Annals of Arid Zone 32(1) 1–12 1993

Effect of Drought on *Kharif* Foodgrains Production : A Retrospect and Prospect

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Abstract The effect of drought on foodgrains production has been assessed on the national scale as well as for individual crops, taking state as a unit. But these are post cropping analyses.

An early warning system was developed by Steyaert *et al.* (1981) to assess the effect of drought on foodgrains production. The model evolved by Doorenbos and Kassam (1979) on "Yield response to water" can be used for assessing the proportionate of the potential achievable based on the rainfall as it progresses in relation to the phenology of the crop.

In the monsoon foodgrains production, the percieptible effect of drought is more visible with rice and coarse cereals grown under better endownments.

Some suggestions on tackling the high variability and almost plateauing that is taking place in foodgrains production in *kharif* season are made based on the responses available with the interventions (long and short term) at the goverment, farmer and researchers levels

Key words Drought, *Kharif* foodgrains production, Interventions, Tackling drought effects

During one of the favourable years (1990-91), the total foodgrains production was 176.23 million tonnes (Mts) of which 59.2 % was produced in the monsoon (*kharif*) season. It is well known that the precipitation during *kharif* season is 78% of the total of 1100 mm in our country.

In this paper the effect of drought on *kharif* foodgrains production is discussed in retrospect and prospect in three facets. Firstly the concept of drought and how it is being classified by the India Meteorological Department (IMD) is presented. Secondly, the various efforts made to assess the effect of drought on foodgrains production is discussed. Finally the means to face or mitigate drought effects are highlighted, ending with a brief resume including some issues.

Drought

Definition

Drought indicates dryness or want of rainfall or water. There are three categories of drought as follows :

Meteorological

A situation when there is a significant (25%) decrease from normal precipitation over an area.

Agricultural

It is said to occur when the soil moisture and rainfall are less adequate during the growing season to support healthy crop growth and cause extreme crop stess and even wilt. This leads to reduced productivity or even total loss of crops.

Hydrological

When drought is prolonged it leads to marked depletion of surface water and consequent drying up of the reservoirs, lakes, streams, rivers, cessasion of spring flows and fall in ground water levels.

It is the agricultural drought that is of great consequence in *kharif* crop production.

Classification

The Government of India (GOI) had been using the concept of meteorogical drought only for classifying drought occurrence in any given area in the country. This leads to considerable anomalies. For instance, the rainfall unless well distributed, is inadequate in the arid Rajasthan, for growing a successful crop of pearl millet. So a deviation of 25% from normal total precipitation has no sense. In fact for 1991-92, the area affected by the two classifictions are as depicted in fig 1 and 2. The agricultural drought in relation to pearl millet has been quantified based on the moisture availability (AE/PE) during different phenophases of the crop.

