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RESEARCH NOTES

Dynamics of Cropping Pattern in Sorghum Growing States of India

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I

INTRODUCTION

Sorghum is one of the main staples for the world's poorest and most food insecure people across the Semi-Arid Tropics (ICRISAT, 1996). In India, sorghum was a major cereal during 1950s and occupied more than 18 million hectares area which has come down to 11.6 million hectares as a result of continuous decline over the last three decades (NRCS, 1998). However, it still plays a key role in the lives of millions of rural people by providing food security in less-endowed regions of India (Kelley *et al.,* 1994). A host of competing crops like rice, oilseeds, pulses, groundnut, cotton, etc., have gained area at the expense of sorghum (Hall, 2000 and Kelley and Rao, 1993). However, Dhillon *et al.,* (2001) stated that despite severe competition from major cereals and commercial crops and general neglect by the policy makers and development authorities, this crop has continued to be grown in large chunk of areas in the country.

The cropping patterns are determined in large measures by agro-climatic factors such as soil, temperature and rainfall distribution, i.e., the physical conditions of the region. Crops suited to the given conditions are grown and this is popularly known as traditional cropping pattern of the region. Thus, while agro-climatic factors determine the conditions under which crops are grown, farmers are increasingly influenced by changes in economic, technological, institutional and policy-induced factors (Gulati and Kelley, 1999).

Developments in cropping patterns of the semi-arid tropics (SAT) have important implications for the supply-demand balances of various crops, as well as for efficiency in the use of domestic resources. Shifts in crop area have accounted for deficits of particular crops in the domestic market and pressures for increased imports. With the area under coarse cereals declining without a commensurate increase in yields, the burden of adjustments falls on other cereals particularly wheat and rice. In addition, if raising crop prices above the import parity prices induce crop area changes, it gives an indication of inefficiency in resource use or distortions in cropping patterns. The cropping pattern change in India was a focus of the studies

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during 1960s when a number of investigations on all-India, states and district level exist. However, in recent years the interest of the researchers in these areas has diminished. The recent studies on cropping patterns are more limited or focused on specific crops or states. Moreover, the above studies have considered all the crops at a time without making a distinction between differences that exists in rainy and post-rainy crops, irrigated and unirrigated crops, commercial and subsistence crops. A large number of literature have shown that the area under coarse cereals like sorghum, pearl millet, etc., has been taken away by the crops like rice, wheat, oilseeds, etc., which are winter season crops. Narain (1977) in a study on the cropping pattern changes in India over two periods, viz., 1953/54 to 1961/62 and 1961/62 to 1972/73 reported that low value crops such as coarse cereal grams (sorghum and pearl millet) lost a significant share of area to high value cereals like wheat. Reddy (1985) found a stagnation in the area under sorghum between 1920-21 to 1969-70 in Andhra Pradesh. In another study, Johl and Sidhu (1988) analysed the changes in cropping pattern in different states and in the country as a whole during the triennium ending 1984-85. They reported a 3.85 per cent decrease in area under coarse cereals and replacement of coarse cereals by fine cereals like wheat and rice.

In a diversification study based on growth rates, Ram and Tripathy (1996) found that the cropping pattern change in Orissa has favoured oilseeds and pulses particularly sesamum, groundnut and mung bean. Further, Sharma *et al.* (1996) also reported that the share of cereals in the gross cropped area declined over the years and the decline was mainly due to a larger declining share of sorghum and pearmillet in rainy season. Thus, the change in cropping pattern has favoured the cultivation of more remunerative crops.

Most of these studies on cropping pattern changes are quite general and pertain to the data before 1970s. Thos studies did not make any distinction between rainy and post-rainy season crops, irrigated and unirrigated crops do not make a mention of the shifts of the area under a particular crop and transactions of its area with other crops. With this backdrop, the present study has been undertaken to analyse the transactions of area among different crops in relation to sorghum in six major sorghum-growing states in the country.

II

DATA AND METHOLOGY

The secondary data on area under all major crops were collected for the following six target states: Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Rajasthan for a period of 29 years from 1970 to 1998. These states together account for 89 per cent of the total production and 84 per cent of the area under sorghum crop in the country (Table 1). Data were collected from the Directorate of Economics and Statistics, Government of India, New Delhi. The districts with more than 5,000 hectares of area under rainy sorghum were shortlisted from each of the states. Thereafter, two districts from Andhra Pradesh

(Mahabubnagar and Adilabad); three districts from Maharashtra (Akola, Nanded and Jalgaon); one district from Gujarat (Mehsana); one district from Rajasthan (Nagaur); two districts from Madhya Pradesh (Indore and West Nimar) and two districts from Karnataka (Belgaum and Dharwad) were selected purposively for the analysis.

