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9. ABSTRACT

This report describes how a region's natural resources, the level of technology, relative commodity prices, and market infrastructure determine the cropping pattern of an area. Farm level resources are separated into two categories: (1) those for which utilization is more or less rigidly determined by ownership and (2) those where accessibility to and utilization of the resource is not determined by ownership. The first category includes resources such as land, while the second includes such things as labor, bullocks, and farm equipment. The topics discussed include the impact of: major resource investments, canal irrigation, tractorization, and cross sectional analysis of resource differences. Within the resource base, the land types, irrigation, and rainfall play the most important roles. These basic resources, together with the availability of crop varieties, markets and the relative prices of commodities determine the comparative advantage of different crops and crop mixes on the various soil types and also the rate of return to investment in improvement of the resource base. Massive resource transformations which alleviate major constraints such as those indicated by canal irrigation and tractorization overshadow the impact of other resource differences and can lead to shifts in cropping patterns in particular directions for farms in different categories. Such resource improvements orient the cropping patterns towards high value crops and tend to reduce the importance of mixed crops. Introduction of new varieties tends to change patterns of comparative advantage of different crops and may lead to shifts in cropping patterns as well as investment incentives for other capital items.

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RESOURCE BASE AS A DETERMINANT OF CROPPING PATTERNS

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Resource Base As A Determinant of Cropping Patterns*

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A region's natural factor endowment together with the level and type of technology and relative commodity prices and market infrastructure set the broad limits within which the potential cropping pattern of an area are determined. However, the extent to which this potential is realized in practice depends to a substantial degree upon farmers' capacities to harness it. This in turn depends upon their resource position. It is in this sense that the resource base may be considered as one of the major determinants of cropping patterns. The impact of the resource base on cropping patterns may be measured by (i) changes in cropping patterns over time, following changes in resource base; or (ii) differences in cropping patterns of farmers with varying farm-level resource endowments at a point in time.

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Viewed retrospectively, the quantitative and qualitative make-up of the farm-level resource base is generally an accumulated outcome of the cropping pattern itself. The agronomic and related requirements of crops determine (from the demand side) the type and quantity of man-made and other resources, and the returns from the crops determine (from the supply side) the ability of a farmer to acquire and sustain the type and quantity of resources required. We do not propose to enter into a discussion here of the way the causality runs.

The direct impact of the resource base on cropping patterns is mainly through the use of resources as inputs into the production process. Since the utilization of a resource as a factor in crop production is not always rigidly tied with its ownership, the association between resource position of individual farms and their cropping pattern is not straightforward.

The total availability of the household's own resources influences the pattern of deployment or utilization of those resources on the farm. However, the actual decision about the use of resources is dictated by the relative availability of profitable alternatives on and off the farm. The crops potentially possible on one's own farm constitute only a part of the total alternatives. Other employment possibilities--on one's own as well as other farms--or engagement in non-farm activities are alternatives which must be taken into account. If substantial resources are deployed off one's own farm the direct impact of total resource availability on one's cropping pattern will not be reflected.1/

One way of handling the above problems is to separate farm-level resources or production factors into two categories : (i) those for which utilization is more or less regidly determined by their ownership, (ii) those where accessibility to, and utilization of the resource is not determined by their ownership. The former category will comprise resources such as land, the availability of which for a given household is fixed, at least for any single crop season. There is little possibility of intra-seasonal lease/sale transactions, and hence cropping decisions for the season may be influenced by the total availability of land. The second category would comprise resources like labour, bullocks, or farm-equipment etc., where utilization need not be tied with ownership. The hire or purchase market for these resources is never dormant (as in the case of land after the inception of the crop season) and the possibility of acquiring or supplying them to others is always open. Accessibility to the second category of resources through factor markets, rather than by possession (as a part of households' fixed resource base), is of relevance while studying their impact on cropping patterns.

1/ For instance, households with a larger number of family workers theoretically should grow more labour intensive crops. Owing to the above reasons they may go in for low labour intensive crops which help in releasing labour for exploiting alternative and better earning opportunities offered by other farms during the crop season.

The difference between the two categories of resources based on the extent of deviation between their ownership or possession and actual utilization may tend to disappear once one proceeds from micro to macro levels of observation. In otherwords, the utilization of a resource will be more and more conditioned by actual possession (or availability) as one moves from household to village, from village to a cluster of villages and from a cluster of villages to a much bigger geographical unit, such as a district or a region. This is so because mobility which reduces the gap between requirement and availability of most of the physical resources becomes more difficult as one moves from smaller to bigger spatial units.2/

The above arguments have the following implications for the subsequent discussion :

a) Household-level analysis of the impact of resource base on cropping patterns can be meaningfully attempted only in terms of the relationship between operational holdings and cropping patterns. This is justified because land use and cropping decisions are more effectively conditioned by amount of land possessed rather than any other resources owned. Moreover, in traditional agriculture, land ownership (symbolizing wealth position) primarily determines one's capacity to hire in or hire out other complementary factors--labour, bullocks and so forth. A more aggregative analysis at the village or regional level is appropriate for the other resources.

2/ Difference between resource possession and the extent and pattern of its utilization, may still persist because of weather variability. For example, in rainfed areas the intensity with which a resource can be used and what crops can be planted during a year will be determined by the timing and quantum of rains, notwithstanding the availability of other complementary resources.

b) If some major transformation of the resource base (such as through an irrigation project) takes place at the regional level and overshadows the impact of other resource differences, then similar cropping patterns could result both at the household and the more aggregative level. This will be demonstrated by measuring the impact of canal irrigation and tractorization on cropping patterns in Rajasthan (Tables 1 and 2).

IMPACT OF MAJOR RESOURCE INVESTMENTS

As mentioned earlier, one convenient way to observe the role of the resource base in determining cropping patterns is to examine the changes in resource base and consequent changes in the cropping patterns over time. Examples of the substantial changes which can occur in cropping patterns due to a large-scale increase in the resource base were observed in studies in Rajasthan reported by Bapna (1973) and Jodha(1974).

IMPACT OF CANAL IRRIGATION

Table 1 contains data for 1966-1967 and 1971-1972 from four villages in the semi-arid tropical district of Kota in Rajasthan state of India. This largely rainfed area received irrigation for the first time from the Chambal Irrigation Project during the early sixties and it has initiated the process of transformation of the whole area.[3] Even during the period under consideration, the proportion of irrigated area to total cropped area, 21 to 76 percent in the base year, has increased to between

3/ For details see Agro-Economic Research Centre(1970), Bapna (1973).

Table 1 : Changes in cropping patterns following the increase of irrigation in four SAT villages of Kota, Rajasthan (India) (1966-1967 and 1971-1972)

Crops	Proportion of total cropped area under various crops in different villages 1966-67 and 1971-72							
	Dhakarkheri		Kishanpur		Kishorepura		Digod	
	66-67	71-72	66-67	71-72	66-67	71-72	66-67	71-72
	-(%)-							
Irrigated area a/	76	92	36	72	21	50	34	60
Crops :								
Paddy	8	27	2	7	--	2	1	15
Sorghum alone or as mixed crop b/	4	1	37	10	21	3	31	16
Other Kharif crops c/	10	7	8	4	5	2	5	2
Irrigated wheat	48	56	--	49	14	41	18	39
Dry wheat alone or as mixed crop d/	11	1	27	--	20	11	23	14
Chickpeas	9	6	16	9	25	30	9	5
Other rabi crops e/	10	2	10	21	15	11	13	9

a/ As percent of sown area.

b/ Mixed crop is usually sorghum (as the main crop) grown with pulse crops.

c/ Maize, pulses, sesamum, groundnut, and fodder crops, mainly.

d/ Local (non-HYV) wheat; mixed crop is usually with barley or chickpeas

e/ Linseed, Coriander, vegetables, etc. (Source: Bapna 1973).

Table 2 : Changes in cropping patterns on 112 farms following tractorization in a cluster of three villages in Nagaur district, Rajasthan, India

Farm size groups	Year	Tractor cultivation (%) a/	Land use intensity b/	Proportion of total cropped area under						
				Pearl Millet	Sorghum	Sesamum	Green gram	Moth bean c/	Cluster bean	Fodder sorghum
(ha)		-(%)-								
1.0-6.1	64-65	1	89	30	25	2	1	20	16	6
	73-74	64	95	37	31	12	7	8	4	1
6.2-12.1	64-65	7	73	28	24	5	4	14	14	11
	73-74	58	88	31	28	16	13	4	7	1
12.1 & above	64-65	5	68	22	24	9	5	17	13	10
	73-74	88	93	29	28	12	13	6	10	2
Tractor users	64-65	4	86	25	24	7	3	16	15	10
	73-74	74	94	30	29	14	12	5	9	1
Non-tractor users d/	64-65	--	84	26	20	7	6	13	15	13
	73-74	--	87	24	21	5	5	15	17	13

a/ Proportion of total cropped area receiving tractor cultivation.

b/ Percentage of total cultivable area (including current fallow, old fallow, permanent fallow, and cropped area)put under crops.

c/ *Phaseolus aconitifolius*.

d/ Twenty three farmers did not use a tractor in either of the years

(Source : Jodha 1974)

50 and 92 percent. This has generated a change in cropping pattern; high-value crops such as paddy, irrigated wheat, and vegetables have in some cases replaced the low-value crops of sorghum, maize, pulses, chick-peas, and barley. Mixed crops (dominated by sorghum in rainy season plantings and by non-HYV wheat, chickpeas, and barley during the post-rainy season) were common features in cropping patterns in the region, and these have lost ground to high-value crops, which are generally sown alone. The gradual disappearance of low-value crops, particularly coarse cereals, following the upgrading of the resource base through irrigation has been a common feature observed in different areas of India (Jodha, 1973). In the case of the Kota village, the pace of disappearance of low-value crops and mixed cropping seems to have been accentuated by almost simultaneous availability of high-yielding varieties of paddy and wheat.4/ The reasons for the above changes include inability of the low value crops to "compete" in the changed context, redundance of mixed cropping as a strategy against risk once irrigation arrives and the advent of HYV technology which seems to lead to more sole cropping.

4/ For details of the spread and impact of HYV's in Kota District see Agro-Economic Research Centre (1970) and Bapna (1973).