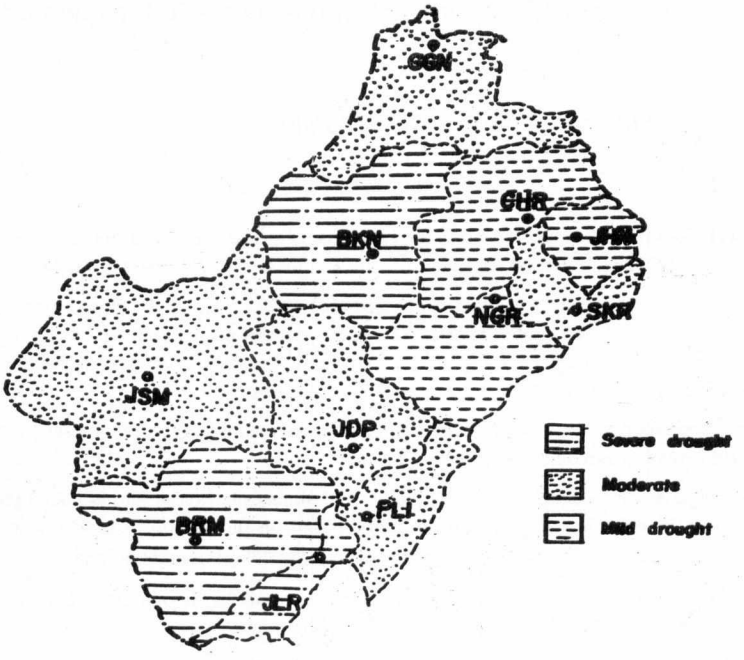

Fig 1 Meteorological drought situation over W. Rajathan *kharif* season 1991

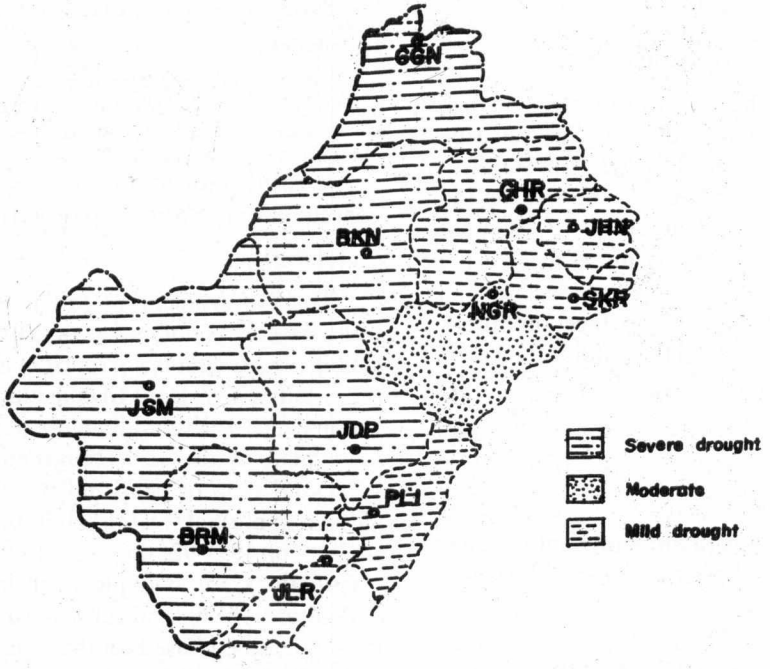

Fig Agricultural drought situation over W. Rajsthan *kharif* season 1991 (pearl millet)

The two figures give different interpretations. The results are as follows.

Districts affectd as per meteorological drought

Severe : Barmer, Bikaner, Jalor

moderate : Ganganagar, Jaisalmer, Jodhpur, Pali & Sikar

Mild : Churu, Jhunjunu & Nagaur

Districts affected as per agricultural drought for pearl millet

Severe : Jaisalmer, Barmer, Bikaner, Ganganagar, Jalore & Jodhpur

Moderate : Nagaur

Mild : Churu, Jhunjunu, Sikar and Pali

At the field level the agricultural drought classification and crop condition were tallying.

Similarly even if there is a deviation of 25% from an annual rainfall of say 1200 mm, a very good crop of rice can still be grown if there is a good distribution of the rest of the rain over a period of 3 to 3.5 months.

The IMD classified the whole country into 35 meteorological sub-divisions and give out the number of sub-divisions affected by drought. This may give a wrong picture for the following reasons.

i. Each sub-division is different from the other not only in terms of rainfall, but also varies in the geographical area as well as the foodgrains production potential.

ii. The sub-divisions do not tally with the rainfall isohyets and are bound by the geographical boundaries.

Effect on foodgrains production and monitoring

Foodgrains production in the meteorological sub-divisions : Further examination of the foodgrains production potential of these sub-divisions, also shows that different crops are important in different areas. Taking district-wise data of 1983-84 (a good rainfall year), the contribution of different important crops in foodgrains production was estimated for each of the sub-divisions and their relative rating worked out (Table 1).

From perusal of these data it becomes evident that for the immediates appraisal, crop zonation could be more relevant. While overall development is very important to tackle the drought affects of *kharif* foodgrains production, perhaps an emphasis on the more important states would be meaningful for the individual crops. In fact such an approach was made by GOI through their special foodgrains production programme (SFPP) launched in 1988.

Action plans were proposed for the identified food crops in potential areas, taking district as a unit for planning. While identifying the potential districts due consideration was given to :

- soil and rainfall conditions,
- dependable water availability through surface and ground water schemes,
- technological packages available on the basis of agroclimatic zones (cluster of districts),
- existing levels of development and rates of agricultural growth (e.g. fertiliser use, irrigation potential created), and
- based on this analysis, 169 districts were identified in consultation with 14 participating states. Accordingly 106 districts for rice, 72 for wheat, 28 for maize, 20 for pigeon pea and 28 for gram were identified.

In any case, for the more efficient use of the existing meteorological data, the sub-division and crops as suggested in table 2 be considered.

Present crop-weather review system

While reviewing the progress of monsoon and the relative crop performance the Crop Weather Watch groups at Central as well as State level have primarily considered the rainfalll thus far received and future possibilities as per probability analysis. Further an attempt was made to classify a week receiving 25, 35 and 40 mm as adequate to meet the evapotranspiration demands for coarse cereals, maize and rice respectively. Pulses were grouped with coarse cereals. In assessing the success of the irrigated rice crop in command areas,the general rainfall received in the catchment areas was taken into account. The sensitivity of the crop to the drought in different phenological states was also

Table 1 *Foodgrains production (t) and relative contribution in kharif foodgrains production in meteorological sub-divisions (1983-84)*