TABLE 1. AREA AND PRODUCTION OF SORGHUM IN INDIA

States	Area ('000ha)	Production ('000mt)
(1)	(2)	(3)
1. Maharashtra	5093.5	3988.0
	(50.98)	(51.69)
2. Karnataka	1781.0	1634.0
	(17.83)	(21.18)
3. Andhra Pradesh	634.6	512.7
	(6.35)	(6.64)
4. Rajasthan	673.4	134.5
	(6.74)	(1.74)
5. Gujarat	163.2	98.0
	(1.63)	(1.27)
6. Madhya Pradesh	659.8	478.4
	(6.60)	(6.20)
7. All India	9991.4	7715.8
	(100.0)	(100.0)

Source: National Sample Survey, Government of India, New Delhi.
Note: Figures in parentheses indicate the percentage to all India level.

The present study takes into account the area transaction between rainy sorghum and other rainy crops only. There are various reasons for this separation. These are technological (hybrid varieties, input supply), qualitative (grain mould, colour, etc.), economic (price, demand, supply, etc.) and storage factors which come into play between rainy and post-rainy season sorghum. Further the nature of competing crops differs significantly in irrigated and unirrigated and rainy and post-rainy conditions. Most of the studies have ignored this aspect. Therefore, only rainy and rainfed crops were analysed for the purpose. The data collected for the period of 29 years were divided into sub-periods by identifying threshold points. The threshold points were determined by plotting three years moving averages of state-wise production of rainy sorghum. A transition probability matrix was constructed for each sub-period for the state as well as the target districts using Markov chain analysis described below.

Markov Chain Analysis

Markov chain analysis is an application of dynamic programming to the solution of a stochastic decision process that can be described by a finite number of states. The Markov process was used to study the shifts in cropping pattern and thereby gain an understanding about the dynamics of the changes (Kumar, 2000).

Markov Probability Model

A stochastic process is one which can analyse a set of trials or experiments probabilistically. For a stochastic process, it is assumed that the movements (transitions) of objects from one state (possible outcome) to another are governed by a probabilistic mechanism. A finite Markov process is a stochastic process whereby the outcome of a given trial t (t=1.2……T) depends only on the outcome of the proceeding trial (t-1) and this dependence is the same at all stages in the sequence of trials (Lee *et al*., 1965). Consistent with this definition, let Si = i-th state of 'r' possible outcomes (i = 1, 2, ….r);

W_{it} = probability that state 'S_i' occurs in trial 't' or the proportion observed in trial 't' in alternative outcome state of a multinomial population based on a sample of size 'n', i.e., Pr (Sit);

Pij = transitional probability which denotes the probability that if for any time t-th process is in state 'S_i' it moves on next trial to state 'S_i', i.e.,

$$Pr(Si,+1/Sjt)=Pij \quad \ldots.(1)$$

P = (p_{ij}) = transitional probability matrix which denotes the transitional probability and has the following properties

$$0 \leq Pij \leq 1 \quad \ldots.(2)$$

$$\text{and } \Sigma Pij=1, \text{ for } i=1, 2\ldots\ldots r. \quad \ldots.(3)$$

Since the set of notations and definitions for a first order, Markov chain, the probability of a particular sequence 'S_i' on trial 't' and 'E_j' on trial 't+1' may be represented by

$$Pr(Sjt,Sjt+1) = Pr(Sjt)\ Pr\ (Sjt+1/Sjt) = Wit\ Pij \quad \ldots.(4)$$

and the probability of being in state at trial t+1 may represented by

$$Pr\ (Sjt + 1) = \Sigma Wjt\ Pj = Wjt + 1 = \Sigma\ Wit\ Pij \quad \ldots.(5)$$

The data for the study are the proportions of area under the crops. The proportion changes from year to year as a result of the factors like weather, technology, price and institutional changes. It is reasonable to assume that the combined influence of these individually systematic forces approximates a stochastic process and the propensity of farmers to move from one crop state to another differs according to the crop state involved. If these assumptions are acceptable, then the process of cropping pattern change may be described in the form of a matrix 'P' of first order transition probabilities. The element of 'P_{ij}' of the matrix indicates the probability of a farmer in crop state 'i' in one period will move to crop state 'j' during the following period. The diagonal element 'P_{ij}' measures the probability that the proportional share of j-th category of the crop will be maintained.

Estimation of Transition Probability Matrix

Equation (5) derived above forms the basis for estimating the transition probability matrix. If errors are incorporated in equation (5) to account for the difference between the actual and estimated occurrence of W_j (t+1), the sample observations may be assumed to be generated by the following linear statistical model.

$$W_{jt} = \Sigma \text{ Wit Wi, t-1 Pij} + ujt \quad \ldots.(6)$$

In matrix form, it can be written as

$$Y_j = X_j P_j + \mu_j \quad \ldots.(7)$$

Where Y_j = (Tx1) vectors of observations reflecting the proportion in cropping pattern 'j' in time 't'.

