability in the Dry Region of Rajasthan

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Introduction

Low and unstable crop production has been a chronic problem of agriculture in the dry region of Rajasthan, which is spread over 11 north-western districts and covers nearly three-fifths of the State. This paper, after reviewing briefly the weather variability and the principal source of crop instability in the region, discusses the yield variability of the principal crops of the dry region. This is followed by a discussion of certain other features of crop instability, which tend to reduce the effectiveness of the measures adopted by the desert farmers to minimize the impact of instability and uncertainty in arid agriculture. The crop yield data for 15 to 17 years pertaining to 11 arid districts of Rajasthan have been used.

Weather Variability

Because of the largely subsistence and primitive character of crop farming in most parts of the region, market and technology seldom act as sources of instability and uncertainty in arid agriculture. On the other hand, weather conditions, particularly rainfall, are so unstable that wide fluctuations in crop yields are inevitable.

Table 3.1 summarizes the behaviour of rainfall during the last 45–76 years in different districts, indicating the extent and variability of rainfall. This variability, if viewed in the context of the negligible irrigation facilities and overall moisture deficit indicated by aridity index prepared by using Thornthwaite's method of climatic classification [Krishnan and Thanvi, 1969], can give ample evidence of the fluctuations in rainfed agriculture.

At the same time, however, it may be noted that the above calculations, based on annual averages, do not throw any light on the distribution pattern of rains during the crop season, which is a more relevant factor for evaluating the impact of weather (rains) on crop instability. Information about weekly behaviour of rains during the crop season can serve the purpose better. The meteorologists have analysed such information for different meteorological subdivisions of the country [Mallik and Govindaswamy, 1963].

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TABLE 3.1
BEHAVIOUR OF RAINFALL IN RAJASTHAN

District	Number of years	Average rainfall	Highest rainfall	Lowest rainfall	Coefficient of variation	Average number of rainy days in a year	Extent of irrigation (% of gross cropped area)	Mean aridity index
		(Rainfall in inches)						
Barmer	50	10.90	32.01	1.13	62.0	13	0.77	82
Bikaner	50	11.96	29.46	1.06	51.0	17	0.02	81
Churu	45	14.48	30.56	3.04	39.0	19	0.02	78
Jalore	50	14.29	33.73	1.07	51.0	19	8.39	72
Jaisalmer	50	7.03	22.77	0.00	86.0	8	0.15	89
Jhunjhunu	50	15.26	29.84	3.65	36.0	27	3.54	72
Jodhpur	76	14.22	46.69	1.00	53.0	18	2.21	78
Nagour	50	12.20	31.75	2.48	42.0	22	1.67	73
Pali	50	16.19	37.19	3.10	42.0	23	19.73	71
Sikar	50	17.36	31.89	7.06	38.0	30	7.35	69
Sirohi	65	22.24	51.89	5.74	47.0	29	25.60	–

Source: Jodha and Vyas [1969].

We can profitably make use of the same. The results are, however, available for the region as a whole rather than for the individual districts.

According to the study cited above, if a wet season is interrupted by four or more consecutive "drought" weeks (that is, when the rainfall is equal to half of the normal rainfall – 5 millimetres or 0.2 inches or less) it creates a "drought" condition damaging crop prospects. Such droughts can occur at the time of commencement of the wet season, in the middle of the wet season, or towards its end. And droughts have been named accordingly. The analysis of weekly rainfall data for 47 years, ending 1955, indicates the following probability of droughts in the arid zone. Early droughts – 13 per cent; mid-season droughts – 22 per cent and late droughts – 11 per cent.

In other words, in the arid region of Rajasthan crop production is likely to suffer more than four times in a period of 10 years because of: (1) delayed sowing or complete prevention fo sowing due to early droughts for more than once in 10 years, (2) retarded crop growth or complete scorching of standing crops due to mid-season droughts for more than twice in a period of 10 years, (3) withering of otherwise promising crops due to late droughts more than once in ten years.

The situation described above is broadly supported by the records of scarcity and famine conditions in the arid region [Jodha, 1969].