Meteorological sub-division	Rice	Sorghum	Pearl millet	Maize	Finger millet	Pigeon pea	Total
A & N Islands	22000(0.04)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	22000(0.03)
Arunachal Prad.	106000(0.19)	0(0.0)	0(0.0)	30482(0.39)	0(0.0)	0(0.0)	136482(0.16)
Assam & Megha.	2632758(4.79)	0(0.0)	0(0.0)	33473(0.42)	0(0.0)	8684(0.36)	2674915(3.16)
N M M & T	757325(1.38)	0(0.0)	0(0.0)	32458(0.41)	0(0.0)	269(0.01)	790052(0.93)
SHWB & Sikkim	647480(1.18)	0(0.0)	0(0.0)	84470(1.07)	12258(0.43)	80(0.00)	744288(0.88)
G West Bengal	5962670(10.85)	367(0.0)	215(0.0)	33289(0.42)	634(0.02)	30190(1.23)	6027365(7.12)
Orissa	4758000(8.66)	37376(0.43)	9562(0.12)	203855(2.52)	270909(9.49)	87901(3.60)	5367503(6.34)
Bihar Plateau	2082461(3.79)	1063(0.01)	5452(0.07)	248442(3.16)	72316(2.53)	23658(0.97)	2434392(2.87)
Bihar Plains	2843748(5.18)	4132(0.05)	2122(0.03)	617797(7.84)	32089(1.12)	84126(3.49)	3584014(4.23)
East UP	4781410(8.70)	362961(4.16)	212249(2.70)	388949(4.93)	1968(0.07)	538910(22.04)	628444(7.42)
Plains of WUP	1544021 (2.81)	175323(2.01)	645573(8.22)	668997(8.49)	119(0.0)	150141(6.14)	3184174(3.76)
Hills of WUP	462505(0.84)	5(0.000)	41(0.00)	61930(0.79)	45431(1.59)	1078(0.04)	570990(0..67)
Haryana	1325000(2.41)	20000(0.23)	552000(7.03)	70000(0.89)	0(0.0)	16451(0.67)	1983451(2.34)
Punjab	4536000(8.26)	1100(0.01)	54000(0.69)	538000(6.82)	0(0.0)	35700(1.46)	5164800(6.10)
Himachal Prad.	111530(0.20)	37(0.00)	0(0.00)	588611(7.47)	7120(0.25)	0(0.00)	707298(0.84)
Jammu & Kashmir	563437(1.03)	66(0.00)	7971(0.10)	286397(3.63)	0(0.00)	0(0.00)	857871(1.01)
West Rajashan	59618(0.11)	55838(0.64)	1783065(22.70)	35200(0.45)	0(0.00)	492(0.02)	1934213(2.28)
East Rajasthan	157839(0.29)	535053(6.14)	673576(8.51)	193499(15.14)	0(0.00)	12002(0.49)	2571969(3.04)
West MP	439500(0.80)	1843700(21.15)	124100(1.58)	870110(11.04)	604 (0.02)	355200(4.53)	3633214(4.49)
East MP	4293100 (7.82)	90900(1.04)	700(0.01)	218000(2.74)	5499 (0.19)	112800(4.61)	4720999(5.57)
Gujarat region	742400(1.35)	334300(3.83)	916200(11.66)	492000(6.24)	49100(1.72)	205200(8.39)	2739200(3.23)
Saurashtra & Kutch	13900(0.03)	106300(1.72)	691100(8.80)	10100(0.13)	0(0.00)	100(0.00)	821500(0.97)
Konkan & Goa	956775(1.74)	0(0.0)	0(0.0)	300(0.0)	97240(3.41)	2300(0.09)	1056615(1.25)
Madhya Maharastra	508600(10.93)	1093800(12.53)	778800(9.91)	126200(1.60)	150600(5.28)	90500(3.70)	2748500(3.25)
Marathwada	108600(0.20)	984100(11.29)	359700(4.58)	14500(0.18)	300(0.01)	173900(7.11)	1641100(1.94)
Vidarbha	946500(1.72)	1018400(11.68)	9900(0.13)	4500(0.06)	600(0.02)	220300(9.01)	2200200(2.60)
Coastal AP	3821400(6.96)	44500(0.51)	161600(2.06)	41000(0.52)	131200(4.60)	32600(1.33)	4232300(5.00)
Telangana	1894700(3.45)	292400(3.35)	76500(0.97)	453500(5.75)	41800(1.46)	29600(1.21)	2788500(3.29)
Rayalaseema	440300(0.80)	154700(1.77)	112000(1.43)	6100(0.08)	83400(2.92)	11300(0.46)	807800(0.95)
Tamil Nadu	4414360(8.04)	540000(6.19)	391720(4.99)	58660(0.74)	278290(9.75)	69690(2.85)	5752720(6.79)
Cost.Karnataka	398754(0.73)	636(0.01)	0(0.0)	344(0.0)	1565(0.05)	216(0.01)	401515(0.47)
NI Karnataka	569155(1.04)	793254(9.10)	274137(3.49)	297741(3.78)	148120(5.19)	133869(5.48)	2216276(2.62)
SI Karnataka	951798(1.73)	226468(2.60)	13567(0.17)	174465(2.21)	1421047(49.80)	17205(0.70)	2804550(3.31)
Kerala	1077770(1.96)	512(0.01)	0(0.0)	0(0.0)	1066(0.04)	138 (0.01)	1079486(1.27)
Lakshadweep	0(0.0)	0(0.00)	0(0.0)	0(0.0)	0(0.0)	0.(0.0)	0(0.0)
Total	54931414	8717291	7855750	7884366	7853275	2444600	84686696

Note : – Prad : Pradesh ; NMM&T : Nagaland, Mizoram, Manipur & Tripura ; SHWB : Submontane Hilly West Bengal;
W : West; UP : Uttar Pradesh ; MP : Madhya Pradesh;
NI : North Interior; SI : South Interior;

Table 2 *Thrust areas for kharif foodgrains production*.