X_j = (Txr) matrix of realised values of the proportion in cropping pattern 'i' in time (t-1),

P_j = (rx1) vector of unknown transition parameters to be estimated, and

μ_j = vector of random disturbances.

III

RESULTS AND DISCUSSION

The results are presented as transition probability matrices for in the Appendices 1 and 2. The transition probability matrices for Andhra Pradesh and its two targeted districts, viz., Adilabad and Mahabubnagar are presented in Appendix 1. Appendix 1 demonstrate that the crop of rainy sorghum had a marginal retention of 14 per cent and 16 per cent in Adilabad and Mahabubnagar districts respectively as against a fair retention probability of 41 per cent at the state level in the first period (1970-77) of the study. On the contrary, both the districts have registered a greater probability (51 per cent in Adilabad, 61 per cent in Mahabubnagar) in the later period as against a similar scenario at the state-level (57 per cent). At the state-level, rainy sorghum lost its area to cotton and groundnut with a gain from maize, finger millet and pearl millet, whereas at the district level, Adilabad buttressed a similar pattern by losing its area under the crop to cotton and sesamum. However it gained from sesamum and groundnut. In the case of Mahabubnagar district, the loss of area is mainly towards groundnut, other pulses and castor and gains are from finger millet and pearl millet. This analysis clearly indicate that the area under rainy sorghum declined heavily during 1970s and reached a certain plateau which has showed a fair stability in its area since 1978. So far as the competition is concerned, cotton and groundnut have emerged as the main competitor both at the district- and state-level. The possible reason for the shift of the farmers from rainy sorghum to the cash crops such as cotton and groundnut might be the fact that the farmers in Andhra Pradesh have become more commercialised with the expectation of high returns from farming.

In the state of Maharashtra, the analysis revealed that the probability of rainy sorghum will retain its previous year's area, has decreased over the last three decades (Appendix 2). It was 58 per cent during the first period of the study which decreased to 53 per cent during 1978-84 and further slipped down drastically to 19 per cent during the third period. During 1992-98, the crop registered a probability of 32 per cent to retain its previous year's area. This indicates a declining trend with a mixed result. The major crops which emerged to take over on rainy sorghum's area are pulses, pearl millet and cotton at the state-level. Three districts were targeted for the analysis (Appendix 2). The district of Jalgaon registered a stability of 50-60 per cent in its area till 1992. Since then, the retention probability decreased to 10 per cent. Here, the crop lost mainly to groundnut, pearl millet and cotton. In case of Akola, the retention probability slipped down from 72 per cent during 1970-77 to 2 per cent till 1992 which again went up to 62 per cent during 1993-98. That is to say that the area decreased and reached a certain minimum which has been continued to be allotted to this crop in the study district. Cotton is the most important crop showing a heavy gain from sorghum while mung bean gained marginally. Nanded district stand the strongest of all the three districts which registered a retention probability of its previous year's area between 50 and 85 per cent. It was 64 per cent during 1970-77 and a high of 84 per cent during 1978-84, 61 per cent in 1985-92 and 53 per cent in 1993-98 periods. Though it has come down slightly over years in the recent decade, it has a retention probability of 53 per cent. Like Akola, cotton and mung bean, are the most important competing crops in Nanded.

The dynamics of cropping pattern as captured in the transition probability matrix clearly demonstrates that Karnataka had retention of 31 per cent in 1970-73 with zero retention till 1991. As the first period is quite shorter, it can be stated that the crop of rainy sorghum had a zero probability of retention of its previous year's area till 1992, after which, it has come to heavily stablilise at about 48 per cent. Once again, it might be the case that the area declined continuously with a certain minimum remaining under this crop which is being repeatedly continued with a small portion of reduction every year. It is clear that groundnut and cotton are the competing crops at the state-level (Table 2A). Looking at the district-level, (Table 2B and C) Belgaum shows a fair retention while Dharwad shows mixed results, with high and low levels. In Belgaum, pearl millet and maize were the competing crops whereas in Dharwad, groundnut and cotton turned out to be competing crops of rainy sorghum for its area.

Madhya Pradesh showed a greater instability in its area under rainy sorghum during the 1970s as demonstrated by 11 per cent of retention in the first period and 38 per cent in the second period. However, the third period, i.e, 1988 to 1998 showed a greater retention of 81 per cent. The major losses are towards other pulses and other oilseeds at the state-level. Contrary to this finding, the target districts showed a poor stability in the later periods. In Indore, the retention percentage was 75 per cent during the first period (1970-77) which came down to 17 per cent during 1978-87 and again rose to 36 per cent during 1988-98, whereas in West Nimar, rainy sorghum had

a retention of 65 per cent, 51 per cent and 4 per cent in the first, second and third periods respectively. This demonstrates a huge loss of area in West Nimar in the last decade. Other oilseeds, redgram and gram were found to be the competing crops in Indore while it was groundnut and cotton in West Nimar (Table 3A, B and C).