IMPACT OF TRACTORIZATION

Qualitatively different, but equally strong, cropping pattern changes occured in a cluster of villages in the arid region of Rajasthan State in India. The annual average rainfall of the area is 31.9 cm. and less than one percent of the cropped area has an irrigation facility. The only change in the factor endowment of this area during the last 15 years has been the replacement of bullocks by tractors for cultivation on a substantial scale. The overall extent of tractor cultivation increased from 4 percent of the total cropped area in 1965-1966 to 74 percent during 1971-1972 (Table 2).[5/] On the face of it, the agro-climatic conditions of the area--low and unstable rainfall and sandy loam soils--would seem to make the tractor a risky, uneconomical, and wasteful innovation. However, in reality, these very conditions have enhanced the spread of tractor cultivation in the area for reasons which we will explain.

The area not only has low rainfall, but the rains occur usually in two to four showers during July and August. This limits the sowing period to 2 to 4 weeks. The wet period is further shortened by fast winds in the area. Thus the success of the crop is determined by one's

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5/ Average size of farms ranged from 8 to 12 hectares. For details see Jodha (1974).

capacity to exploit the short wet periods. The consequences of delayed sowing (for want of sufficient draft power during the peak periods) include need for resowing or lower crop yields due to poor germination, poor crop stand and dessicating winds (described as Jhola) during mid-September to October which adversely affect the late-sown crops at their seed formation stage.6/ Thus from the demand side, for technical reasons alone, any facility which helped farmers overcome the problem created by a short wet period vis-a-vis their limited draft power was readily acceptable. Furthermore, any potential user of the tractor service did not have to own a tractor. Informal custom-hire-services offered by tractor owners operating large farms (or by groups of owners of medium-sized farmers) became popular. One of the reasons for the popularity of custom hiring was its flexibility in terms of time and the form of payment of the charges. The charges were accepted only when the customer was in a position to pay, e.g. during the harvest period. Payment in any form, including cash, grain, fodder, fuel, labour or leased-out land, was welcome. For the tractor-owners it became an important source of income as well as an instrument of influence in the village product and factor markets, and also in the non-economic sphere of community life. The

6/ Plotwise details collected from the area indicated that more than 50 and 67 percent of the total plots sown after 7 and 15 days of soaking showers respectively required resowing. Pearl millet yields of the plots sown with these delays were 31 and 79 percent lower compared to the yields of pearl millet sown within 7 days of soaking rains respectively. For details see Jodha (1974).

process supported both by demand and supply forces (including the Land Development Bank's loan facilities to purchase tractors), brought about a significant qualitative change in the resource base of the community.7/ Mechanization's first impact was to intensify land use by reducing the extent of fallowing of land, which was partly due to the inability to plant a larger area within the very short wet periods. Consequently on sample farms, the net cropped area as a proportion of the total operational area increased from 86 percent in 1964-65 to 94 percent in 1973-74.

The cropping pattern also underwent a considerable changes due to tractorization. On the basis of their features and relative importance in acreage allocation prior to tractorization the crops could be put under three categories.

a) The subsistence crops--pearl millet and sorghum. Being main staple food of the people, these crops got highest priority in terms of acreage allocation as well as their planting soon after the rains.

b) Crops like moth bean, cluster bean (guar) and fodder sorghum received next priority. They were mostly planted towards the end of wet season. Since the maturity of the late sown crops is not certain in these areas, farmers preferred these crops because, when not fully ripe, they ensured at least fodder if not grain. Moreover, owing to their low moisture requirement these crops have better chances of success even though planted late.

7/ The process worked so effectively that in an area of just six villages the number of tractors (mostly 35 HP Massey-Ferguson) increased from 10 in 1964-1965 to 35 in 1968-1969 and 59 in 1973-1974. Jodha(1974)

Other crops like sesamum and green gram, though higher priced (unlike pearl millet and sorghum) neither filled in to the subsistence considerations of the farmer, nor ensured partial returns through fodder. Consequently they received lowest priority in acreage allocation.

After the tractor use became popular the priorities in terms of acreage allocation to different categories of crops have substantially changed. The use of tractor which facilitated timely planting of crops on larger area favoured crops under categories (c) and (a), which performed well only when sown in the early phase of wet periods. The disappearance or at least relaxation of draft power constraint owing to tractors reduced the need for planting crops at the end of wet season. This adversely affected the crops under category (b), which as mentioned earlier were preferred by the farmers as late sown crops.

For all the tractor-using farms (i.e. those who at least used tractor for crop planting) put together, the share of pearl millet in the total cropped area increased from 25 percent in 1964-1965 to 30 percent in 1973-1974. Sorghum increased its share from 24 to 29 percent, sesamum from 7 to 14 percent, and green gram from 3 to 12 percent. The proportion area planted to moth bean, cluster bean, and fodder sorghum was reduced during the same period from 16 to 5 percent, 15 to 9 percent, and from 10 to 1 percent, respectively. This changing pattern is visible across different farm-size groups also. The fact that these changing crop proportions occurred on a much larger total cropped area further adds to their significance.

Attributing changes in cropping pattern to tractorization--a major qualitative and quantitative change in the resource base of the community--is further supported by the absence of similar changes in the cropping pattern of the non-tractor-using farmers during the same period.8/ The latter farmers continued to allocate substantial acreage to the more drought-resistant crops, as they could not plant all of their land during the brief moisture period.

CROSS-SECTIONAL ANALYSIS OF IMPACT OF RESOURCE DIFFERENCES

In what follows I shall use data from six villages in the SAT parts of India where ICRISAT is currently conducting Village-Level Studies.9/ The results discussed below are *preliminary*, as the final processing of the data is still in progress.

Farm Level Resource Base : A summary picture of the resource position of the farms in the three different landholding groups in the six villages, as obtained at the beginning of the 1975-1976 agricultural year, is presented in Table 3. The average size of operational holding broadly follows the

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8/ Incidentally, 1964-1965 and 1973-1974 were two of the best rainfall and crop years in the area. Mild droughts occurred in the years immediately preceding. Hence, the differences in cropping pattern at two points of time cannot be attributed to the impact of different weather conditions.

9/ For details see Jodha and Ryan (1975), Jodha(1976-a), and Binswanger and Jodha (1976).

Table 3 : Resource bases by farm size group in six SAT villages in India (1st July, 1975)

Village [a]/ Farm size groups	Operational area of holding size group	Average size of holding	Irrigable area	Bullocks per 10 ha.	Area per bullock	Family workers per 10 ha.	Area per worker	Value of farm equipment [b]/	
	(ha)	(ha)	(%)	(No)	(ha)	(No)	(ha)	(Rs/farm)	(Rs/ha)
1. Aurepalle, Mahbubnagar District (red soil)									
Small	0.2-1.2	0.8	4.8	5	2.1	47	0.2	186	226
Medium	1.3-3.2	2.3	10.8	3	2.8	18	0.5	902	401
Large	>3.2	4.9	13.9	4	2.8	4	2.8	3657	317
All farms	---	2.6	13.0	4	2.7	8	1.3	1582	325
2. Dokur, Mahbubnagar District (red soil)									
Small	0.2-0.8	0.6	75.3	3	3.0	31	0.3	493	813
Medium	0.9-2.1	1.7	53.3	4	2.9	19	0.5	872	507
Large	>2.1	2.4	39.3	6	1.6	8	1.3	2845	601
All farms	---	1.6	38.3	5	1.9	12	0.8	1403	596
3. Shirapur, Sholapur District (deep black soil)									
Small	0.2-2.0	1.4	10.3	4	2.8	20	0.5	321	231
Medium	2.1-5.3	4.5	5.4	2	6.0	10	1.0	785	163
Large	>5.3	7.3	10.2	2	2.7	5	2.1	1656	227
All farms	---	4.5	10.1	2	4.5	8	1.2	787	175
4. Kalman, Sholapur District (deep & medium black soil)									
Small	0.2-3.6	2.9	11.4	4	2.9	12	0.9	256	90
Medium	3.7-8.5	6.5	7.8	1	8.1	4	1.6	947	146
Large	>8.5	8.0	11.1	2	6.2	5	3.0	1692	129
All farms	---	5.8	11.0	2	5.8	4	2.3	985	129
5. Kinkheda, Akola District (medium black soil)									
Small	0.2-2.0	2.4	1.7	4	2.6	11	0.9	198	85
Medium	2.1-4.5	4.3	3.8	2	4.1	7	1.4	395	93
Large	>4.5	6.4	1.3	3	4.1	3	3.4	767	61
All farms	---	4.3	2.1	4	3.9	5	2.1	454	71
6. Kanzara, Akola district (medium black soil)									
Small	0.2-1.8	1.4	17.0	1	14.2	33	0.3	282	199
Medium	1.2-5.3	3.9	2.0	2	4.4	15	0.7	316	80
Large	>5.3	5.8	4.5	3	3.5	5	2.3	120	132
All farms	---	3.7	4.5	3	3.9	9	1.1	724	125

a/ Mahbubnagar district, in Andhra Pradesh, averages 71 cm rainfall annually. Sholapur and Akola districts, in Maharashtra, average 69 and 82 cm annual rainfall, respectively. Village-Level Studies have been conducted in these villages since May 1975. The number of farms in each group in the case of each village is 10.

b/ Farm and irrigation machinery, hand tools, other farm implements.

trend dictated by rainfall and irrigation conditions in the region. The two Sholapur villages have the lowest average rainfall; their average operational farm sizes are 4.5 and 5.8 hectares. The corresponding figures for the two Mahbubnagar villages, with a slightly better rainfall and substantially more irrigation facilities, are 1.6 and 2.6 hectares. The average size of landholdings in the two Akola villages, having the highest and most stable rainfall, are 3.7 and 4.3 hectares. The number of bullocks per 10 hectares of operational area in the Sholapur villages is almost half that of the other villages. This was primarily due to the effects of successive drought years in the early 1970's, which depleted bullock herds in the Sholapur villages. Possession of farm machinery and equipment, as indicated by their value per hectare of operational area, was largely dictated by the availability of irrigation. Dokur and Aurepalle villages both have a more irrigation and a higher per-hectare value of equipment when compared to the other villages.

<u>Extent of Rabi cropping</u> : The impact of differences in regional resource endowment is clearly reflected in the seasonal distribution of cropping in different villages. According to Table 4, in Mahbubnagar (red soil) and Akola (medium deep black soil) villages, kharif cropping accounts for 70 to 96 percent of the net sown area.[10/] In Sholapur villages character-

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10/ The average net sown area shown by Table 4 differs from the average size of holding (Table 3) in several land holding groups. The information presented in Table 3 was collected at the time field work began. The land details of Table 4 were collected on the basis of plot by plot area during the cultivation season. (Which was also confirmed by actual measurement). Some changes occurred due to new leasing arrangements.