Sub-division	Important crops
Assam & Meghalya	Rice
Gangetic West Bengal	Rice
Orissa	Rice, Finger millet
Bihar Plains	Rice, Maize
East UP	Rice, Maize, Pigeon pea
Plains of West UP	Maize, Pearl millet, Pigeon pea
Haryana	Pearl millet
Punjab	Rice,Maize
Himachal Pradesh	Maize
East Rajasthan	Sorghum, Pearl millet, Maize
West Rajasthan	Pearl millet
Gujarat region	Pearl millet, Maize, Pigeon pea
Saurashtra	Pearl millet
West MP	Sorghum,Maize, Pigeon pea
East MP	Rice, Pigeon pea
Madhya Maharashtra	Sorghum, Pearl millet, Finger millet
Marathwada	Sorghum, Pearl millet, Pigeon pea
Vidarbha	Sorghum, Pigeon pea
Coastal Andhra Pradesh	Rice, Finger millet
Telengana	Maize
Tamil Nadu	Rice, Sorghum, Pearl millet, Finger millet
North interior Karnataka	Sorghum, Finger Millet, Pigeonpea
South interior Karnataka	Finger millet

Region with 5% or more of the national production of the particular crop has been included for thrust area identification

considered. However, much of it had been a qualitative assessment.

Assessment of drought effects on foodgrains production

Several quantitative estimates have been made only after the rainy season comes to an end. These estimates were successful, more so at the national level.

Production as affected by rainfall and area of cropping : The production of sorghum and pearl millet were tested at national and state level based on long term rainfall and total area, taking state as a unit (Table 3). From the analysis, it is evident that the productivity of sorghum is enhanced over years only in Madhya Pradesh, east Rajasthan and Maharashtra besides a small area in Uttar Pradesh. In all these cases the endowments, in terms of rainfall and soil, are superior. Similarly in the case of pearl millet, the yield increse was significant in Gujarat followed by Maharashtra which again proves the same point. In other words our crop production technologies, as of now, are adequate for the advantaged areas.

Coming to the effect of rainfall on production, sorghum was affected only in Rajasthan and Gujarat while pearl millet showed effect in Gujarat, Uttar Pradesh and Maharashtra. The overall effect on the national basis was perceptible only with pearl millet. This is to be expected as it is relegated to poorer resource based situations.

Steyaert et al. (1981) model of for warning system : But what is now needed is preparing ourselves for the immediate future by developing a fore warning system. Steyaert *et al.* (1981) have evolved such a model for different crops for the south and south east Asia.

Using this model the yield of *kharif* rice and sorghum were estimated. The per cent explained variance for important states are as follows.

State	Per cent explained variance		
	Model	Trend	Weather
		Rice	
UP	79	56	23
MP	79	–	79
Orissa	87	32	55
Punjab	96	93	3
		Sorghum	
Maharashtra	85	71	14
Gujarat	87	71	16
Tamil Nadu	75	37	38
Karnataka	84	–	84

From the above it is clear that weather plays a significant role in production of rice when the area under irrigation is less or when the soil conditions are poorer. Similarly with sorghum the relative variance explained by weather is more with relatively less rainfall or poor soils. These results are in

Table 3 *Regression analysis of production of sorghum and pearl millet in important states.*
Production $= b_0 + b_1 Y = b_2 A + b_3 R$

State	b_0	b_1	b_2	b_3	R^2
			Sorghum		
Maharashtra	– 8163	45.00*	2.64**	0.48	0.88*
(ML, 3.0)		(17.96)	(0.45)	(0.55)	
Mahdya Pradesh	– 3566	30.49**	1.18**	0.29	0.47*
(ML., 2.0)		(11.49)	(0.32)	(0.33)	
Karnataka	– 1325	21.02	0.64	0.17	0.12
(LM, 0.8)		(14.44)	(0.50)	(0.53)	
Andhra Pradesh	– 252	2.15	0.18	0.06	0.07
(LM, 1.0)		(5.52)	(0.21)	(0.14)	
Uttar Pradesh	– 1510	13.24*	1.00**	0.18	0.23
(HM, 0.6)		(7.00)	(0.50)	(0.12)	
Rajasthan	– 1247	9.70**	0.75**	0.32*	0.67**
(LM, 0.9)		(3.05)	(0.14)	(0.12)	
Tamil Nadu	– 107	–2.12	1.18*	0.18	0.74**
(LM, 0.5)		(2.49)	(0.23)	(0.21)	
Gujarat	– 269	5.99	–0.07	0.33*	0.79**
(LM, 0.8)		(3.92)	(0.15)	(0.05)	
All India	–19185	217.05**	–0.84*	1.75	0.72**
		(41.41)	(0.39)	(1.38)	
			Pearl millet		
Rajasthan	– 3550	0.55	0.78**	2.52	0.50*
(L, 4.8)		(19.25)	(0.23)	(0.83)	
Gujarat	– 2568	27.70**	0.67*	0.98**	0.69**
(LM, 2.0)		(11.56)	(0.32)	(0.23)	
Uttar Pradesh	– 1036	6.59	0.85	0.57**	0.56*
(M, 1.0)		(6.00)	(0.54)	(0.17)	
Maharashtra	– 1223	10.02*	0.36*	0.64**	0.86**
(L, 1.7)		(3.13)	(0.08)	(0.13)	
Haryana	– 533	4.28	0.69	0.12	0.13
(L, 0.8)		(8.10)	(0.58)	(0.14)	
All India	–19210	125.95**	0.97**	5.82**	0.70*,*
		(40.41)	(0.30)	(1.68)	

1. Production : x 000 tonnes
Y = Year (e.g. 1980 is 1980 – 1900 = 80)
A = Area : x 000 hectares; R = Av. Rainfall in mm
*P = 0.05 ; **P 0.01

2. Notations in parantheses are as follows :
1st group : Rainfall pattern in order of importance
L : Low (< 750) M : Medium (750 – 1150) H : High (> 1150 mm)
2nd group : Area in million hectares

general agreement with earlier model discussed for sorghum and pearl millet.