TABLE 2. *KHARIF* SORGHUM AREA TRANSITION PROBABILITY MATRICES FOR KARNATAKA AND ITS SELECTED DISTRICTS

(*per cent*)

Sr. No. (1)	Period (2)	Retention of previous year's area (3)	Gains from crop (4)	Per cent Gain (5)	Losses to crop (6)	Per cent Loss (7)
			A-Karnataka			
1.	Period 1 (1970-73)	30.57	Total pulses Finger millet	47.19 11.13	Groundnut	69.43
2.	Period 2 (1974-76)	0	Cotton	87	Finger millet Groundnut Cotton	5.89 35.98 58.13
3.	Period 3 (1977-91)	0	Total pulses Cotton	31.41 40.84	Total pulses Pearl millet Cotton	52.6 29.44 17.97
4.	Period 4 (1992-98)	47.5	Total pulses Pearl millet Redgram	7.93 21.46 14.14	Finger millet Groundnut	16.11 36.96
			B-Belgaum			
1.	Period 1 (1970-73)	15.56	Pearl millet Cotton	100 35.5	Safflower Pearl millet Maize Finger millet	9.92 55.3 12.53 6.58
2.	Period 2 (1974-76)	89.85	Groundnut	2.23	Maize	12.53
3.	Period 3 (1977-91)	49.5	Other pulses Finger millet	80.64 4.18	Maize	32.27
4.	Period 4 (1992-98)	75.78	Safflower Other pulses	86.73 2.49	Pearl millet Maize	12.53 3.92
			C-Dharwad			
1.	Period 1 (1970-73)	40.13	Groundnut Finger millet Redgram Gram	50.43 100 96.64 100	Other pulses Groundnut Cotton Pearl millet Finger millet Redgram	11.25 14.03 28.75 0.76 0.82 4.27
2.	Period 2 (1974-76)	3.83	Other pulses Groundnut Cotton Redgram	100 43.98 1.62 100	Groundnut Pearl millet	94.42 1.74
3.	Period 3 (1977-91)	51.49	Cotton	28.07	Groundnut Cotton	45.84 2.66
4.	Period 4 (1992-98)	48.75	Other pulses Gram	27.35 42.11	Other pulses Cotton Finger millet	38.86 4.46 3.44

TABLE 3. *KHARIF* SORGHUM AREA TRANSITION PROBABILITY MATRICES FOR MADHYA PRADESH AND ITS SELECTED DISTRICTS

(*per cent*)

Sr. No. (1)	Period (2)	Retention of previous year's area (3)	Gains from crop (4)	Per cent Gain (5)	Losses to crop (6)	Per cent Loss (7)
			A-Madhya Pradesh			
1.	Period 1	10.56	Other pulses	57.89	Other cereals	31.55
	(1970-77)		Cotton	80.31	Redgram	9.38
					Other pulses	45.55
					Groundnut	2.96
2.	Period 2	37.86	Other pulses	33.52	Maize	21.34
	(1978-87)		Groundnut	10.22	Redgram	9.38
			Cotton	94.29	Other pulses	6.38
					Groundnut	7.17
					Cotton	11.47
					Soybean	7.4
3.	Period 3	80.94	-		Other cereals	19.04
	(1988-98)				Cotton	0.02
			B-Indore			
1.	Period 1	75.2	Gram	14.12	Groundnut	4.48
	(1970-77)		Maize	16.33	Gram	9.61
					Redgram	10.72
2.	Period 2	16.75	Gram	32.39	Gram	72.78
	(1978-87)		Redgram	59.17	Other oilseeds	10.47
			Other pulses	25.92		
			Other oilseeds	11.46		
			Maize	18.29		
3.	Period 3	35.92			Groundnut	0.23
	(1988-98)				Redgram	4.44
					Other oilseeds	59.4
			C-West Nimar			
1.	Period 1	64.52	Pearl millet	26.19	Pearl millet	12.34
	(1970-77)		Groundnut	49.83	Redgram	0.86
			Cotton	4.04	Groundnut	22.28
2.	Period 2	50.62	Cotton	49.53	Cotton	49.38
	(1978-87)					
3.	Period 3	4.34	Cotton	49.98	Pearl millet	5.98
	(1988-98)				Redgram	4.15
					Groundnut	22.14
					Cotton	45.45
					Maize	17.95

The state of Rajasthan has shown a fluctuating probability of retaining its previous year's area share which is also corroborated by the results of target district (Table 4A and B). A retention probability of 25 per cent each is observed in both the first and third periods and in the second and fourth period it was 47 per cent each respectively. Pearl millet and maize turned out to be the most significant competitors of the crop at the state-level. The situation at the district-level is worse as buttressed by the results of Nagaur district. The transition probability matrix constructed for Nagaur district showed zero retention throughout the study period since 1970. The probability of losing its area to pearl millet is the highest and pulses come next. As at the state-level, the district also shows that pearl millet is the most important competing crop of sorghum (rainy).