Table 4 : Proportion of cropped area sown during each of three seasons and that sown in more than one season, and cropping intensity, by farm size group in six SAT villages in India, 1975-76

Village and farm size group[a]	Average net sown area	Area Sown						Cropping intensity[d]
		Kharif only		Rabi only		Summer only	two or more seasons[b]	
	(ha)	(%)	(%)	(%)	(%)	(%)	(%)	
Aurepalle								
Small *	1.4	100	(29)[c]	-	-	-	-	100
Medium	3.6	90	(48)	8	(92)	-	2	102
Large	8.1	77	(42)	10	(78)	2	11	111
All farms	4.4	83	(43)	8	(81)	1	8	108
Dokur								
Small	0.5	74	(81)	5	(100)	-	21	121
Medium	2.1	47	(79)	36	(100)	-	17	117
Large	5.1	79	(69)	8	(100)	-	13	113
All farms	2.6	70	(72)	16	(100)	-	14	114
Shirapur								
Small*	2.0	15	(67)	78	(100)	3	4	104
Medium	3.0	41	(83)	50	(93)	-	9	112
Large	8.1	35	(53)	55	(88)	-	10	114
All farms	4.4	33	(63)	57	(95)	1	9	112
Kalman								
Small*	4.9	45	(31)	50	(51)	-	5	105
Medium*	7.7	34	(23)	60	(58)	-	6	106
Large	11.3	28	(21)	64	(80)	1	7	108
All farms	8.1	33	(25)	60	(69)	-	7	107
Kinkheda								
Small	2.2	97	(1)	--	--	-	3	103
Medium	4.0	96	(6)	--	--	-	4	104
Large	12.1	92	(9)	4	(100)	-	4	104
All farms	6.1	94	(7)	2	(100)	-	4	104
Kanzara								
Small	1.4	94	(2)	--	-	-	6	106
Medium	4.4	93	(19)	3	(100)	-	4	104
Large	11.8	97	(27)	2	(100)	-	1	101
All farms	5.8	96	(23)	2	(100)	-	2	102

a/ Village level studies have been conducted in these villages since May 1975. The number of farms in each group in each village is 10 except in the cases marked(*) In each of the cases marked (*)one farmer leased out whole of his land during the crop year 1975-1976. Thus, the number of farms in such cases is 9.

b/ Proportion of holding cropped in any two, or (like in Shirapur) in all three seasons of the reference years.

c/ The figures in the parentheses indicate the proportion (%) of respective areas of kharif and rabi planted to sole crops.

d/ Cropping intensity = $\frac{\text{Gross cropped area}}{\text{Net sown area}} \times 100$

ized by deep black soils and a bimodal pattern of rainfall, rabi cropping (mainly sorghum, chickpeas, safflower, and wheat) accounts for 57 to 60 percent of the net sown area. The limited extent of rabi cropping observed in Mahbubnagar and Akola regions is largely on irrigated plots. In Sholapur, rabi cropping depends wholly on rains received during the preceding monsoon. The broad seasonal pattern of cropping observed for different villages is also maintained when different farm-size groups are compared. The extent of rabi cropping preceded by fallowing of land during the kharif season indicates the potential for double-cropping in the rabi tracts provided suitable quick-maturing kharif varieties to fit to the rainfall pattern of the rabi tract are available and the methods of land management in deep black soil-areas during the monsoon season are evolved.11/

Apparently the main reasons why farmers prefer not to grow a kharif crop in the deeper black soil areas are :

i) The difficulty of working in the deep soils once rains start. The farmers' dilemma is that in the absence of good soaking rains, deep black soils are too hard to work; and once substantial rains begin, it is then difficult to enter such soils.

11/ It is estimated that nearly 18 million hectares or more than 24 percent of the net sown area in the SAT areas of India are fallowed during the monsoon season to be planted during rabi season. (J.G. Ryan personal communication using data from Malone 1974).

ii) Even if some kharif crops are planted by dry sowing, management of the crop in the subsequent wet period is difficult. Before the soils are dry enough to permit entry of labour weeds will almost completely spoil the crop. Proper management of weeds in such situation may prove to be an uneconomic proposition. There is considerable scope for research on this issue.

iii) Farmers are concerned about the variability and quantity of rains within the monsoon season. Their experience is that rains during the second phase of the monsoon are more dependable than those in the first phase. This makes dry seeding of crops risky. Furthermore, there are many other sources of risk in kharif cropping. If rains in the first phase of monsoon are inadequate, the crop may die; if they are in excess (as in 1975-1976), water-logging may spoil the crops; if rains during the second phase continue for a long period, as they did in 1975-1976, it may spoil the kharif crop at its flowering or ripening stage.

At present, farmers are not aware of crop varieties or land-management practices which can reduce the aforementioned hazards of kharif cropping in deep black soils and continue to follow the traditional practice of fallowing land in the monsoon season. Research at ICRISAT and AICRPDA is attempting to provide new technology for such areas.[12] Given the uncertainty of kharif cropping in these deep black

12/ All India Coordinated Research Project for Dryland Agriculture.

soils and the extreme difficulty of raising two rainfed crops on these lands with traditional technology, the farmer perhaps makes a rational choice in leaving the deep black soils fallow in monsoon. It helps him to improve the temporal allocation of his scarce resources--i.e. concentration on medium and shallow soils during monsoon and on deep black soils during the post-monsoon season. Thus kharif fallowing may not be as irrational as it may look. Its irrationality can be proved only through presenting a viable alternative, and this precisely constitutes the challenge to agricultural research.

Differences in cropping intensities in the six villages seem to be due to availability of irrigation facilities, rather than differences in other resources like bullock power or family labour.13/ Juxtaposition of cropping intensity values with resources position indicators (Table 3) of different holding groups and different villages suggests this. The high cropping intensity in Mahbubnagar villages is largely due to sequential paddy cropping in irrigated plots. According to Table 10, the extent of paddy followed by paddy accounts for 84 percent of the double cropped area in Dokur. The corresponding proportion in Aurepalle is 79 percent. In Sholapur villages particularly in Shirapur the higher cropping intensity is mainly because of sugar cane, vegetables and other crops on the wells which have dependable rechange.

13/ Cropping intensity $= \frac{\text{Gross cropped area}}{\text{Net sown area}} \times 100$

Mixed cropping : Besides the predominance of rabi cropping in the deep black soil areas with bimodal rainfall such as in Sholapur, another feature of cropping patterns in the SAT areas of India and elsewhere is the predominance of mixed cropping.14/ Depending upon the crops a number of agronomic factors such as growth habits, shading effects and root competition, together with economic considerations like risk and returns, crops are mixed together either in segregated rows or by mixing the seeds while sowing. Patch-cultivation is also practised, where within the same plot small areas are put under different sole crops.15/

The proportion of plots sown to mixed crops ranged from 8 to 72 percent of the total number of plots sown in the six villages (Table 5).16/

14/ For an excellent discussion of mixed cropping in the parts of Nigeria see Norman (1972) and Norman (1974). Also see Aiyer (1949).

15/ Very small areas within the plot often have special problems like shading by trees, salinity, prolonged stagnation of water due to depression or bunding, severe erosion, etc. The crops suited to such patches are different from the crops in the rest of the plot. Moreover, for the purpose of self-provisioning, minor crops like tobacco and vegetables are raised in these small corner patches of the plot. Uneven germination or mid-season failures of crops in parts of the plot often lead to resowing with different crops. Such patches, when smaller than 0.05 hectares, make it difficult to record separate input - output details. These have been treated as mixed cropping in ICRISAT studies. See Binswanger and Jodha (1976).

16/ The plots are not necessarily separate land parcels of fragments. For the purpose of collection of plotwise input-output data, often the same land parcel was subdivided into plots (or subplots) according to the differences of cropping patterns existing in different parts of it, provided that the part was more than 0.05 hectares in size. See Binswanger and Jodha (1976).

Table 5 : Distribution of plots, by number of crops per plot, by farm size group in six SAT villages in India, 1975-1976.

Village and farm size group [a]	Proportion of total plots under type of cropping					Total	Per farm
	Sole crop	Two crop mix	Three crop mix	Four crop mix	Five crop mix		
	(%)					(No)	(No)
Aurepalle							
Small	36	--	--	--	64	22	2.2
Medium*	68	6	--	--	26	34	3.8
Large	77	8	--	--	16	90	9.0
All farms	68	6	--	--	26	146	5.0
Dokur							
Small	76	24	--	--	--	17	1.7
Medium	95	5	--	--	--	42	4.2
Large	89	9	1	--	--	76	7.6
All farms	89	10	1	--	--	135	4.5
Shirapur							
Small*	96	4	--	--	--	56	6.2
Medium	92	8	--	--	--	75	7.5
Large	91	7	2	1	--	127	12.7
All farms	92	7	1	--	--	258	8.8
Kalman							
Small*	56	36	8	--	--	86	9.6
Medium *	61	22	14	3	1	125	13.9
Large	76	17	6	1	1	165	16.5
All farms	66	23	9	1	--	376	13.4
Kinkheda							
Small	25	25	43	7	--	28	2.8
Medium	26	17	54	3	--	35	3.5
Large	31	29	35	4	--	68	6.8
All farms	28	26	41	5	--	131	4.3
Kanzara							
Small	22	28	33	17	--	18	1.8
Medium	51	21	26	2	--	53	5.3
Large	59	29	10	2	--	91	9.1
All farms	52	26	18	4	--	162	5.4

a/ Number of farms in each group is 10 except in the cases marked (*), where number of farms is 9. See note a, Table 4.

Similarly, the area devoted to mixed cropping ranged from 15 to 84 percent of the total cropped area (Table 6)17/.

Except in Dokur and Shirapur, the extent of sole cropping tends to increase with an increase in the size of operational landholding. This implies that smaller farms have a stronger preference for mixed cropping, which is plausible as mixed cropping on the same plots fits well into small farmers' crop-diversification strategy against uncertainty and risk. Small farmers resort to mixed cropping to achieve crop diversification also because they do not have a large number of plots on which to plant different sole crops. Large farmers, on the other hand, are able to diversify cropping by using their more numerous plots, for sole cropping. This is fully supported by details of sole crops on different farms (Table 7 col.1). The total number of sole crops grown in different villages differ from 14 in Aurepalle to 23 in Shirapur. But in each of the villages the number of crops planted as sole crop increases with an increase in the size of farm. This in a way suggests the qualitative difference between the crop diversification strategies of well endowed and poorly endowed farms.