Instability of Crop Farming

Despite the highly undependable weather conditions and general unsuitability of lands for crop [Jodha, 1970] in most parts,[1] crop-raising is the principal form of land use in the region. For the region as a whole nearly 58 per cent of the area is put under the plough. Of course, the area under the plough differs from district to district but in the region as a whole, it has been increasing since 1951/52 (that is, the year since the authentic records of land utilization are available) [Swaroop, 1966].

An obvious consequence of raising crops in violation of soil and climatic considerations in the dry area is low and highly unstable crop yields. This is apparent from the levels and variability of yields of principal crops in the region. These crops jointly covering more than 90 per cent of the gross cropped area (average of 5 years ending 1965/66) of the region are bajri (59.73 per cent), *kharif* pulses – including *moth, mung, gowar* (21.34 per cent), jowar (4.69 per cent), and sesamum (5.72 per cent). (See Table 3.2.) The rest of the area is covered by other minor crops and their individual share in the cropped area of the region as a whole does not exceed even 1 per cent [Jodha and Vyas, 1969]. Of course as revealed by Table 3.2, the relative position of these crops varies from district to district. The combined area under the four crops varies from 42 per cent of the gross cropped area in the semi-arid district of Sirohi to 96 per cent in the extremely dry district of Bikaner. The average yields of these crops also show considerable inter-district differences.

1. According to soil scientists and conservation experts nearly 79% of the land in the region could be put under land classes VI and VII (according to the FAO use capability classification of lands for conservation purposes), which are suitable for pasture development and would be exposed to severe erosion if ploughed.

TABLE 3.2
YIELDS AND YIELD VARIABILITY OF PRINCIPAL *KHARIF* CROPS IN RAJASTHAN

District	Bajri			*Kharif* pulses			Jowar			Sesamum			Total
	Area covered (%)	Yield (kg/ha)	Coefficient of variation	Area covered (%)	Yield (kg/ha)	Coefficient of variation	Area covered (%)	Yield (kg/ha)	Coefficient of variation	Area covered (%)	Yield (kg/ha)	Coefficient of variation	area covered 1+2+3+4 (%)
Barmer	70.39	155.44	51.98	3.76	200.20	47.75	0.46	105.57	59.90	1.15	95.48	68.42	75.76
Bikaner	43.61	115.82	76.89	49.05	109.41	59.33	0.15	186.56	54.68	3.12	79.07	80.59	95.93
Churu	46.29	129.84	54.31	31.00	144.96	40.57	0.13	204.72	56.27	0.21	74.94	91.85	77.63
Jaisalmer	89.24	154.29	45.97	0.40	228.31	32.06	4.30	138.76	78.22	0.26	114.37	58.00	94.20
Jalore	47.73	170.85	48.12	2.49	232.16	50.78	0.88	134.19	76.58	5.28	139.33	79.39	56.38
Jhunjhunu	46.45	226.19	48.67	27.28	132.58	40.30	0.44	224.84	55.07	Insig.	139.89	31.97	74.17
Jodhpur	56.42	144.38	58.55	13.28	294.47	57.09	5.59	134.91	99.25	4.21	163.52	51.31	79.50
Nagour	43.78	225.41	33.85	21.01	176.28	37.74	9.66	159.77	61.17	6.25	108.88	62.04	80.70
Pali	23.70	193.10	28.68	2.82	409.18	27.03	21.76	119.42	43.69	19.20	152.62	52.16	67.48
Sikar	46.21	243.74	29.70	27.58	154.27	38.32	0.30	250.32	41.98	Insig.	134.89	33.53	74.09
Sirohi	19.82	150.46	40.89	5.88	389.78	54.10	3.07	136.07	80.66	13.53	180.84	67.49	42.30
Arid region	59.73	168.58	32.48	21.34	142.08	21.97	4.69	116.60	42.74	5.72	123.08	47.16	91.48

Notes: Area covered indicates the percentage of gross cropped area (average of 5 years ending 1965–66).
Calculations based on districtwise area and production.
bajri = pearl millet; jowar = sorghum; *moth* = moth bean; *mung* = *mung* bean (or gree gram); gowar = cluster bean; *kharif* crop = monsoon season crop.