TABLE 4. *KHARIF* SORGHUM AREA TRANSITION PROBABILITY MATRICES FOR RAJASTHAN AND ITS SELECTED DISTRICTS

(*per cent*)

Sr. No. (1)	Period (2)	Retention of previous year's area (3)	Gains from crop (4)	Per cent Gain (5)	Losses to crop (6)	Per cent Loss (7)
			A-Rajasthan			
1.	Period 1 (1970-77)	75.16	Sesamum	74.8	Maize	9.02
			Pearl millet	91.77	Other pulses	0.26
					Sesamum	2.41
					Groundnut	0.98
					Rape and Mustard	4.46
					Cotton	2
2.	Period 2 (1978-83)	74.66	Other pulses	45.43	Maize	5.47
			Groundnut	2.92	Other pulses	21.14
			Pearl millet	68.51		
3.	Period 3 (1984-88)	53.30	Pearl millet	42.62	Maize	14.45
			Maize	21.52	Sesamum	7.96
			Other pulses	43.32	Groundnut	3.02
			Sesamum	100	Rape and Mustard	21.82
4.	Period 4 (1989-98)	48.80	Pearl millet	66.07	Maize	15.77
			Other pulses	47.41	Other pulses	15.44
			Sesamum	87.05	Groundnut	12.71
			Groundnut	85.14	Rape and Mustard	11.46
					Cotton	4.69
			B-Nagpur			
1.	Period 1 (1970-77)	0	Pearl millet	7.76	Pearl millet	100
			Gram	31.86		
2.	Period 2 (1978-83)	0	Sesamum	55.43	Pearl millet	100
			Gram	9.29		
			Groundnut	13.82		
3.	Period 3 (1984-88)	0	Pearl millet	2.66	Pearl millet	100
			Sesamum	35.67		
			Groundnut	13.82		
4.	Period 4 (1989-98)	0	Pearl millet	5.37	Maize	0.48
			Sesamum	14.08	Other pulses	99.52
			Other pulses	0.52		
			Maize	20		

The state of Gujarat registered a weak stability in *kharif* sorghum area with a zero retention probability between 1970 and 1985. However, the crop showed a high retention of 84 per cent for a shorter period of three years and again slid down to 34 per cent during the later period (Table 5A). The major competing crops are groundnut, cotton, pearl millet and maize at the state level. Similar pattern is observed at the district level as corroborated by the results for Mehsana district, which too showed a greater retention (94 per cent) in the last decade (Table 5B). Cotton and castor stood to compete the crop in the district. This gives an indication that only a small portion of area is allocated towards this crop which is being repeated yearly.

TABLE 5. *KHARIF* SORGHUM AREA TRANSITION PROBABILITY MATRICES FOR GUJARAT AND ITS SELECTED DISTRICTS

(*per cent*)

Sr. No. (1)	Period (2)	Retention of previous year's area (3)	Gains from crop (4)	Per cent Gain (5)	Losses to crop (6)	Per cent Loss (7)
			A-Gujarat			
1.	Period 1 (1970-79)	0.00	Pearl millet	9.33	Maize	16.48
			Maize	55	Groundnut	44.08
			Cotton	33.42	Cotton	39.44
2.	Period 2 (1980-85)	0.00	Cotton	65.06	Pearl millet	84.94
					Maize	15.06
3.	Period 3 (1986-88)	84.31	Pearl millet	2.86	Pearl millet	15.69
4.	Period 4 (1989-98)	33.79	Groundnut	22.71	Maize	13.67
			Castor	23.47	Cotton	52.44
			Cotton	5.17		
			B-Mehsana			
1.	Period 1 (1970-79)	51.14	Groundnut	37.22	Groundnut	0.53
			Pearl millet	16.15	Pearl millet	3.59
			Cotton	6.77	Cotton	44.34
			Sesamum	100	Sesamum	0.4
2.	Period 2 (1980-85)	0.00				
3.	Period 3 (1986-88)	1.31	Castor	65.17	Groundnut	0.99
			Cotton	41.96	Castor	64.77
			Sesamum	100	Cotton	8.72
					Redgram	10.76
					Other pulses	11.59
					Sesamum	1.86
4.	Period 4 (1989-98)	94.04			Pearl millet	1.21
					Redgram	4.75

The results clearly reveal that there is a considerable reduction in the area under sorghum which has been taken away by the crops like cotton, groundnut, maize, pearl millet, mung bean, redgram, etc. Among all these crops, cotton and groundnut are the most important competing crops of rainy sorghum in most of the sorghum growing states of India. The possible reason for this shift of the farmers from these traditional crops to other crops can be summarised into two categories viz., (a) Consumption consideration, and (b) Profitability consideration.