The possibility that the risk factor influences the extent of mixed cropping on different holding-size groups is further supported by

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17/ At the time of preparation of this paper the proportions of the area under each crop comprising the mixtures were not available. These are being worked out on the basis of proportions of crops in the seed mixture as well as proportions of rows of different crops. Hence, in the present paper, separate areas of individual crops in the mixture are not presented.

Table 6 : Extent of sole and mixed cropping, irrigated and non-irrigated, by farm size groups in six SAT villages in INDIA, 1975-1976

Village and farm size group a/	Proportion of total cropped area under b/				
	Sole crop	Two crop mix	Three crop mix	Four or five crop mix c/	Total
	-(%)-				
Aurepalle					
Small	30 --	-- --	-- --	70 --	100 --
Medium	52 (28)	1 --	-- --	47 (5)	100 (14)
Large	57 (26)	9 (2)	-- --	34 (1)	100 (15)
All farms	53 (25)	6 (2)	-- --	41 (2)	100 (13)
Dokur					
Small	88 (59)	12 --	-- --	-- --	100 (52)
Medium	92 (73)	8 --	-- --	-- --	100 (67)
Large	82 (57)	15 --	3 --	-- --	100 (47)
All farms	85 (62)	13 --	2 --	-- --	100 (53)
Shirapur					
Small	97 (17)	3 --	-- --	-- --	100 (17)
Medium	93 (12)	7 (9)	-- --	-- --	100 (11)
Large	82 (14)	14 (6)	4 --	-- --	100 (11)
All farms	86 (14)	11 (6)	3 --	-- --	100 (13)
Kalman					
Small	44 (22)	40 --	16 (63)	-- --	100 (10)
Medium	47 (14)	27 (1)	20 (1)	6 --	100 (6)
Large	66 (23)	21 (4)	10 (22)	3 --	100 (15)
All farms	57 (21)	27 (2)	14 (11)	2 --	100 (14)
Kinkheda					
Small	6 (40)	31 -	53 --	10 --	100 (2)
Medium	12 (19)	27 -	57 --	4 --	100 (2)
Large	19 --	28 -	46 --	7 --	100 --
All farms	16 (5)	27 -	50 --	7 --	100 (1)
Kanzara					
Small	12 (44)	27 -	39 --	22 --	100 (5)
Medium	26 (11)	30 -	39 --	5 --	100 (3)
Large	32 (8)	49 -	17 --	4 --	100 (3)
All farms	30 (10)	40 -	24 --	6 --	100 (3)

a/ See note (a/) of Table 4.

b/ Figures in parentheses indicate proportion (%) of the crop that is receiving irrigation.

c/ Five crop mixes were observed only in Aurepalle.

Table 7 : Number of sole crops and number of crop combinations characterising the mixed cropping by farm size group in six SAT villages of India 1975-1976.

Village and farm size group a/	(A) Crops planted sole	(B) Crop combinations used for: Two crop mix	Three crop mix	Four or Five crop mix b/	Total	Total (A+B)
	(No)	(No)	(No)	(No)	(No)	(No)
Aurepalle						
Small	2	--	--	1	1	3
Medium	8	1	--	1	2	10
Large	13	5	--	2	7	20
All farms	14	6	--	2	8	22
Dokur						
Small	4	1	--	--	1	5
Medium	6	1	--	--	1	6
Large	12	2	1	--	3	15
All farms	12	2	1	--	3	15
Shirapur						
Small	13	1	--	--	1	14
Medium	15	6	--	--	6	21
Large	18	5	2	2	9	27
All farms	23	10	2	2	14	37
Kalman						
Small	11	13	7	--	20	31
Medium	13	12	15	6	33	46
Large	17	18	4	8	30	47
All farms	19	26	22	12	60	79
Kinkheda						
Small	7	2	5	4	11	18
Medium	9	2	2	2	6	15
Large	10	6	4	5	15	25
All farms	14	6	6	9	21	35
Kanzara						
Small	4	4	4	5	13	17
Medium	11	4	5	2	11	22
Large	15	7	5	3	15	30
All farms	17	9	7	9	25	42

a/ See note a, Table 4

b/ 5-crop mixture obtains in Aurepalle alone other details in Tables 6 and 9. The greater the certainty of the crop (through germination, early growth, etc.), the less should be the need for crop diversification through mixed cropping. Irrigation is one factor which increases such certainty and reduces risk in cropping. This is borne out by the fact that the bulk of the irrigated crops are raised as sole crops in most of the holding groups. According to Table 6 (bracketed figures in last column) the extent of irrigation ranges from 1 percent (in Kinkheda) to 53 percent (in Dokur) of the total cropped area in different villages. Excepting the small-farm group in Kalman, the proportion of irrigated crops is higher in the case of sole crops. If the irrigated crops alone are considered, Table 9 shows that 85 to 100 percent of the irrigated acreage is occupied by sole crops in different villages. The higher extent of sole cropping in Dokur village in general, and on small farms in particular, may be explained in terms of greater availability of irrigation. The hypothesis about disappearance of mixed cropping following the availability of canal irrigation in Kota villages (Table 1) is thus supported by the Dokur situation.

The decline in mixed cropping with the decline in farm-size in Shirapur village, though representing a situation contrary to the trend in most of the other villages, indirectly supports the risk hypothesis with respect to mixed cropping. Shirapur and Kalman villages belong to a tract characterized by deep black soils and bimodal rainfall. The two peak periods of rainfall are June and September, intervened by a phase of low and variable rainfall. Deep black soils are not only difficult to work after the onset of the monsoon, but the soil profile is generally not fully recharged by the first phase of rains. Consequently farmers with deep black soils mostly keep the land fallow during monsoon and plant rabi (winter season) crops, such as sorghum and safflower, after the monsoon recedes. Since the moisture retention-capacity of deep black soils is high, the crops planted after the monsoon are generally able to mature if the soil profile is relatively full of moisture. In the respect rabi cropping offers assured crop prospects similar to irrigated farms and hence the need for guarding against risk through mixed cropping is reduced. The higher proportion of sole crops in rabi cropping as compared to kharif cropping (bracketed figures in Table 4) broadly supports this hypothesis. This has greater significance in the case of Sholapur villages where 50 to 78 percent of gross cropped area of different farm size groups is devoted to rabi cropping.18/ The negative association between farm size and sole cropping in Shirapur is partly explained by the greater extent of rabi

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18/ In the case of Akola villages having medium deep black soil and high and less variable rains the rabi cropping is quite insignificant. In Mahbubnagar villages despite red soils the extent of rabi-cropping is greater than Akola villages. These crops are mostly confined to tank-beds which are cropped after the tanks are dry. Some farmers irrigate these crops through temporary shallow wells dug in the dry tank beds. In rabi season crops in Sholapur villages are completely unirrigated crops.

cropping on small farms compared to large farms. On the large farms with more of the shallower soils there are more crops grown in the kharif and they generally use mixed cropping to alleviate the risk of crop failure. Large farms devote 35 percent of area to kharif crops and 47 percent of the same is put under mixed crops. The small farms on the other hand devote only 15 percent of their cropped area to kharif and of which only 33 percent is put under mixed crops. Kalman village, which is in the same region does not compare with the pattern of Shirapur. Overall extent of rabi cropping in Kalman is slightly more than compared to Shirapur. Kalman has a much larger area of medium black and shallow soils (which is usually cropped in monsoon season) and unlike Shirapur, proportion of such soils is more in the case of small and medium farms as compared to large farms. Consequently, the rabi-induced sole cropping increases with the size of farm. Kalman has more bunded plots than Shirapur and these allow more opportunities for small-patch cropping involving coriander, linseed, vegetables and paddy near the bunds where water stagnates.19/ These small-patch crops significantly increase the extent of mixed cropping in Kalman.

19/ In Kalman village as a whole, nearly 84 percent of the farms have 90 to 100 percent of their lands bunded. In Shirapur with extensive areas of deep black soils the corresponding proportion of the farms is 25 percent. In deep black soils, it is difficult to maintain bunding and bunding can cause damage to crops (Jodha 1976-a).

Crop Mixtures : Mixed cropping characterizes all the villages but there are considerable differences in the number as well as types of crop combinations used for the purpose in different villages (Tables 7 and 8). For instance, Kalman village has 26 different two-crop mixtures and 22 different three-crop mixtures. Dokur, on the other hand, has only two crop combinations. Other villages fall in between these extremes. The similar pattern obtains even when the number of crop combinations in the case of different farm size groups are considered. In most of the villages there is no clear trend showing relationship between farm-size and number of crop combinations. Yet, practically in all villages large farmers have larger number of crop combination in mixed cropping. This is despite the fact that except in Dokur and Shirapur the proportion of both the total number of plots and the total cropped acreage devoted to mixed cropping declines with the size. This represents yet another facet of the crop diversification strategy of large farms, which as previously mentioned differs from the one adopted by small farms. Firstly, owing to their bigger holdings and more numerous plots the large farms are able to buy insurance against risk through planting more plots to sole crops. Secondly, even when they devote lower proportions of area and plots to mixed cropping, they achieve qualitatively different and perhaps greater crop diversification by planting more combinations of crop mixtures. Their larger land resource base helps in achieving such crop diversifica-

Table 8 : Important crop mixtures and number of crop combinations characterizing mixed cropping on sample farms in six SAT villages of India 1975-1976 a/