The methodology proposed by Steyaert *et al.* (1981) aims at the following :

a) to monitor and assess potential and actual disaster situations due to drought and thereby

b) provide increased lead time for planning strategies to over come the food shortages.

Doorenbos and Kassam (1979) model : Another approach to assess the possible production in advance is the use of the model of Doorenbos and

Kassam (1979). They assessed the effect of water stress on crop yield through an equation, namely

$$1 - \frac{Ya}{Ym} = Ky \left(1 - \frac{ETa}{ETm}\right)$$

Where

Ya = actual harvested yield

Ym = maximum harvested yield

Ky = yield response factor

ETa = actual evapotranspiration

ETm = maximum evapotranspiration

Evidently this model assumes that all other factors affecting the yield are under optimum conditions except water. With some approximations this model was used to estimate the possible effect of moisture stress on yield of rainfed rice grown in the tropical and sub-tropical east Indian conditions with a 1.0 m root profile. The other parameters assumed/adopted are :

ETo = 6.0 m/day

Kc = 1.1 for early vegetative phases (S_1), 1.3 for late vegative phase (S_2), 1.2 for flowering to grain filling (S_3) and 1.0 for ripening stage (S_4)

Ky = 0.5 for S_1, 1.1 for S_2 , 1.5 for S_3 , and 0.5 for S_4

Using the data sets of Doorenbos and Kassam (1979) the per cent of maximum yield obtainable with stress at different phenological stages was estimated (Table 4).

This is no doubt a first attempt with considerable approximations and need refinement, which however is possible.

Seriopus droughts during 1965-90 and kharif foodgrains production

Reduction in kharif foodgrains production in drought affected years : During the last 25 years (1965-90) there had been at least 9 serious droughts (Table 5). The number of sub-divisions and the area affected does not appear to be directly related to the reduction in foodgrains production. So was the case with rice production. As pointed out earlier use of neither of these parameters *per se* determine the

Table 4 *Per cent potential yield obtainable after days of intervel of no rains at different stages of rice crop.*

	Interval (days)				
Stage	7	14	21	28	35
Sowing to early tillering (S_1)	99	92	83	76	–
Late tillering to panicle initiation (S_2)	98	74	54	39	39
Flowering to grain filling (S_3)	97	71	43	22	22
Ripening (S_4)	99.5	95	86	79	–

reduction in production of foodgrains. The soil type, rainfall (amount and distribution) and the physiography seem to be more relevant factors in affecting the moisture availability and fertility and thereby the productivity. Many a time the loss in production of foodgrains is related to loss in rice production. A closer look of the actual *kharif* crop production of foodgrains from 1980-81 to 1987-88 (Table 6) indicates that the loss in production was more reflected by *kharif* rice production. The quantum of reduction is related to the area and the extent of irrigation as well.

Efforts to mitigate drought effect

In order to mitigate the effects of drought the intervention of GOI level had been both long term and short term. At the farmer level, depending on the available production technologies and

Table 5 *Recent droughts : Dimension and their effect on foodgrains production*

	Drought affected		Reduction in foodgrains production from the previous good year (Mts)	
Year	Sub-divisions	Area (%)	Rice	Total
1965	19	66	6.41	17.01
1066	13	48	6.56	15.12
1968	11	22	–	1.05
1972	19	57	3.83	8.14
1974	17	55	4.47	5.36
1979	18	52	11.45	21.80
1982	10	36	6.53	3.18
1986	14	34	3.27	7.02
1987	21	63	6.97	10.01

Table 6 *Kharif rice and total foodgrains production*

Year	Foodgrains production (Mts)		No. of met. sub-divisions affected by drought	Names of important sub-divisions affected by drought with rice as predominant crop
	Rice	Total		
1980-81	50.01	77.65	4	Tamil Nadu & Pondichery
1981-82	49.24	79.38	4	East Madhya Pradesh
1982-83	41.11	69.90	10	Bihar plains, Tamil Nadu
1983-84	55.03	89.23	2	–
1984-85	53.78	84.52	9	Coastal Andhra Pradesh
1985-86	59.39	85.25	9	–
1986-87	53.56	80.20	14	Assam, Bihar plains
1987-88	48.76	74.56	21	Orissa, East MP, East UP, Coastal AP

Table 7 *All India production of foodgrains (Mts)*

Year	*Kahrif*	*Rabi*	Total
1966-67	48.89	25.34	74.23
1967-68	60.76	34.29	95.05
1968-69	59.57	34.44	94.01
1969-70	62.35	37.15	99.50
1970-71	68.92	39.50	108.42
1971-72	62.99	41.18	105.17
1972-73	58.64	38.39	97.03
1973-74	67.84	36.83	104.67
1974-75	59.10	40.73	99.83
1975-76	73.89	47.14	121.03
1976-77	66.53	44.64	111.17
1977-78	77.72	48.68	126.41
1978-79	78.08	53.82	131.90
1979-80	63.25	46.45	109.70
1980-81	77.65	51.94	129.59
1981-82	79.38	53.92	133.30
1982-83	69.90	59.62	129.52
1983-84	98.23	63.14	152.37
1984-85	84.52	61.02	145.54
1985-86	85.25	65.19	150.44
1986-87	80.20	63.22	143.42
1987-88	75.56	65.79	140.35
1988-89	95.64	74.28	169.92
1989-90	100.94	69.69	171.04
1990-91	99.93	76.30	176.23

economics he had been adjusting to the new production systems. Several long and short term research interventions also have been made and being made.