Pertaining to the consumption consideration of the local people, sorghum is considered as inferior commodity as against the fine cereals such as wheat and rice. The cultivation of these two fine cereals has been favoured by a host of factors such as irrigation, government policy like PDS (Public Distribution System). Expansion of irrigation has favoured the crops like rice and wheat which are invariably irrigated. Further, the availability of fine cereals through PDS has made the people to change the tastes and preferences towards fine cereals which in turn has led to the decline in consumption demand for sorghum. This has been reflected in lower area allocation by the farmers over years (Table 6).

TABLE 6. AVERAGE PER CAPITA MONTHLY CONSUMPTION OF SORGHUM

(kgs per capita per month)

	Andhra Pradesh		Maharashtra		Karnataka	
Year	Rural	Urban	Rural	Urban	Rural	Urban
1972-73	3.2	1.5	5.9	1.8	4.6	2.6
1988-89	1.2	0.5	5.8	1.8	4.1	2.0
1993-94	1.0	0.3	4.7	1.5	4.0	1.7
1998-99	0.44	0.13	3.05	1.13	3.27	0.89

Source: National Sample Survey Organisation (NSSO) various rounds, New Delhi.

The National Sample Survey (NSS) data clearly show that the average per capita consumption of sorghum has dropped steadily for the last three decades. This has happened in both rural and urban sectors and amongst the poor as well as in high income groups.

Regarding the profitability motive of the farmers, the relative prices of sorghum has not been on par with those of other crops in competition and thus has not encouraged the farmers to go for sorghum cultivation (Table 7). It clearly demonstrates that though the price variable has a positive coefficient, the appreciation is far below when compared to that of the competing crops like cotton and groundnut over a period of 29 years in almost all the states across India. This provides disincentive to the farmers to allocate their area to sorghum crop. This confirms that the farmers are profit-motivated and in the case of sorghum cultivation, both price and non-price factors are responsible for decline in sorghum area in general and in that of rainy sorghum in particular but the profit motive dominate the scenario.

TABLE 7. ESTIMATES OF LINEAR TRENDS IN ANNUAL WHOLESALE PRICES OF SELECTED CROPS (1980-98)

Sr. No.	Crop	Andhra Pradesh	Karnataka	Maharashtra	Madhya Pradesh	Rajasthan	Gujarat	Tamil Nadu
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	Rainy sorghum	29.08** (10.56)	17.35** (7.43)	28.34** (8.53)	17.45** (8.97)	-	29.94** (8.19)	24.51** (9.73)
2.	Post-rainy sorghum	35.25** (9.26)	-	-	-	-	-	-
3.	Finger millet	-	17.48** (7.16)	26.37** (11.74)	-	-	-	20.03** (11.87)
4.	Pearl millet	23.26** (11.00)	19.35** (8.64)	22.08** (9.12)	-	17.54** (9.69)	21.05** (11.60)	20.42** (10.55)
5.	Maize	-	19.83** (12.16)	-	22.10** (9.03)	20.37** (10.98)	21.13** (10.09)	-
6.	Groundnut	60.11** (7.17)	48.94** (8.01)	86.81** (17.58)	71.40** (8.29)	-	61.13** (7.16)	76.28** (16.71)
7.	Redgram	93.50** (10.48)	125.53** (5.48)	73.61** (10.75)	102.60** (10.32)	63.71** (9.69)	-	105.92** (9.05)
8.	Cotton	84.16** (9.75)	-	-	-	71.75** (7.37)	75.90** (6.71)	142.92** (9.05)
9.	Sunflower	-	55.52** (8.72)	-	-	-	-	-
10.	Soybean	-	-	-	31.99** (8.12)	-	-	-

Source: Various issues of *Agricultural Situation in India*.

Figures in parenthesis indicate 't' values.

** Denotes significance at one per cent level of P.

Given such a situation, a basic question arises that why the farmers still continue to cultivate sorghum. This can be justified by examining the relative importance of sorghum as food and fodder to the local people. It is clear from Table 8 that both the food and fodder requirement has bearing on sorghum cultivation. In fact with the increase in income of the households over years, the preference of sorghum as food has declined and while that of fodder increased. It is also discerned from the table that except in Nanded district, the other three districts have a larger proportion of the respondents expressing that fodder is the main purpose of growing sorghum rather than grain. This was true with respect to the average of all the rainy districts and also for the entire set of the respondents. It can also be derived that when grain and fodder are taken together, less than half of the respondents (43 per cent) gave equal importance to them.