Crop Mixture Codes	Percentage share of crop mixtures in villages					
	Aurepalle	Dokur	Shirapur	Kalman	Kinkheda	Kanzara
S+P	--	57	--	--	--	--
S+B	--	--	--	--	4	7
S+Sf	--	--	--	23	--	--
S+Gg	--	--	--	--	9	--
S+B+Gg	--	--	--	--	17	--
S+Gg+P+Pm	--	--	--	--	6	--
S+Pm+Op+V+Ov	75	--	--	--	--	--
P+Ov	--	--	22	--	--	--
P+Mm	--	--	--	7	--	--
P+Op	--	--	--	7	--	--
P+Sf	--	--	--	8	--	--
P+Oc+Pm	--	--	22	--	--	--
P+Pm+Ov	--	--	--	5	--	--
Op+Ov	--	--	16	--	--	--
C+P	--	--	--	--	9	38
C+P+S	--	--	--	--	39	16
C+P+Gr+S	--	--	--	--	7	--
C+B+P+S	--	--	--	--	--	16
W+Ch	--	--	7	--	--	--
Cr+V	12	--	--	--	--	--
G+P	--	40	--	--	--	7
Sc+V	--	--	18	--	--	--
Others c/	13	3	15	50	9	16

a/ See note a/, Table 4

B = Black Gram; C = Cotton; Cp = Chickpea; Cr = Castor; G = Groundnut; Gr = Green Gram; Mm = Minor millets; Oc = Other cereals; Op = Other pulses; Ov = Other fibre-cum-vegetable crops; P = Pigeonpea; Pm = Pearl millet; S = Sorghum; Sc = Sugarcane; Sf = Safflower; Sn = Sunflower; V = Vegetable; W = Wheat.

c/ Other crop mixtures mainly include various combinations of green gram, castor and different vegetable crops in Aurepalle; Pearl millet, other pulses, groundnuts vegetables in Dokur; Maize, safflower, chickpea, coriander, sorghum, pigeonpea, linseed in Shirapur; Minor millets, other pulses, sorghum, sunflower, safflower, seasonal vegetables, maize groundnut, tobacco etc., in Kalman; Cotton, mungbean, black gram, sesamum sorghum mustard, safflower, chickpeas and seasonal vegetables in both Kinkheda and Kanzara.

tion or what could be broadly described as portfolio diversification.[20/]

Irrespective of the number of crop combinations characterizing mixed cropping in the three regions, the main crops dominating the combinations are limited (Table 8). For instance, sorghum dominates crop mixtures in most of the villages, particularly Mahbubnagar. Pigeonpea dominates mixtures in the Sholapur area. In Akola villages the predominant crop in the crop mixture is cotton. Except in the case of castor and sugarcane (where vegetables are mixed as small-patch crops), one or more of the foodgrains are invariably part of the crop mixtures. Within the mixtures of foodgrains, cereal-pulse combinations rather than cereal-cereal or pulse-pulse are more important.

Irrigated crops : Paddy, wheat, maize, sugarcane, chickpeas, green beans, castor, sesamum, safflower and different vegetables are largely grown as sole crops. Most of these crops are also irrigated. The percentage of sole crops receiving irrigation in different villages (Table 6) is Dokur-62, Aurepalle-25, Kalman-21, Shirapur-14, Kanzara-10 and Kinkheda-5. The picture emerges more sharply once the distribution of total irrigated acreage under different crops is examined (Table 9). As previously mentioned, 85 to 100 percent of irrigated acreage is allocated to sole

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20/ Number of crop combinations is also influenced by diversification of consumption requirements. The small farmers concentrate on simple and limited crop combination to meet their subsistence needs. The large farmers try to get different quantity of varied products to meet their own as well as their servants' consumption needs. For instance sorghum, pearl millet and pigeonpea may be preferred combination for small farmers. The large farmers would like to add green beans, black gram and some seasonal vegetables to such combination.

Table 9 : Distribution of crops on irrigated acreage by farm size groups in six SAT villages of India 1975-1976

Village and farm size group a/	Proportion of total irrigated area under								
	Paddy/Wheat b/	Sugar cane	Vegetables	Groundnuts	Maize	Sorghum	Other sole crops c/	All d/ mixed crops	Total area irrigated
	-(%)-								
Aurepalle									
Small	-	--	--	--	--	--	--	--	--
Medium	72 (29)	--	--	--	--	2	11	15	4.8
Large	88 (62)	--	2	--	--	4	3	3	13.2
All farms	85 (53)	--	2	--	--	2	5	6	18.0
Dokur									
Small	100 (90)	--	--	--	--	--	--	--	3.4
Medium	68 (63)	--	--	32	--	--	--	--	16.3
Large	90 (85)	--	1	8	--	--	1	--	26.9
All farms	83 (78)	--	--	17	--	--	--	--	46.6
Shirapur									
Small	33	--	16	24	20	--	7	--	3.1
Medium	5	38	10	--	8	31	3	5	3.6
Large	9	25	22	7	5	9	16	7	10.4
All farms	12	23	19	9	8	12	11	5	17.1
Kalman									
Small	11	--	5	--	--	57	13	15	4.4
Medium	25 (4)	--	18	3	26	17	7	4	4.7
Large	20	4	4	5	3	34	13	17	18.7
All farms	19 (1)	3	5	4	6	35	12	15	27.8
Kinkheda									
Small	92 (92)	--	8	--	--	--	--	--	0.5
Medium	44 (44)	--	56	--	--	--	--	--	0.9
Large	--	--	--	--	--	--	--	--	--
All farms	62 (62)	--	48	--	--	--	--	--	1.4
Kanzara									
Small	100 (100)	--	--	--	--	--	--	--	0.8
Medium	100 (100)	--	--	--	--	--	--	--	1.2
Large	87 (43)	4	9	--	--	--	--	--	3.3
All farms	92 (65)	3	5	--	--	--	--	--	5.3

a/ See Note a/, Table 3.

b/ Paddy in Aurepalle and Dokur, wheat in the other villages. Value in parentheses represents the proportion (%) of total irrigated area seeded to high-yielding varieties of respective crops.

c/ Includes cotton, fodder crops, garden crops, and (in some cases)chickpeas, sunflower and castor.

d/ Includes vegetables,wheat,chickpeas and oil seeds.

crops in different villages. If Sholapur villages are excluded, 53 to 78 percent of the irrigated acreage is planted to high yielding varieties of wheat or paddy in different villages.

Furthermore, irrespective of the total availability of irrigation in different villages, 50 to 100 percent of the irrigated acreage is devoted to high-value crops like paddy, wheat, sugarcane, groundnuts, vegetables, etc. This pattern persists when different land-holding-size groups are considered. The Sholapur villages (particularly Kalman) are the exception where low-value-crops like sorghum, maize, and chickpeas also account for a substantial proportion of irrigated acreage. This difference is due to the undependable recharge in most of the wells which does not allow high-water-consuming (high-value) crops to be grown in these villages. (The tanks and wells in Mahbubnagar villages ensure intensive irrigation during different seasons). This difference highlights the dangers of comparing the irrigated acreage in villages with different irrigation systems and irrigated acreages of crops with different intensities of irrigation. For example five hectares of irrigated land under paddy (in Dokur) and sorghum (in Kalman) do not imply the same extent of irrigation. However, in the absence of precise data about number of waterings etc., to different crops it is difficult to avoid comparing irrigated acreage under different crops or in different villages. But the point relating to different intensities of irrigation on different crops further strengthens the basic argument that high-value crops occupy a higher proportion of irrigated acreage. Because of their higher water requirements (and number of waterings) these crops utilize a much higher proportion of the available irrigation facility than what is suggested by irrigated acreages planted to them. Farmers prefer to irrigate high-value crops on small areas rather than irrigating a larger area of low-value crops. This poses a serious dilemma for irrigation development in low-rainfall areas. If the irrigation is given to what are called I.D. crops (irrigated dry crops, i.e. low-water-requiring crops), it may cover a larger area and help more farmers stabilize and increase agricultural production in these areas and hence have greater social benefits. However, the bulk of irrigation facilities purposefully created for drought-prone areas in India have tended to devolute into irrigation of high-value, high-water requiring crops instead of being used for ID crops. This causes pockets of prosperity within the dry areas (Jodha, 1976-b).21/

Paddy occupies most of the irrigated land in the Mahbubnagar villages, unlike the other villages (Table 9). This is largely due to differences in the irrigation systems. In Mahbubnagar, community tanks which collect runoff water during the monsoon are the major source of

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21/ One of the effects of small pockets of irrigated areas in vast rainfed tracts takes the form of concentration of regional resources on these small areas with high-value irrigated crops. Not only does intra-regional resource allocation on public account favour these pockets, but even on private account resources like labour are diverted from rainfed crops to high-value irrigated crops. For instance, paddy transplanting and weeding in several villages receive priority over operations for rainfed crops and this adversely affects the performance of the latter.

irrigation. Historically tank irrigation has been used primarily for paddy cultivation. In Sholapur and Akola, wells with varying depths and stability of recharge are the only sources of irrigation. Crops are selected depending upon the water availability.

The impact of differences in irrigation systems also gets reflected in the pattern of double cropping in different villages. As previously mentioned, of the total double-cropped area the paddy-paddy sequence accounts for 79 and 84 percent in the two Mahbubnagar villages (Table 10). No similar sequence of paddy or any other crop (except sugarcane in Shirapur) is observed in any of the remaining villages. Table 10 also shows that crop sequences involved in double-cropping are more varied in the case of Sholapur villages than in the others. The heterogeneity factors which caused more crop combinations and mixed cropping probably also give rise to more variation in the crop sequences used in double-cropping.

Individual crops : In the preceding discussion of mixed and sole cropping the importance of individual crops in the cropping patterns did not get much attention. In view of the large extent of mixed cropping and the absence of information about the proportion of individual crops in the mixtures it is difficult to discuss the cropping patterns

Table 10 : Proportion of double-cropped area devoted to various cropping-sequence schemes in six SAT villages in India, 1975-76.