Government of India

Short term interventions : Important among the GOI interventions are the contingent crop planning and compensatory programmes. To mitigate the effects of aberrations in rainfall detailed contingent crop plans were prepared and circulated. However, seed used to be a constraint in the success of this programme. In another effort, areas left unsown or capable of taking a second crop, contingent cropping was suggested, particularly with pulses of the Phaseolus group. That is how the area under short pulses had been gradually increasing in the recent past.

Long term interventions : The major interventions are provision of additional irrigation and developing rainfed farming on a watershed basis.

The per cent coverage under irrigation which was at 17.8 in 1949- 50 stands to-day at 33.2 for the foodgrains. No doubt the two important cereals under irrigation are wheat and rice. Other commodities in importance are maize and gram.

As a consequence, the *rabi* cropping increased and so was its contribution to the national food basket (Table 7). The contribution of *rabi* crop was 35.6% for the triennium ending 1968-69 and it increased to 42.0% for the triennium ending 1990-91.

However, more recent ominous trends indicate gradual shift from foodgrains production to other crops/activities, in the name of crop diversification and economic prosperity. Shifts from rice and wheat to other crops in Punjab and from rice to prawn culture in coastal Andhra Pradesh are a case in point. The best resources go for these ventures. No doubt these activities are minor in nature as on date. But they are likely to increase. It should be our endeavour to prioritise the use of national assets (e.g. Irrigation) provided at such huge costs to the Nation. Foodgrains production should be the priority for us. We are falling short of the target in this regard inspite of concerted governmental intervention. On the one hand, based on trend analysis on the demands of foodgrains Hanumantha Rao Committee suggested the demand for rice and wheat would be 90 and 70 Mts by 2000 AD. And

on the other hand we are unable to be near to these targets even with the SFPP of the GOI. There does not appear to be something in the pipe line to make us confident of a possible break through to achieve these targets. In fact we can even import wheat but not rice from elsewhere. May be this warrants a National debate as any serious drought is going to first affect rice production.

More recent efforts are for developing rainfed farming on watershed basis.

Farmers interventions

In their own way, the farmers had evolved their own contingent cropping and compensatory programmes. Some important aspects are :

i. There is a gradual increase in non-food crops under rainfed farming. The increases in sunflower, safflower and soybean are significant. May be the price support is a possible reason for the shift.

ii. Additional cropping through Phaseolus group/short pulses is on increase in Orissa, Bihar and southern states; of course in the later case it is after rice under protective irrigation.

iii. Under irrigation rape/mustard is on increase.

iv. Potato production increased from 3.91 Mts in 1969-70 to 15.14 Mts in 1989-90. Unfortunately tapioca and sweet potato (both grown more in tribal areas) are on the decline.

Research intervention

Rainfed farming : A well organised crop in rainfed farming would by itself withstand mild stress. And technologies are developed for various agro-climatic zones.

A rainfall analysis on amount, distribution and dependability provides the assured moisture availability periods. Further fine tuning of the methodologies is receiving attention. The possible single, intercropping and double cropping areas in the coutries have been identified and the systems of cropping also suggested (Fig. 3).

For efficient rainwater management, several systems have been suggested. Two issues are now coming into sharp focus. Firstly improved soil management practices to increase efficiency in the use of rainwater help in extending the moisture availability to crops, but does not entirely avert the dangers of drought or prevent crop failure in exceptional seasons. Secondly, there is a need to lay stress on inexpensive and easily adoptable techniques for rainwater management.

For reducing the costs on tillage, several attempts have been made. Off-season tillage, for more efficient use of the idle animal draft, widening the inter-row distance while sowing crops so as to cover more area after a good rain event are some examples. Use of the cheaper and less toxic herbicides with simple but reliable sprayers and seed planters have to be identified.

Irrigated systems : Use of limited water without affecting the yield of crops had been the most important suggestion, more so in years of drought.

The next in importance is the shift from high water demanding crops to low water needing crops, particularly with ground water. A shift from wheat to rapeseed/mustard is one such example.

Possible critical irrigation for rainfed crops in potential areas is another aspect. Pre-sowing irrigation to charge the root profile to take a first crop of pearl millet or mungbean followed by an assured *rabi* crop in east UP, a critical irrigation in the 'Tal' areas of east India for ensuing a good *rabi* crop and supplemental irrgation for pearl millet in south coastal AP and a pre-sowing irrigation for gram in north west India are some examples. Such systems lead sustainable production systems.