TABLE 8. RELATIVE IMPORTANCE OF SORGHUM GRAIN AND FODDER

(*per cent of the respondents*)

Districts / Factors	Nanded	Akola	Amravati	Mahabubnagar	Total
(1)	(2)	(3)	(4)	(5)	(6)
Mainly for grain	25.97	13.16	14.29	21.54	17.72
Mainly for fodder	19.48	46.05	34.52	29.23	33.33
Gave equal importance	51.95	40.79	50.00	43.08	47.68
Others	2.60	0.00	1.19	6.15	1.27
Sample size	76	90	98	47	311

Source: NRCS-NRI-ICRISAT, 1999.

IV

CONCLUSIONS AND POLICY IMPLICATIONS

The in-depth analysis of cropping pattern changes in the rainfed farming system of India with regard to sorghum revealed that the area under rainy sorghum crop declined significantly in all the states and districts. The replacement of the sorghum crop is judged by its status in the transition probability matrix over other crops. The results differ across the states and across the districts within them. There is clear indication that in almost all the states, the area under sorghum was highly unstable losing to other competing crops during the 1970s and 1980s. The loss has reached a certain plateau during 1990s and that is being continued with a steady decline every year. In the state of Andhra Pradesh, cotton and groundnut turned out to be most important competing crops of sorghum at the state-level and was also buttressed by the results of Adilabad district whereas in Mahabubnagar district, other pulses and castor also competed with rainy sorghum. In the state of Maharashtra, cotton appeared to compete both at the state and district level while other pulses and pearl millet were other crops competing at state level. Mungbean showed up in Nanded district and groundnut in Jalgaon district. Rajasthan had consistent competing crop, i.e., pearl millet, both at the state and district (selected) level. Out of the two selected

districts in Madhya Pradesh, Indore confirmed to the competing crops at the state-level while in West Nimar, a whole set of other crops such as groundnut and cotton were competitors of rainy sorghum. Similar is the case with Karnataka as one of the two target districts, viz., Dharwad had the same competing crops at the state-level while the Belgaum district had another set of competing crops such as pearl millet and maize, Gujarat has cotton as the most important competitor of rainy sorghum both at the state and district level.

An examination of the transactions of the area under rainy sorghum with other crops indicates that the crop has lost its area to cotton, groundnut, pulses, oilseeds, pearl millet, etc., over the last three decades. This is due to the fact that the crop fails to be accounted for consumption consideration and/or profitability consideration. The constant decline in consumption (both rural and urban) has not been able to bind the farmers to allocate their area to this crop. Besides, with growing commercialisation and liberalisation of the economy, the once subsistence farming system is taking a turn towards the commercial farming system. In such a scenario, cash crops like cotton, groundnut, etc., have been more profitable and attractive thus taking the area away from sorghum. However it is heartening to note that the farmers still continue to grow sorghum. This is due to the fact that sorghum is being increasingly given importance as a fodder. Nevertheless, in this structural transformation, it is more likely that the area under this crop will further come down if only the staple food requirement alone is taken into consideration by the policy makers. This necessitates the focus of the scientific research and policy measures on the alternative and commercial utilisation of sorghum which will augment its use and make it a profitable crop.

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APPENDIX 1

KHARIF SORGHUM AREA TRANSITION PROBABILITY MATRICES FOR ANDHRA PRADESH AND ITS SELECTED DISTRICTS

(*per cent*)

Sr. No. (1)	Period (2)	Retention of previous year's area (3)	Gains from crop (4)	Per cent Gain (5)	Losses to crop (6)	Per cent Loss (7)
			Andhra Pradesh			
1.	Period 1 (1970-77)	41.21	Finger millet	19.68	Pearl millet	1.76
			Maize	100	Other pulses	5.81
			Groundnut	28.18	Groundnut	24.3
					Cotton	26.92
2.	Period 2 (1978-98)	56.86	Pearl millet	35.94	Finger millet	13.18
			Finger millet	51.8	Other pulses	5.68
					Groundnut	24.28
			Adilabad			
1.	Period 1 (1970-77)	14.33	Redgram	100.00	Castor	7.70
			Other pulses	59.00	Sesamum	6.98
			Cotton	26.00	Cotton	77.70
2.	Period 2 (1978-98)	50.68	Groundnut	69.93	Sesamum	49.00
			Mahabubnagar			
1.	Period 1 (1970-77)	15.52	Pearl millet	91.32	Pearl millet	7.38
			Other pulses	11.15	Other pulses	22.52
			Groundnut	78.88	Groundnut	15.27
			Castor	64.87	Castor	34.73
					Cotton	3.10
2.	Period 2	61.03	Pearl millet	55.91	Groundnut	36.86
	(1978-98)		Other pulses	9.28	Finger millet	2.11
			Groundnut	7.65		
			Finger millet	100.00		