Village a/	Percentage of double-cropped area under: b/
Aurepalle (double-cropped area : 9.1 ha)	
	Paddy/Paddy 79; castor/safflower 14; mixed-crop sorghum/safflower 15; paddy/wheat 2.
Dokur (double-cropped area : 11.2 ha)	
	Paddy/paddy 84; sorghum/groundnuts 7; finger millet (Ragi)/paddy 5; paddy/groundnuts 4.
Shirapur (double-cropped area : 7.7 ha)	
	Groundnuts/sorghum 16; maize/wheat 14; vegetables/sorghum 10; Sugarcane/sugarcane 7; mixed-crop oilseeds/wheat 6; maize/wheat 5; sunflower/wheat 5; mixed-crop vegetables/wheat 5; groundnuts/chickpeas 5; cotton/chickpeas 5; vegetables/maize 4; groundnuts/groundnuts 3; others 20.c/
Kalman (double-cropped area 14.9 ha)	
	Maize/wheat 27; paddy/chickpeas 14; groundnuts/vegetables 7; mixed-crop kharif pulses/sorghum and chickpeas 15; mixed-crop wheat and sorghum/chickpeas 14; mixed-crop maize/safflower and mixed-crop sorghum and chickpeas and groundnuts 11; mixed-crop vegetables/sorghum and sugarcane 6; sunflower and vegetables/chickpeas 6.
Kinkheda (double-cropped area 4.2 ha)	
	Sorghum/chickpeas 36; green gram/wheat 23; mixed-crop cotton and groundnut/chickpeas 23; chickpeas/vegetables 8; Wheat/vegetables 8; green gram/sesamum 4.
Kanzara (double-cropped area 6.8 ha)	
	Sorghum/wheat 33; paddy/chickpeas 30; sorghum/chickpeas 23; green gram/wheat 14.

a/ See note a/, Table 4.

b/ Share of total double-cropped area devoted to local and/or high-yielding varieties of these crops. Includes all areas cropped twice during the year. In shirapur, some areas are cropped with mainly vegetables and sugarcane three times during the year; these areas are not included.

c/ Includes fodder crops, sorghum other cereals, vegetables, chickpeas and several mixtures.

with reference to actual area of individual crops.[22/] Hence, in the following discussion the details of the same crops when raised as sole crop and planted as main crop of the mixture (without specification of its actual share in the mixture) have been analysed separately. Table 11 and 12 clearly illustrate the inter-regional differences in the cropping patterns with respect to the relative importance of different crops. In Mahbubnagar paddy and castor predominate as sole crops(Table 11). Similarly importance of sorghum and to some extent chickpeas as sole crops in Sholapur is quite clear. In Akola, sorghum, wheat, chickpeas and cotton are important sole crops.

It may be added that the high yielding varieties of crops grown in the selected villages are planted only as sole crops. This is so because HYVs have largely been evolved in the context of sole cropping systems.[23/] Even if they perform equally well under mixed cropping systems, at least at the extension stage they are recommended as sole crops.[24/] Table 7 (bracketed figures) indicates the propor-

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22/ The data collection procedure involved recording the main crop in crop mixtures as the first crop, other components, depending upon their share in the mixture, were recorded as second, third, fourth crop, etc., for the same plot (Binswanger and Jodha, 1976). The share of the main crop in the crop mixture could range from 50 to 90 percent of the total acreage under that mixture.

23/ No case except 0.2 ha. of hybrid cotton in Kanzara was observed where HYV of any crop had been raised as mixed crop.

24/ The farmers' difficulties in incorporating HYVs in the mixed cropping system may hamper the adoption of HYVs in some cases.

Table 11 : Cropping pattern by farm-size groups in six SAT villages of India 1975-1976 : Sole Crops

Villages and farm-size group a/	Proportion of total area of sole crops under :											
	Sorghum	Paddy	Wheat	Other b/ cereals	Pigeon-pea	Chick-pea	Other c/ pulses	Ground-nuts	Other oil-seeds d/	Veget-ables	Cotton sugar-cane e/	Total sole crops f/
	(%)											
Aurepalle												
Small	-	-	-	-	-	-	8	-	92	--	-	30
Medium	1 -	25 (52) g/	-	-	-	-	1	-	53	20	-	52
Large	4 -	35 (64)	--	2	-	-	5	-	50	4	-	57
Dokur												
Small	3 -	97 (99)	-	-	-	-	-	-	--	--	-	88
Medium	16 -	56 (94)	--	3	-	-	-	25	--	--	-	92
Large	19 -	53 (95)	-	12	-	-	-	15	--	1	-	82
Shirapur												
Small	42 -	-- --	12 -	4	7	15	-	4	9	3	4 -	97
Medium	26 -	4 --	4 -	1	21	12	14	4	7	1	6 -	93
Large	36 -	1 --	6 -	3	15	14	8	1	2	4	10 -	82
Kalman												
Small	61 (4)	8 --	3 -	3	3	4	--	1	15	1	1 -	44
Medium	64 --	6 --	5(11)	5	5	3	4	3	1	3	1 -	47
Large	65 --	6	7 --	4	1	7	4	3	1	1	1 -	66
Kinkheda												
Small	-- --	9 --	36(100)	-	-	13	26	-	-	16	- -	6
Medium	-- --	2 --	8(100)	-	-	21	7	25	6	10	21(100)	12
Large	18 (95)	4 --	5 -	-	-	33	23	3	-	--	14 -	19
Kanzara												
Small	46(100)	- --	43(100)	-	-	--	--	11	-	--	-- --	12
Medium	45 (68)	4 --	18(60)	-	-	12	14	4	-	3	-- --	26
Large	23 (46)	5 --	17(50)	1	-	3	--	18	1	1	31 (22)	36

a/ see note a/, Table 4.
b/ Maize, finger millet, pearl millet.
c/ Green gram, black gram and mothbean.
d/ Indicates castor in the case of Aurepalle and safflower, sunflower and sesamum in the case of other villages.
e/ Cotton in the case of Kinkheda and Kanzara and sugarcane in the case of Shirapur and Kalman.
f/ Proportion (%) of total gross cropped area devoted to sole crops.
g/ Figures in the parentheses indicate the proportion (%) of area of respective crops planted to HYVs. The bulk of the castor area is devoted to its high yield varieties. However its precise extent has not been indicated.

Table 12 : Cropping pattern by farm-size groups in six SAT villages of India, 1975-1976 : Mixed Crops

Villages and farm-size groups a/	Proportion of total area of mixed crops under crop mixtures dominated by different crops :										
	Sorghum	Paddy	Wheat	Other cereals b/	Pigeon-pea	Chick-pea	Other c/ pulses	Ground-nuts	Other oil seeds d/	Veget-ables	Cotton
	(%)										
Aurepalle											
Small	100	-	-	-	-	-	-	-	-	-	.
Medium	98	-	-	-	-	-	-	-	-	2	.
Large	80	-	-	-	-	-	15	1	-	4	.
Dokur											
Small	47	-	-	-	-	-	-	53	-	-	-
Medium	27	-	-	-	-	-	-	73	-	-	-
Large	42	-	-	-	-	-	-	58	-	-	-
Shirapur											
Small	-	-	-	14	32	-	19	-	22	13	-
Medium	18	-	27	8	31	-	6	5	-	5	-
Large	35	-	-	12	36	-	11	1	5	-	-
Kalman											
Small	30	2	-	2	45	9	9	--	3	-	-
Medium	43	2	3	2	39	3	7	--	-	1	-
Large	32	2	2	1	50	4	6	--	2	1	-
Kinkheda											
Small	53	-	-	-	-	-	-	-	-	-	47
Medium	50	-	-	-	-	-	-	-	-	-	50
Large	46	-	-	-	-	-	-	5	-	-	49
Kanzara											
Small	22	-	-	-	-	-	-	19	-	-	59
Medium	13	-	-	-	-	-	-	17	-	-	70
Large	20	-	-	-	-	4	-	5	-	-	71

a/ See Note a/ Table 4 ; b/ Maize, pearl millet and other minor millets; c/ Green gram, black gram and moth bean
d/ Safflower, sunflower and sesamum.

tion of HYVs with respect to different crops. HYVs of paddy are quite important in Mahbubnagar villages with tank irrigation. In Akola villages, HYVs of sorghum, wheat and cotton are important but their higher proportions (bracketed figures under Table 11) do not mean much when viewed in the context of fairly limited extent of sole cropping in these villages. In the case of Sholapur villages there is practically no adoption of any HYVs. This being a predominantly rabi sorghum tract and non-availability of any high yielding variety of sorghum to suit rabi season cropping this is quite understandable.

In the case of mixed crops (Table 12) the sorghum dominated mixtures are quite common in all the three regions. The prominent crop mixtures are different in different regions. In Akola region cotton dominated mixtures predominate while in Sholapur region pigeonpea dominated mixtures are more important. In the case of Mahbubnagar groundnut dominated and sorghum dominated crop mixtures account for bulk of the area planted to mixed crops.

<u>Crop grouping by common characteristics</u>: There is no uniform relationship between the size of farm and the importance of different crops in the cropping patterns, as Tables 11 and 12 reveal. This may be partly due to the fact that farmers' cropping preferences are in terms of groups of crops with common attributes like druought-resistance, rather than in terms of individual crops. Hence the relationship between farm size

and cropping patterns can be reflected better if crop groups are considered. Tables 13 and 14 present the data relevant for this. Two main categories--foodgrain crops and cash crops - have been defined. These have been further broadly subclassified into drought-resistant (low-water-requiring) crops and drought-sensitive (high-water-requiring) crops.25/ This classification can help in obtaining at least a broad indication of the farmer's behaviour *vis-á-vis* his crop-planning priorities with respect to subsistence considerations, risk aversion, cash income preference, etc. These preferences in turn may depend on a farmer's resource position.

25/ Categorization of crops as foodgrain and cash crops has lost much of its sharpness with the increased commercialization of agriculture, as foodgrains in many cases are not only raised for subsistence purposes but also for marketing purposes to earn cash. However, in the absence of a more convenient alternative, this classification has been used. The crops falling in each of not-so precise sub-categories are as follows :

i) *Drought-resistant foodgrain crops* : Pearl millet, sorghum, finger millet, other minor millets, pigeonpea, chickpeas, black gram and other pulses (except green gram).

ii) *Drought-sensitive foodgrain crops* : Paddy, wheat, maize, green gram.

iii) *Drought-resistant cash crops* : Castor, sunflower, safflower.

iv) *Drought-sensitive cash crops* : Groundnuts, sesamum, mustard, linseed, cotton, sugarcane, vegetable crops (except rainfed ones).

ıble 13 : Proportion of total area of sole crops under drought-sensitive and drought-resistant food grain and cash crops.

