To offer you some guideline to the subjects dealt with in this session, I would like to remind you of the already-agreed-upon phases of research activity, namely:

- identification
- design
- testing, and
- extension

Not specifically in that order, considering the overlapping nature of the phases, the first two papers will present basic ideas about the scope, objectives, coverage, and methodological approaches of the economic aspect of cropping systems study.

The next three papers provide perspective, with more details, utilizing data already collected, analyzed, and interpreted in the development of the study.

With this preliminary guideline, Professor Vincent, I offer you the floor.

30

30-E

RESOURCE BASE AS A DETERMINANT OF CROPPING PATTERNS

N.S. Jodha

A region's natural factor endowment, in association with its level and type of trade and technology, sets the broad limits within which the cropping pattern potential of an area is determined. However, the extent to which that potential is realized depends upon farmers' capacity to harness it. That in turn depends upon farmers' resource position. In such a sense alone, resource position may be considered a major determinant of cropping patterns. The impact of resource base on cropping patterns may be demonstrated by (1) changes in cropping patterns over time following changes in resource base, or (2) differences in cropping patterns of farmers with varying farm-level resource endowments.

A few points that are central to any discussion of the impact of resource base on cropping patterns need to be stressed at the outset.

1. Viewed retrospectively, the quantitative and qualitative makeup 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 a certain type and quantity of resources. However, because it could lead to a prolonged hen-versus-egg type of argument, I do not intend to discuss this point further.

2. The direct impact of resource base on cropping patterns is mainly as an input in the production process. Since the utilization of a resource in crop production is not always rigidly tied with its ownership, the association between resource position of individual farms and their cropping patterns is not straightforward. Moreover, the apparent association between the two may give a misleading picture.

N.S. Jodha, Associate Economist, Department of Economics, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), 1-11-256 Begumpet, Hyderabad-500016, A.P., India.

Consider family labor. The availability of a household's own resource definitely influences the deployment of that resource on the farm. However, the actual decision about the use of resource is significantly dictated by the availability of alternatives within and outside the farm that offer different levels of return. The crops possible on one's own farm offer only some of the possibilities for use of family labor. Other possibilities of employment on one's own or on other farms, or engagement in off-farm activities are alternatives which must be taken into account. If a resource is deployed off one's own farm, the impact of total resource availability will not be reflected in one's cropping pattern.[1]

One way to account for the resource problem is to separate farm-level resources or production factors into two categories: (a) resources for which utilization is more or less rigidly determined by ownership, and (b) resources for which that is not true. The first category comprises resources like land, the availability of which, for a given household, is fixed at least for a crop season. There is little possibility of intraseason lease/sale transactions, hence cropping decisions may be influenced by what land is available. The second category comprises resources like labor, bullocks, farm equipment, and so on, whose utilization need not be tied to their ownership. The hire or purchase market for such resources is never dormant (as is that for land after the crop season begins), and the possibility of acquiring them or supplying them to others is always open.

In such cases, the pattern of household utilization of resources may differ greatly from the pattern of possession. Furthermore, their utilization or demand by individual farmers may be determined by cropping pattern rather than vice versa. Thus it is accessibility to the resources through factor markets rather than possession of them (as a part of households' fixed resource base) that is of relevance in studying their impact on cropping patterns. However, the difference between the two resource categories based on difference between ownership and utilization may tend to disappear when one moves from the microlevel to the macrolevel of observation. The utilization of a resource will be more rigidly determined by ownership as one moves from household to village, from village to village cluster, and from village cluster to a bigger geographical unit like a district or a region.[2] That is so because mobility of most of the physical resources becomes more difficult as one moves from smaller to bigger spatial units.[3]

[1]For instance a household with a large number of family workers should go in for labor-intensive crops. But they are likely to go in for crops that are not labor intensive and which spare labor for exploiting better earning opportunities offered by other farms during the crop season.

[2]The term "more rigidly determined" broadly implies that ownership in a household or local availability in a village or a region operates as a major constraint on the utilization of a resource.