Sources: Rajasthan [1951/52–1955/56]
Rajasthan [1956/57–1965/66]

TABLE 3.3
EXTENT OF DEVIATION OF ACTUAL YIELDS FROM NORMAL (OR MODAL) YIELDS

Crop	Number of observations with extent of deviation										
	30–50%			50–100%			Above 100%		Total		
	(+)	(–)	(T)	(+)	(–)	(T)	(+)	(T)	(+)	(–)	(T)
Bajri	17 (9.09)	16 (8.56)	33 (17.65)	30 (16.04)	34 (18.18)	64 (34.22)	11 (5.88)	11 (5.88)	58 (31.01)	50 (26.74)	108 (57.75)
Kharif pulses	7 (3.74)	24 (12.83)	31 (16.57)	25 (13.37)	25 (13.37)	50 (26.74)	9 (4.81)	9 (4.81)	41 (21.92)	49 (26.20)	90 (48.12)
Jowar	20 (10.69)	15 (8.02)	35 (18.71)	17 (9.09)	45 (24.06)	62 (33.15)	12 (6.42)	12 (6.42)	49 (26.20)	60 (32.08)	109 (58.28)
Sesamum	11 (5.88)	18 (9.63)	29 (15.51)	18 (9.63)	39 (20.86)	57 (30.49)	17 (9.09)	17 (9.09)	46 (24.60)	57 (30.49)	103 (55.09)

Notes: Calculations are based on the districtwise area and production data of crops for 17 years ending 1967/68.
(+) = Deviation in positive direction.
(–) = Deviation in negative direction.
(T) = Total of the two.
Figures in parentheses indicate the observations mentioned as percentages to the total (11 districts X 17 crop years = 187) observations.

Sources: Rajasthan [1951/52–1955/56].
Rajasthan [1956/57–1967/68].

The extent of yield instability is indicated by the coefficient of variation of crop yields calculated from the yield data for 15 years ending 1965/66. The values of coefficient of variation vary from 28.68 to 76.89 in the case of bajri, 27.03 to 59.33 in the case of *kharif* pulses, 41.99 to 250.32 in the case of jowar, and 31.97 to 91.85 in the case of sesamum in different districts.

Further, it may be added that where agriculture is characterized by wide fluctuations, the average yields (which formed the basis of the above calculations) do not represent the normal yields. In fact there is a substantial gap between average yields and modal yields (indicating normal yields) of different crops. Hence a more meaningful picture of crop instability can be had by examining the deviation of actual yields from normal (or modal) yields of different crops in different districts.

Table 3.3 presents the extent to which actual yields deviated from normal yields during the period of 17 years ending 1967/68.[2]

During the 17 years for all the 11 districts, in nearly 58 per cent of the total (17 X 11 = 187) observations the actual bajri yields deviated (on positive or negative side) from normal yield by more than 30 per cent. The deviation of such magnitude was in 48 per cent of observations in the case of *kharif* pulses, followed by sesamum (55 per cent), and jowar (58 per cent). The deviation exceeding 30 per cent of the normal yield on the negative side was found in more than one-fourth of the observations in the case of each of the four crops. The severity of yield instability is further indicated by the fact that in 30 to 40 of the observations (in the case of different crops) the actual yields deviated from normal yields by more than 50 per cent.

Incidence of Instability

The foregoing discussion tells only a part of the story of crop instability in arid agriculture. There are certain other aspects of the problem which rendered even the time honoured devices of the farmer to adjust to instability and uncertainty in agriculture less effective.[3] These aspects relate to incidence of instability in terms of time, space, etc. [Schikele, 1950].

2. Modal yields were found for different crops for individual districts. The extent of deviation of actual yields from modal yields was then calculated for individual districts. The results thus obtained for different districts were pooled and a consolidated picture of the same for the region as a whole was obtained and has been presented (in different forms in Tables 3.3 to 3.6). The total number of observations in the case of each crop thus came to be 187 (11 districts multiplied by 17 crop years from 1951/52 to 1967/68).
3. Some of the important devices adopted by the desert farmer to minimize the impact of crop instability and uncertainty are as follows:
   (1) Diversification of farm enterprises not only through cultivation of more crops but by adoption of mixed farming (where cattle, sheep, goat, and camel raising is practised along with crop raising) is a common practice in the desert areas.
   (2) Migration of animals for grazing and of humans both as labourers and as farmers (to cultivate the leased-in lands or undertake custom work during the season) in the neighbouring areas or districts which have better rains during the year is another practice adopted by desert farmers faced with poor crop prospects in their own locality.
   (3) Reserve maintenance (of both fodder and food grains) is another age-old means of security