Water budgeting for any region is important for proper and efficient use of water. More often over exploitation of groundwater or excessive use of canal water takes place leading to ground water depletion or water logging and consequent salinisation. In areas with subsoil salinity, extensive but limited irrigation was found to be superior to intensive irrigation. Areas with physical restrictions like hard pans also warrant extensive but limited irrigation or use of sprinklers and drip system. For any

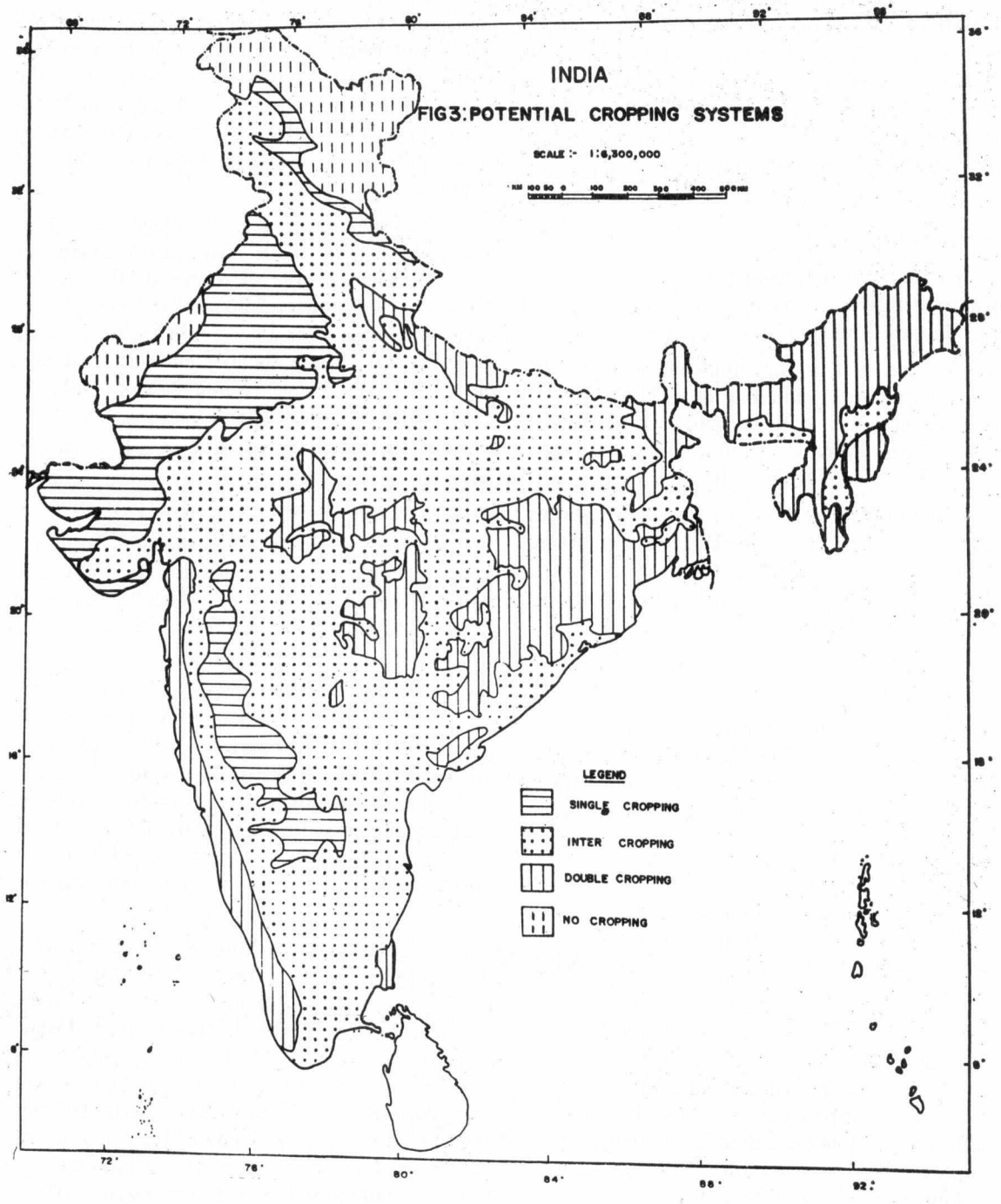

Fig 3 Potential cropping systems.

river valley project, it is important to have a water budget plan for the command area.

The degradation of the catchment area leads siltation of the reservoirs. The live storage capacity of the reservoirs would diminish. Neither the catchment treatment nor provision of drainage for the command area had been components of the earlier river valley projects. May be for the fear that the cost would escalate. All these warant corrections.

At this juncture the FAO's call for shifts in focus of agricultural research and development is relevant which are as follows.

Past	Present
Non–food and cash crops	Upgrading subsistence food crops
Large scale production	Small–scale production
Primeland	Marginal land
Increased productivity	Substainable production
HYVs	Stress resistant cultivars
Mechanization	Animal traction
Monoculture	Intercropping
Irrigation	Rainfed agriculture
Mineral fertilizers	Nutrients recycling
Chemical pesticides	Integrated pest control
Limited number of crops	Crop diversification

Some Issues on tackling drought effects

Good weather code : The foodgrains production is affected by drought. There are two ways of tackling the situation. Firstly the good rainfall years should be fully exploited for developing adequate buffer stock to meet the possible shortages in the drought years. Thus good weather code also needs to be evolved and practised. Secondly there should be more efforts to mellow the effects of drought on foodgrains production. And technologies are available for both the situations. What seems to be more important is post harvest care of the produce particularly of the coarse cereals and pulses. Both R and D efforts seem to be inadequate. Also ware housing facilities that are now concentrated in north western states and partly in Andhra Pradesh must be extended to other areas. They should cover all foodgrains.