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

a. Impact of the household resource base on cropping patterns can be meaningfully analyzed largely in terms of the relationship between operational landholding and cropping pattern. Such analysis is justified not only by the relatively rigid relationship between effective possession and the utilization of resources but also by the fact that in traditional agriculture, landholding primarily determines one's capacity to hire in or hire out other factors like labor or bullocks. Impact of resources other than land are more appropriately analyzed at the village or regional level than at the household level.

b. A related point is that if some massive transformation of the resource base (through an irrigation project, for instance) takes place at the regional level, its impact, which overshadows the impact of other resource differences, could be reflected in changed cropping patterns at both the household level and the more aggregative level. That has been demonstrated by the impact of canal irrigation and the introduction of tractors on cropping patterns, as discussed in the following section.

IMPACT OF MAJOR RESOURCE INVESTMENTS

As mentioned earlier, a convenient way of observing the role of resource base in determining the cropping pattern is to examine the changes in the resource base and consequent changes in the cropping pattern. The changes may take place for a variety of reasons, such as increased input absorption capacity of the land, changes in agrobiological and physical constraints on land use, changes in the cost-to-benefit ratios of different crops, and so on. The substantial changes in cropping patterns which can occur due to a large-scale increase in the resource base are clearly illustrated in Tables 1 and 2. The resource changes and consequent crop shifts are qualitatively very different in the two cases, but the point under consideration—that resource improvement leads to rapid changes in cropping patterns—is testified to by both.

Impact of canal irrigation. Table 1 contains data for 1966–67 and 1971–72 from four villages in the semiarid tropical district of Kota in Rajasthan State of India. That largely rainfed area received irrigation for the first time in the early 1960's from the Chambal Irrigation Project, which initiated the transformation of the whole area (AERC, 1970; Bapna,

[3]Difference between resource possession and its extent and pattern of utilization—for a whole region, for example—may persist because of weather variability. For example, in rainfed areas, how intensively a resource can be used and what crops can be planted during a year will be determined by timing and amount of rain, notwithstanding the availability of complementary resources.

Table 1. Cropping pattern changes after increases in irrigation in the semiarid villages of Kota, Rajasthan, India.[a]

Village	Irrigated area[b] (%)	Share of crops (%) in total cropped area: Paddy	Sorghum and mixed crops[c]	Other kharif crops[d]	Irrigated wheat	Dry wheat and mixed crops[e]	Chick-peas	Other rabi crops[f]
1966–67								
Dhakarkheri	76	8	4	10	48	11	9	10
Kishanpur	36	2	37	8	—	27	16	10
Kishorepura	21	—	21	5	14	20	25	15
Digod	34	1	31	5	18	23	9	13
1971–72								
Dhakarkheri	92	27	1	7	56	1	6	2
Kishanpur	72	7	10	4	49	—	9	21
Kishorepura	50	2	3	2	41	11	30	11
Digod	60	15	16	2	39	14	5	9

[a]Data extracted from Bapna (1973). [b]Irrigated area as % of net sown area. [c]Crop mixtures mainly include pulse crops and sorghum; latter is grown as a main crop in mixed crops. [d]Other kharif (monsoon) crops include maize, pulses, sesame, groundnut, and fodder crops mainly. [e]Includes local (non-HYV) wheat raised generally as a mixed crop with barley and gram (chick-peas) and also raised as a sole crop. [f]Includes linseed, coriander, vegetable crops, etc.

Table 2. Cropping pattern changes following tractor introduction in an arid area of Rajasthan, India.[a]

Farm size (ha)	Year	Tractor culti-vation[b] (%)	Land use inten-sity[c] (%)	Share of crops (%) in total cropped area: Pearl millet	Sorghum	Sesame	Green gram	Moth beans[d]	Cluster bean	Fodder sorghum
1.0–6.1	1964–65	1	89	30	25	2	1	20	16	6
	1973–74	64	95	37	31	12	7	8	4	1
6.2–12.1	1964–65	7	73	28	24	5	4	14	14	11
	1973–74	58	88	31	28	16	13	4	7	1
12.1 and above	1964–65	5	68	22	24	9	5	17	13	10
	1973–74	88	93	29	28	12	13	6	10	2
For tractor users										
	1964–65	4	86	25	24	7	3	16	15	10
	1973–74	74	94	30	29	14	12	5	9	1
For nonusers of tractors[e]										
	1964–65	—	84	26	20	7	6	13	15	13
	1973–74	—	87	24	21	5	5	15	17	13