The Time Incidence

It is the time incidence of poor years rather than the amplitude of yield fluctuations that creates serious economic problems. The occurrence of poor yields in a sequence of 2 or more years tends to restrict the farmers' capacity to withstand the scarcity situation by means of inventory and reserves management.

An idea of the time incidence of instability can be had by observing the sequence of years with below normal crop yields. Table 3.4 presents the distribution of total observations with low (below normal) yields according to the yield position (normal, above normal, and below normal) in the years which followed them. Accordingly 44–58 per cent of the low yield observations in the case of different crops were followed by one or more low yield years in succession. The low yield observations followed by 2 and 3 years with low yields in succession constituted 10–16 per cent and 2–9 per cent of the total low yield observations respectively. This indicates that continuance of poor crop conditions for successive 3 to 4 years is nor uncommon in arid agriculture. Obviously, in the face of such situations the farmers' defence system against crop instability and uncertainty is bound to collapse.

TABLE 3.4

DISTRIBUTION OF LOW (BELOW NORMAL) YIELD OBSERVATIONS ACCORDING TO YIELD POSITION

Crop	Number of low yield observations followed by					Total
	Years of normal/higher yields	Years of low yields				
		One	Two	Three	Four	
Bajri	37 (56.06)	19 (28.80)	9 (13.63)	1 (1.51)	–	66 (100)
Kharif pulses	27 (42.18)	21 (32.80)	10 (15.63)	6 (9.39)	–	64 (100)
Jowar	41 (51.25)	26 (30.25)	9 (11.25)	4 (5.00)	1 (1.25)	80 (100)
Sesamum	37 (50.68)	23 (31.51)	7 (9.58)	4 (5.47)	2 (2.76)	73 (100)

Notes: Figures in parentheses indicate percentages.
Sources: Rajasthan [1951/52–1955/56],
Rajasthan [1956/57–1967/68].

against uncertainty. The desert farmer also adopts the same to the extent permitted by occasional bumper crops.

Incidence Over Space and Crops

The desert farmers' position is further weakened because the phenomenon of low yields in a year is rarely restricted to one small area or one crop; indeed low yields are universal in the sense that: (1) they affect vast tracts and areas having physical contiguity, (2) yields of all the crops are low. Tables 3.5 and 3.6 bear this out.

Table 3.5 presents the number of observations (during the whole period under review) according to the number of contiguous districts affected by low crop yields. There were 8 observations when 2 to 5 contiguous districts (during one or other year) simultaneously had below normal yields of bajri. The corresponding number of observations in the case of *kharif* pulses, jowar, and sesamum crops were 13, 10, and 7 respectively. The number of observations when 6 to 10 contiguous districts were simultaneously affected by below normal yields ranged from 1 to 6 in the case of different crops.

The phenomenon of widespread low yields simultaneously covering a large number of contiguous districts poses the problem for desert farmers' adjustment system to local scarcity through migration and custom work in the neighbouring areas and districts. In such situations the advantage of spatial mobility in livestock farming (a component of mixed farming in arid areas) is considerably reduced. Thus, diversification of farm enterprises as a remedy against uncertainty in farming is rendered less effective.

The farmers' adaptability to uncertainty by keeping flexibility in farm production organization through diversification is further restricted because the yields of all principal crops (and even pastures and grazing lands), generally move in the same direction. This is illustrated in Table 3.6.