APPENDIX 2
KHARIF SORGHUM AREA TRANSITION PROBABILITY MATRICES FOR MAHARASHTRA AND ITS SELECTED DISTRICTS

(*per cent*)

Sr. No. (1)	Period (2)	Retention of previous year's area (3)	Gains from crop (4)	Per cent Gain (5)	Losses to crop (6)	Per cent Loss (7)
			Maharashtra			
1.	Period 1 (1970-77)	58.41	Gram	100	Pearl millet	9.4
			Redgram	100	Redgram	16.74
			Groundnut	19.03	*Kharif* pulses	15.44
			Safflower	8.22		
2.	Period 2 (1978-84)	52.75	Pearl millet	9.85	Redgram	6.75
			Gram	17.35	Cotton	37.87
			Kharif pulses	31.69	Safflower	2.63
			Groundnut	31.74		
3.	Period 3 (1985-92)	19.40	*Kharif* pulses	84.7	Pearl millet	32.34
			Cotton	12.02	Gram	14.55
					Kharif pulses	2.51
					Groundnut	18.35
4.	Period 4 (1993-98)	19.10	*Kharif* pulses	85.5	Pearl millet	32.30
			Cotton	12.5	Gram	15.30
					Kharif pulses	2.40
					Groundnut	18.46
			Jalgaon			
1.	Period 1 (1970-77)	47.14	Groundnut	100	Pearl millet	17.14
			Redgram	50.72	Cotton-rainfed	11.73
					Groundnut	20.15
					Redgram	3.84
2.	Period 2 (1978-84)	56.6	Pearl millet	22.43	Pearl millet	11.5
			Cotton-rainfed	21.62	Mung	14.27
			Groundnut	42.88	Cotton-rainfed	2.05
					Groundnut	14.54
					Safflower	1.04
3.	Period 3 (1985-92)	61.08	Cotton-rainfed	49.23	Mung	8.75
					Cotton-rainfed	2.26
					Groundnut	22.51
					Safflower	4.43
					Redgram	0.97
4.	Period 4 (1993-98)	10.46	Pearl millet	90.88	Pearl millet	19.36
			Cotton-rainfed	1.23	Mung	12.91
			Groundnut	14.62	Cotton-rainfed	24.08
			Sesamum	68.42	Sesamum	28.88
			Redgram	100	Redgram	4.31
			Akola			
1.	Period 1 (1970-77)	72.39	Redgram	44.00	Redgram	6.85
			Cotton-rainfed	13.00	Gram	1.60
			Groundnut	44.00	Cotton-rainfed	11.07
			Sesamum	47.00	Pearl millet	2.10
2.	Period 2 (1978-84)	18.10	Gram	100.00	Cotton-rainfed	98.19
			Mung	43.00		
			Cotton-rainfed	65.00		
			Groundnut	8.33		
			Pearl millet	100.00		

(Contd,)

APPENDIX 2 (Concld.)

Sr. No. (1)	Period (2)	Retention of previous year's area (3)	Gains from crop (4)	Per cent Gain (5)	Losses to crop (6)	Per cent Loss (7)
3.	Period 3 (1985-92)	2.30	Redgram	3.70	Gram	6.95
			Mung	7.00	Cotton-rainfed	88.08
			Cotton-rainfed	68.00	Groundnut	1.84
					Pearl millet	0.74
4.	Period 4 (1993-98)	62.00	Gram	46.41	Redgram	6.51
			Cotton-rainfed	13.13	Gram	7.04
			Groundnut	55.07	Mung	19.00
					Cotton-rainfed	6.11
					Pearl millet	0.45
					Sesamum	0.67
			Nanded			
1.	Period 1 (1970-77)	64.2	Redgram	90.59	Redgram	15.84
			Mung	71.09	Mung	13.89
			Groundnut	100	Cotton-rainfed	3.44
			Sesamum	11.21	Sesamum	2.35
2.	Period 2 (1978-84)	84.44	Mung	88.78	Safflower	0.28
			Cotton-rainfed	0.28	Redgram	15.56
			Groundnut	28.01		
			Safflower	43.83		
			Sesamum	75.26		
3.	Period 3 (1985-92)	61.42	Mung	88.78	Redgram	15.56
			Cotton-rainfed	0.28		
			Groundnut	28.01		
			Sesamum	43.83		
			Safflower	75.26		
4.	Period 4 (1993-98)	52.57	Redgram	100	Redgram	12.1
			Mung	8.17	Mung	1.43
			Cotton-rainfed	12.77	Cotton-rainfed	28.98
			Safflower	100	Groundnut	2.52
					Safflower	2.16