ıllage & ırm-size ·oupa/	(A) Food grain crops: Drought resistant[b]	(A) Food grain crops: Drought sensitive[c]	(A) Food grain crops: Total	(B) Cash Crops: Drought resistant[d]	(B) Cash Crops: Drought Sensitive[e]	(B) Cash Crops: Total	All crops (A+B): Drought resistant	All crops (A+B): Drought sensitive
	(%)							
ırepalle								
ıall	8	--	8	92	--	92	100	
ːdium	2	25	27	53	20	73	55	45
ırge	11	35	46	50	4	54	61	39
l farms	9	30	39	53	8	61	62	38
ıkur								
ıall	3	97	100	--	--	--	3	97
ːdium	19	56	75	--	25	25	19	81
ırge	34	53	87	--	13	13	34	66
l farms	27	58	85	--	15	15	27	73
ıirapur								
ıall	65	16	81	5	14	19	70	30
ːdium	72	10	82	4	14	18	76	24
ırge	76	8	84	1	15	16	77	23
l farms	73	10	83	3	14	17	76	24
ılman								
ıall	69	14	83	15	2	17	84	16
ːdium	77	16	93	1	7	8	78	22
ırge	77	18	95	--	5	5	77	23
l farms	76	17	93	3	3	6	79	21
ınkheda								
ıall	3	82	85	--	15	15	3	97
ːdium	21	17	38	--	62	62	21	79
ırge	51	32	82	--	16	16	51	49
l farms	44	32	76	--	24	24	44	56
ınzara								
ıall	45	44	89	--	11	11	45	55
ːdium	56	37	93	--	7	7	56	44
ırge	36	13	49	1	50	51	37	63
l farms	40	19	59	1	40	41	41	59

See Note a/, Table 4

Pearl millet, sorghum, other minor millets, pigeonpea, chickpeas, black gram and other kharif pulses (other than green gram).

Paddy, wheat, maize, green gram.

Castor, sunflower, safflower.

Groundnuts, sesamum, mustard, linseed, cotton, sugarcane, vegetable crops (other than rainfed ones).

Table 14 : Proportion of total area of mixed crops under crop mixtures dominated by drought-resistant and drought-sensitive foodgrain and cash crops.

illage and arm-size roup a/	(A)Food grain crops			(B) Cash Crops			All crops(A+B)	
	Drought resist-ant b/	Drought sensi-tive c/	Total	Drought resist-ant d/	Drought sensi-tive e/	Total	Drought resist-ant	Drought sensi-tive
	-(%)-							
urepalle								
mall	100	--	100	--	--	--	100	--
edium	99	--	99	--	1	1	99	1
arge	80	--	80	15	5	20	95	5
ll farms	88	--	88	9	3	12	97	3
kur								
mall	47	--	47	--	53	53	47	53
edium	27	--	27	--	73	73	27	73
rge	42	--	42	--	58	58	42	58
ll farms	40	--	40	--	60	60	40	60
irapur								
all	--	--	--	--	100	100	--	100
dium	55	27	82	--	18	18	55	45
rge	89	--	89	5	6	11	94	6
l farms	83	3	86	4	10	14	87	13
lman								
all	96	4	100	--	--	--	96	4
dium	93	6	99	--	1	1	93	7
rge	92	4	96	3	1	4	95	5
l farms	93	6	99	1	--	1	93	7
nkheda								
all	53	--	53	--	47	47	53	47
dium	50	--	50	--	50	50	50	50
rge	45	--	45	--	55	55	45	55
l farms	47	--	47	--	53	53	47	53
nzara								
all	21	--	21	--	79	79	21	79
dium	13	--	13	--	87	87	13	87
rge	24	--	24	--	76	76	24	76
l farms	21	--	21	--	79	79	21	79

See Note a/, Table 4

Pearl millet, sorghum, other minor millets, pigeonpea, chickpeas, black gram and other kharif pulses (other than green gram).

Paddy, wheat, maize, green gram.

Castor, sunflower, safflower.

Groundnuts, sesamum, mustard, linseed, cotton, sugarcane, vegetable crops (other than rainfed ones).

The conventional presumption is that the small farmer devotes a greater proportion of his land to foodgrain crops and to drought-resistant crops because of his subsistence requirements, inability to take risk, etc. Preferences of the larger farmer should be the opposite as the maximization of profits rather than maintenance of subsistence is presumably his main goal and he is apparently able to take the greater risk involved in drought-sensitive crops.26/ Large farms also depend on hired labour to a greater extent. They frequently make wage payments in kind and consider drought-resistant low-value crops like sorghum, pearl millet, and minor millets as wage goods. They have to devote considerable area to such crops, not only for their own subsistence purposes but for the production needs of their farm enterprise.

In a number of cases, large farmers cultivate a part of the land more as a device to safeguard their property claims than to seriously undertake a cropping enterprise. Large areas of unused land or land given on tenancy may carry the risk of being lost or being involved in prolonged litigation due to recent government measures relating to land ceiling and tenancy. Farmers therefore may prefer to put any low-cost drought-resistant crop in such areas and avoid potential problems created

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26/ For a discussion of the conventional presumptions and empirical work supporting or contradicting them, see Krishna (1963) and Bharadwaj (1974).

by land-reform laws.[27/]

Large farms may have more resources than smaller ones, but invariably they are not adequate for uniformly intensive use of the whole land. The farmers concentrate their efforts on their relatively better lands (in terms of fertility, irrigation facility etc). The remaining lands are used according to their crop suitability and thus become "subsidiary crop enterprises" for the large farms. Depending upon the proportion of inferior lands in total operated area, these "subsidiary crops", may dominate the cropping patterns of large farms. Often when large farmers have preferences for particular "subsidiary crops", the lack of timely and adequate rains may neutralize this. For instance, in such situations in the medium deep soils in the Sholapur villages groundnut and sesamum crops are replaced mainly by pulse crops.

At times institutional factors like customary practice of release of water from irrigation tanks during specific times for irrigating paddy crops may influence cropping decisions or cropping patterns

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27/ In a few cases where better personal understanding exists between the large farmer and his tenant, share-cropping continues. In such cases cropping decisions are as per the requirements and capacity of the small farmer (tenant). But that area is included in the cropped area of the larger farmer. This is more so where attached labour is paid in terms of informal allotment of land by the large farmer to him for raising his subsistence requirements.

differently than the manner in which a household's own resources would influence it.[28/]

Other factors which may neutralize the cropping preferences (in terms of subsistence or risk considerations), *vis-à-vis* the size of the holding are regional characteristics, such as predominance of paddy and castor in the Mahbubnagar area, rabi cropping in Sholapur, and cotton cultivation in Akola villages.[29/]

In Aurepalle village if mixed crops alone are considered, the hypothesis regarding small farmers' concern for subsistence and risk are supported by the increase in area under foodgrain crop-dominated and drought-resistant crop-dominated mixtures with the decline in size of operational holding (Table 14). The support for the hypothesis is strengthened by Table 12 which indicated that the bulk of the mixtures in Aurepalle consist of drought-resistant foodgrains.

28/ Farmers with sufficient irrigation from tanks in Dokur village cultivate paddy. In Sholapur farmers with dependable irrigation from wells go in for sugarcane.

29/ In the Akola region cotton is most suited to the agro-climatic conditions. Hence every farm, irrespective of size, may give priority to the crop, which in turn may overshadow the effects of holding size on crop preferences.

When sole crops are considered, paddy and castor change the trend in Aurepalle so that the area under foodgrains increases with the size of holding (Table 13). In fact, paddy is really more of a cash crop than a subsistence crop and when this is taken into account it does not violate the foodgrain-based hypothesis. Similarly, the increase in the proportion of cash crops (mainly castor) as the size of holdings in Aurepalle decrease does not run counter to the expected behaviour of small farmers. Castor has numerous virtues like low input cost, drought resistance, long duration of crop conducive to a more dispersed labour-use pattern and it supplies fuel materials as a byproduct. The larger proportion of drought-resistant crops on large sized farms compared to medium-sized farms is largely due to castor and kharif season pulses. These were earlier described as large farmers' "subsidiary crops".

Dokur village is in the same region as Aurepalle, but has significantly more irrigation facilities. This makes its situation quite different. In the case of sole crops the proportion of drought-sensitive crops mainly because of paddy declines with increased size of landholdings (Table 13). In other respects such as in the area of food-grain crops raised both as sole crops or as the main crop of mixtures, and the area of cash crops, the Tables 13 and 14 do not suggest a clear trend. The principal reason for the above situation is the greater extent of irrigation (Tables 3, 6 and 9) on small farms and consequently the greater acreage allocation to paddy and groundnut as the main crop of mixtures (Tables 11, 12). The higher proportion of foodgrains and drought-resistant crops on large farms compared to medium farms may be attributed to the "subsidiary crops" argument mentioned earlier, as Dokur is one of the villages where land concentration is high (Jodha 1976-a).

The cropping pattern in Shirapur reveals the trends which are completely contrary to those hypothesised. Accordingly, the extent of both drought-resistant crops and foodgrain crops increases with the size of farm. This applies to both sole crops and mixed crops (Tables 13 and 14). These trends can be explained partly in terms of the extent of rabi cropping in the deep black soils which varies considerably between different farm-size groups in this village. As mentioned earlier the extent of rabi-cropping is higher on small farms than on large farms (Table 4). The higher proportion of kharif cropping on large farms is partly due to the fact that larger farms have more lands which are generally planted with drought-resistant crops in the kharif season and partly due to their ability to take the added risk involved in kharif cropping. Hence, in terms of risk behaviour, growing kharif crops in an area not well suited to kharif cropping is comparable to taking drought-sensitive crops and is thus in keeping with the risk-related hypothesis about crop preferences of large and small farms.

Rabi cropping on the other hand usually provides more assured prospects. The actual choice about rabi sorghum versus wheat, safflower and chickpeas during 1975 was influenced by the continuation of the monsoon until early November, which left too little time for sorghum planting normally done by early October. Most small farmers could not plant sorghum during such a short period due to lack of animal power, which explains the greater extent of crops like wheat (drought sensitive) and safflower (Tables 11, 12).30/

The situation in Kalman village is fairly different from Shirapur. Mixed crops have a higher proportion in Kalman and increase as the size of farm declines (Table 6). The extent of foodgrain crops in mixed cropping (Table 14) is inversely related to farm size. Drought-resistant (mixed) crops are more common on small farms compared to other farm-size groups, though there is no clear trend. There is clear inverse relationship between farm size and drought-resistant crops when sole crops only are considered (Table 13). The positive relationship between farm size and the extent of sole foodgrain crops which contradicts the subsistence-related hypothesis, is largely because of higher proportion of drought-resistant (sole) cash crops like safflower and sunflower on small farms.

30/ Moreover, delayed and inadequate rains in the early part of monsoon season (1975-1976) favoured more drought-resistant foodgrain crops rather than cash crops like sesamum and groundnut.