Accordingly, the observations when bajri alone showed low yield constituted only 15 per cent of the total observations of low bajri yield. The rest of the observations indicated that low yield of bajri was accompanied by low yield of one or more of the remaining crops too. A similar situation was found on other crops where 71–91 per cent of their total low yield observations indicated that the phenomenon of low yield simultaneously affected more than one crop. Thus, irrespective of the relative yield differen-

TABLE 3.5

DISTRIBUTION OF OBSERVATIONS ACCORDING TO NUMBER OF CONTIGUOUS DISTRICTS AFFECTED BY LOW YIELDS

(over 17 years)

Crop	Number of observations when contiguous districts with low yields numbered								
	Two	Three	Four	Five	Six	Seven	Eight	Nine	Ten
Bajri	3	2	2	1	2	1	–	1	–
Kharif pulses	4	4	3	2	–	–	–	2	1
Jowar	4	1	2	3	–	1	–	2	2
Sesamum	2	3	1	1	2	–	1	1	2

Sources: Rajasthan [1951/52–1955/56]
Rajasthan [1956/57–1967/68].

TABLE 3.6
DISTRIBUTION OF OBSERVATIONS ACCORDING TO NUMBER OF CROPS SIMULTANEOUSLY AFFECTED BY LOW YIELD

Crop	Number of observations indicating low yield of one crop accompanied by low yield of remaining crops														
	Nil	One crop					Two crops							Three crops	Grand Total
	–	B	J	K	S	Total	BJ	BK	BS	JK	JS	KS	Total		
Bajri (B)	10 (15.14)	–	6	7	5	18 (27.29)	–	–	–	8	7	5	20 (30.31)	18 (28.29)	66 (100)
Kharif pulses (K)	9 (14.08)	7	5	–	4	16 (25.00)	8	–	5	–	8	–	21 (32.80)	18 (28.12)	64 (100)
Jowar (J)	25 (31.25)	6	–	5	3	14 (17.50)	–	8	7	–	–	8	23 (28.75)	18 (22.50)	80 (100)
Sesamum (S)	23 (31.56)	5	3	4	–	12 (16.45)	7	5	–	8	–	–	20 (27.39)	18 (24.60)	73 (100)

Sources: Rajasthan [1951/52–1955/56].
Rajasthan [1956/57–1967/68].

tials, when the yield rates of all the principal crops move in the same direction, diversification through the adoption of more crop enterprises ceases to be an effective method to defend against the crop uncertainty.

Remedial Measures

The situation described above tends to make the economy of the desert farmer highly precarious. Since the principal source of crop instability is variability of moisture for plant growth, the best remedy to mitigate or at least minimize the instability of farming is the provision of irrigation facilities. A comparative study of the two districts falling in the same soil-climatic zone, namely, Ganganagar (with 36 per cent of cropped area under irrigation) and Bikaner (with 0.02 per cent) supports this view [Jodha and Vyas, 1969]. But as it is clear from Table 3.1, the extent of irrigation in most of the arid districts is less than even 5 per cent of the gross cropped area, and most of them do not have bright prospects for increasing the irrigated area in the near future; irrigation as a solution to the problem of instability therefore does not hold much promise.

The second best alternative to minimize the variation of moisture availability, through prevention of loss of usable moisture, is provision of conservation measures like bunding, shelter-belts, and windbreaks, etc., the efficacy of which in raising and stabilizing production within the given rainfall conditions have been proved by experiments conducted by the Central Arid Zone Research Institute. But since most conservation measures imply some sort of control or discipline in the matter of land use practices, the measures do not fit well in the prevailing system of farming. The scant attention given by the desert farmer to conservation measures is amply revealed by the structure of farm capital. According to the Reserve Bank of India surveys and other studies, the conservation measures (as farm assets) accounted for less than 4 per cent of the total capital formation by the cultivators during different years in the different arid districts [Jodha, 1971]. However, the situation needs to be changed in the interest of higher and stable crop production in the arid areas.

Yet another alternative for imparting stability to arid agriculture is massive adoption of native perennial grasses like sewan (*Lasiurus scindicus*) as regular crops in drier parts of the region. These grasses are not only more adapted than other crops to the desert conditions of the region [Dhabadgao *et al.*, 1963] but they can strengthen the foundations of livestock farming, particularly pasture-based sheep and cattle raising which are inherently more stable enterprises and have comparative advantage in arid areas. But this switch over to grass farming and consequent specialization in livestock farming demands far-reaching structural changes, including proper marketing arrangements for animal products, etc., which are almost non-existent at present.

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