Importance of root and tuber crops : World over, root and tuber crops like potato, tapioca and sweet potato are considered as staple food crops. The FAO, in fact, reports their production along with food crops in different countries. Our country produces 21 Mts of root and tuber crops which contributes 2.0 per cent of food intake. This is against 12.1 per cent in the case of the other populous country, China. As said earlier, we are in a happy position with reference to potato. But with regard to the other two commodities, it is a declining trend. They are gorwn by tribals and can be grown under low input systems. Additional efforts are needed to improve their production.

Trends in foodgrains production over the last two decades : A perusal of the *kharif* food crops performance over the last two decades clearly brings out that rice, maize, short pulses, potato, tapioca and sweet potato have improved well in eighties in terms of productivity as compared to seventies. The coarse cereals are declining while pigeon pea is consistent as in seventies. Thus the technology for coarse cereals that contribute upto 30 Mts to the *kharif* kitty, should be more closely looked into and improved. Presently these crops are getting relegated to poorer environments and we do not seem to have adequate technology for such environs as pointed out earlier. Further improvement in pigeon pea also should be seriously attempted.

Rainfed rice–Pros and cons for replacement : Overzealously we point out that rice can be economically replaced with other crops like finger millet, maize, groundnut, etc. in the eastern sector. Out of 29.2 Mha of rice in this sector, estimates suggest that about 1/3rd area only is ideal for such a replacement. Even that would not be possible as "rice is life" and a prestigious crop for the tribals in the region. So we have to evolve graded systems of technology to take the farmers out of the 1.0 t ha-1 level to 2.5-3.0 t ha^{-1} level to solve the perpetual inadequacy in rice supplies at the National level.

Watershed development based rainfed farming : The rainfed farming is tied with watershed development. The funding agencies, in this case World Bank, argue that increase in production is a routine extention activity and resource conservation and rainwater management alone need funding. But

both are equally important. We must get away from the impression that for improved rainfed farming resource conservation is a preamble. All the projects that were launched in low-resource areas with high cost development programmes have failed, perhaps because they address only the sysmptoms, rather than the causes of land degradation. Most of such projects are imposed from above without adequate cultural sensitivity or involvement of local people (Redclift 1988).

The farmer must first be convinced that his land is capable of producing much more than what he has been traditionally obtaining by adopting the simple and easily implementable practices that are already available. Once he realises the potential, then he would automatically care for his land. Then our intervention for resource conservation would be timely and become a catalyst.

Rainwater management: Rainfall is the main source of water for rainfed corps. And the entry of rainwater into the root profile is thus important. From the thirties it is made clear (be it the Bombay Dryland Farming or be it the Dry Farming in the mid west Dust Bowl of USA) that the best way to conserve rainwater is by re-charging the root profile. The criss cross ploughing in castor before the second peak of rains in the Telengana or 'bueshening' operation in upland rice in east India are steps in this direction. If we agree that any suggestion for *in situ* rainwater harvesting has to be easily implementable with the existing tools at the farmer level, we may realise that options are not too many. Off-season tillage, contour farming and ridging and furrowing are some possibilities to conserve rainwater *in situ*, using the existing tools at the farm level.

Place for a critical irrigation : Wherever it is possible, a critical irrigation, if provided, goes a long way in enhancing and stabilizing crop production in rainfed areas. The pearl millet in Nellore District (AP) is grown primarily rainfed but is provided with protective irrigation, if needed. That is why the average yield of pearl millet of this district is double of the national average. Such possibilities exist more in areas where shallow wells are possible o common (e.g.plains of UP and Bihar).

Concluding remarks

Present use of meteorological sub-divisions i the crop/weather monitoring is inadequate as i neither follows the rainfall isohyets nor the crop ping zones. Further the contribution of these sub divisions varies from 0.00 (Laksha dweep) to 7.42% (East UP). This calls for a new approach. May b crop zoning could be one such alternative. Anothe is to adopt the agroecological zones that are nov being finalised by the ICAR and Planning Commis sion. In these zones the assured moistur availability periods, physiography and soil type have considerable commonalities.

Another anolomous aspect in notifyin drought is the use of variation in rainfall. If th rainfall is less than 25% of the normal, that sub division is identified as drought affected. It ha nothing to do with the actual amount received an its distribution. In fact these two paratmeters, whe related to the various phenophases of the crops provide the factual position on the performance o the crop. If AE/PE is less than 0.25, the crop is sai to be drought affected. In simple words it is calle agricultural drought and would be a better index.

Acknowledgements

The assistance of Dr YS Ramakrishna and Dr AS Rao i the analysis for agricultural drought and contribution o meteorological sub-divisions and Dr NL Joshi in the attempt i use of yield response to water model for assessing rice yields i east India is gratefully acknowledged. Most of the data used i the paper emenates from the records of the Ministry of Agricul ture, GOI and is hereby acknowledged.

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(Received 1992 Accepted January 1993).