In Kinkheda village, if mixed crops which account for bulk of the cropped area, are considered, the proportion of foodgrain crops declines with the size of holding (Table 14). On the other hand, the share of drought-sensitive cash crops increase with the size. These trends support the subsistence and risk-related hypotheses. In the case of sole crops, the extent of foodgrain crops on small farms is greater than other groups, but there is no clear trend (Table 13). The extent of drought-sensitive sole crops declines with the size of farm. This is mainly due to the existence of more wheat on small farms.

In the case of Kanzara, the second village in the cotton belt, the cropping pattern does not show clear trends in any of the crop categories under discussion. Of course, compared to large farms, the small farms have more foodgrain crops and drought-sensitive crops.

The fact that cropping patterns *vis-á-vis* size of farm do not reveal uniform trends across all villages, suggests that in practice the cropping pattern is influenced by many complex factors and cannot be fully explained in terms of land-holding size as a measure of the farmer's overall resource position. The factors which quite convincingly explain the cropping patterns in one situation prove ineffective in other situations. This shows the diversity of both the cropping patterns and the factors underlying them and illustrates the dimensions of the problems facing cropping-systems research in rainfed areas.

CONCLUSIONS

Cropping patterns are affected by a multiplicity of factors of which the resource position is one. Within the resource base, the land types, irrigation, and (of course) rainfall play by far the most important roles. These basic resources, together with the availability of crop varieties, markets and the relative prices of commodities determine the comparative advantage of different crops and crop mixes on the various soil types and also the rate of return to investment in improvement of the resource base.[31/] In the long run the availability of capital resources (and also of labour) are also determined by land and water resources and the stage of technology.

Massive resource transformations which alleviate major constraints such as those indicated by canal irrigation and tractorization overshadow the impact of other resource differences and can lead to shifts in cropping patterns in particular directions for farms in different categories. Such resource improvements orient the cropping patterns towards high-value crops and tend to reduce the importance of mixed crops.

31/ A colleague at ICRISAT Matthias von Oppen, is at present undertaking research into the impact of market infrastructure and prices on aggregate productivity, output supply, cropping patterns. For this reason these determinants of cropping patterns were explicitly excluded in this paper, although it is recognised they are extremely important. A further reason for concentration on the resource base question was that the invitation to present a paper at the IRRI(International Rice Research Institute) Conference specified this topic.

Augmentation of major resources may also have a more substantial impact on cropping patterns than marginal improvements in terms of various cultural practices or even crop mixes. Similarly, introduction of new varieties tend to change patterns of comparative advantage of different crops and may lead to shifts in cropping patterns as well as investment incentives for other capital items.

The more heterogeneous the resource base, particularly soils, the more complex and heterogeneous will be the cropping pattern and the more numerous the crop mixtures observed. This tendency is further reinforced if rainfall is highly variable. The overall feasible choices in such cases are very limited, yet as a part of the adjustment mechanisms against uncertainty and risk caused by this heterogeneity and variability the farmer tries to multiply the alternatives (through crop combinations) within the overall narrow limits of feasibilities. This is particularly illustrated by the situation in Kalman village..On the other hand, more uniformity of the resource base leads to simple (i.e. one or two crops) cropping patterns, even under the rainfed conditions. This was illustrated by the castor crop in the Mahbubnagar area and by sole crops of sorghum and wheat in the rabi cropping areas with deep black soils near Sholapur.

Irrigation imparts uniformity and stability to the resource base and opens up a wide range of cropping options. But despite the large number of available options, the cropping pattern tends to become less and less heterogeneous. This is partly due to the reduction in the uncertainty--induced need for diversification of cropping. More importantly, the stable crop environment provided by irrigation allows better expression and perception of comparative advantages or differential profitabilities of different crops. This facilitates selection of the most profitable crops.

Thus, where cropping options are numerous the tendency is towards simple and one-or-two-crop cropping. Where overall range of possible crops is limited, the tendency is towards more varied and complex cropping patterns. In the former the farmer is facilitated to select a few out of the large number of options. In the latter the farmer is forced to multiply cropping arrangements to exploit the limited and highly variable production opportunities.

IMPLICATIONS FOR AGRICULTURAL RESEARCH

An important finding of the present study is that the extent of mixed cropping is closely associated with the quality and size of the resource base. Mixed cropping decreases and sole cropping increases with the improvement in the resource base, whether at the farm or regional level.

This has a most significant implication for research in intercropping. Any breakthrough in intercropping research is likely to benefit small farmers more than large farmers and less well-endowed areas more than richer areas. This in a way allows us to identify the target group of potential beneficiaries of intercropping research. Being able to do so in an *ex ante* framework is both illuminating and rather unusual.

Efforts to generate intercropping systems for rainfed areas where, in the absence of irrigation, the inherent micro-level heterogeneity of the resource base persists, are faced with the following problems :

Firstly the logistics of multilocation and multi-crop combination experimentation to capture the total cropping possibilities and to satisfy the spatially and temporally varied requirements of the rainfed areas are huge and costly. Further, even with the best of efforts, it is difficult to escape the location-specificity characterizing the experimental results.

Secondly, the degree of realism and relevance of a new cropping system would largely depend upon the extent to which it has been regorously compared with prevailing cropping systems. But this poses more serious problems than multilocation trials. The complexity of farmers' systems stem from their heterogeneous adjustment mechanism against instability and uncertainty characterizing rainfed agriculture. Unless these mechanisms are fully understood and replicated in some form at research stations, it may prove quite impossible to inject the desired degree of diversity and complexity in the prospective cropping system. Understanding and replication of farmers' adjustments are still difficult as they are sensitive to small changes which are difficult to perceive at the research farm. Moreover, the farmers' own cropping system is a result of informal experimentation over a long period.32/ Given the resource base and varieties, how far formal experimentation can improve upon the cropping system evolved by farmers is an open question.

Thirdly, recognition of the above helps in clarifying the approach which should be adopted by formal experimentation on intercropping. Formally experimented intercropping technology can score over the system evolved through farmers' informal experimentation if it contains some substantive new elements. These elements may consist of new varieties of crops and improved management systems, including better soil and moisture conservation. Thus the prospective intercropping technology of ICRISAT must fully complement the crop-centered and resource-centered technologies and be simple in application. Then through informal experimentation, farmers will add new elements as their adjustment process requires.

32/ The existence of 26 cropping combinations in a single village like Kalman in the case of two crop mixtures alone is a result of such informal experimentation.

Fourthly, homogeneity of the resource base tends to impart simplicity to cropping patterns. Hence, efforts leading to reduced heterogeneity of the resource base may be a step toward widening the area of applicability of prospective intercropping technology. The reduction in the heterogeneity or improvement in the resource base in the absence of irrigation can be promoted through improved land and moisture management.33/ This in turn will be complementary to prospertive intercropping technology.

Finally, development of a kharif-cropping technology for the traditional rabi cropping tracts like Sholapur is another instance where cropping systems, crop improvement and land and water management research can have a coordinated approach. Recognizing that more than half of the land in these areas is kept fallow during the monsoon, the potential payoff from prospective kharif-cropping technology for these areas can hardly be overstated.34/ Further, in the typically deep black soil areas

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33/ Such resource-base improvement through land levelling, ridge-furrow system etc., as tried by ICRISAT (unlike irrigation) may not be strong enough to facilitate replacement of mixed cropping by sole cropping. But land levelling, removal of defective bunds, etc., are obvious examples of measures which can reduce the heterogeneity of the land-resource base. It is this type of heterogeneity which is partly responsible for the more complex cropping pattern in areas like Kalman.

34/ It estimated that some 18 million ha. of cultivable land which is equal to more than 24 percent of net sown area in SAT India, remains fallow during the kharif season (Ryan, personal communication, using data from Malone (1974).

like Shirapur village, the extent of kharif fallowing in the case of smaller farmers is as high as 78 percent of the total cropped area. This again illustrates where a prospective technology has a potential, not only for large productivity gains, but also for generation of relatively more income for the less-affluent farmers.

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REFERENCES

Aiyer A.K.Y.N., 1949, Mixed cropping in India, *Indian Journal of Agricultural Sciences* 19 : 4-15.

Agro-Economic Research Centre, 1970, " *A Study of High Yielding Varieties Program in the Kota Districts, Rajasthan,* AERC, Sardar Patel University, Vallabh Vidyanagar, India (Mimeo).

Bapna S.L., 1973, *Economic and Social Implications of Green Revolution - A case study of Kota Disrict,* Agro-Economic Research Centre, Sardar Patel University, Vallabh Vidyanagar, India.

Bharadwaj, Krishna, 1974, *Production conditions in Indian agriculture : A Study based on Farm Management Surveys,* Cambridge University press.

Binswanger, H.P., B.A. Krantz and S.M. Virmani, 1976, *The role of the International Crops Research Institute for the Semi-Arid Tropics in Farming Systems Research,* ICRISAT, Hyderabad, India (Mimeo).

Jodha, N.S., 1973, Prospects for coarse cereals : permanent constraints of jowar and bajra, *Economic and Political Weekly, Review of Agriculture, 8 : A145-A150.*

Jodha, N.S., 1974, A case of process of tractorization, *Economic and Political Weekly, Review of Agriculture 10 : A111 - A118*

Jodha N.S., and J.G. Ryan, 1975, *ICRISAT study of traditional farming systems in the semi-arid tropics of India : Work plan and related aspects.* Occasional paper 9, Economics Department, ICRISAT, Hyderabad, India (Mimeo).

Jodha N.S., 1976-a, *Preliminary report of activities and results from village level studies in semi-arid tropical India in 1975-76,* Economics Department, ICRISAT, Hyderabad, India.

Jodha, N.S., 1976-b, Dry farming technology : Achievements and obstacles (forthcoming) *in* C.N. Vakil, C.H. Shah and U.S. Mohan Rao eds. *Agricultural Development in India : Policy and Problems,* Orient Longman Ltd., Bombay.

Krishna, Raj, 1963, Rapporteur's report on economics of the cropping pattern, *Indian Journal of Agricultural Economics, 18 : 170-181.*

Malone C. Carl, 1974, *Indian agriculture : Progress in production and equity,* Ford Foundation, New Delhi (Mimeo).

Norman D.W., 1972, *An economic survey of three villages in Zaria Province : Input-Output Study Vol.1, Text.* Samaru Miscellaneous paper 37. Institute of Agricultural Research, Samaru, Ahmadu Bello University, Zaria, Nigeria.

Norman, D.W., 1974, Rationalizing mixed cropping under indigenous conditions : The example of northern Nigeria, *The Journal of Development Studies, 11 : 3-21.*