[a]The data relate to a sample of 112 farms from a cluster of three villages from Nagaur, an arid district of Rajasthan. For details see Jodha (1974). [b]Tractor cultivated area as a percentage of total cropped area. [c]Cropped area as a percentage of total cultivable area including current fallow, old fallow, permanent fallow, and cropped area. [d]*Phaseolus aconitifolius*. [e]Nontractor users (23) are those who did not use a tractor at all in either year.

1973). The proportion of irrigated area to total cropped area in different villages increased from a range of 21 to 76% in the base year, to between 50 and 92% respectively, in the later year. The increase in turn initiated a new cropping pattern. An important feature of the patterns is that high-value crops like paddy, irrigated wheat, and vegetables in some cases have substantially replaced low-value crops like sorghum, maize, pulses, chick-peas, and barley. Furthermore, the mixed crops (dominated by sorghum in kharif, and by non-high yielding wheat, chick-peas, or barley during rabi), which are important features of the cropping patterns in rainfed, semiarid, tropical India, have lost ground to high-value crops that are mostly sown as sole crops. The gradual disappearance of low-value crops, particularly coarse cereals, following the upgrading of the resource base through irrigation is a common feature observed in different areas of India (Jodha, 1973). In the Kota villages, the pace of disappearance of low-value crops and mixed cropping seems to have been accentuated by almost simultaneous availability of high yielding varieties (HYV) of paddy and wheat.[4] The reasons for the changes range from poor competitiveness of the low-value crops in the changed context, redundance of mixed cropping as a strategy against risk once irrigation has lessened the risk, and the advent of HYV technology which has an apparent bias for sole cropping.

Impact of tractor introduction. A qualitatively different but equally strong tendency of crop succession in yet another situation is illustrated in Table 2. In a certain cluster of villages in India, the annual average rainfall is 31.9 cm, and not even 1% of the cropped area has irrigation facilities. The only change in the factor endowment of the area during the last 15 years has been the replacement of bullocks by tractors for cultivation on a substantial scale. The extent of tractor cultivation, embracing all sizes of farms, increased from 4% of the cropped area in 1965–66 to 74% in 1971–72.[5] On the face of it, the agroclimatic conditions of the area—low and unstable rainfall and sandy loam soils—would seem to make the tractor a risky, most uneconomic, and wasteful innovation. In reality those very conditions have enhanced the spread of tractor cultivation.

Not only does the area have low rainfall, but the rain occurs mainly in two to four showers during July and August. That limits the wet periods (or sowing period) to 2 to 4 weeks for the whole season. The wet period is further shortened by strong winds in the area. The success of the crop is determined by the farmer's capacity to exploit the short wet periods. The consequences of delayed sowing (for want of sufficient draft power during

[4]For details of spread and impact of HYV in Kota District, see AERC (1970) and Bapna (1973).

[5]Average size of farms ranged from 8 to 12 ha. For details, see Jodha (1974).

peak periods) are a need for resowing, or lower crop yields, due to poor germination; and poor crop stand of a late-sown crop because of desiccating winds (described as *Jhola*) during mid-September to October which damage the late-sown crops during seed formation.[6] Any facility which helped the farmers overcome the problem created by a short wet period vis-a-vis their limited draft power was readily acceptable. Further, the tractor user did not need to own the tractor. Informal custom-hire services offered by larger tractor-owning farmers (or groups of medium farmers) became popular. One reason was their flexibility in terms of time and the form of payment of the charges. Payment was called for only when the customer was in a position to pay, during the harvest period, for example. Payment was welcomed in any form, including cash, grain, fodder, fuel, labor, or leased-out land. For their owners, the tractors became important sources of income as well as instruments of influence in the village-level product markets, in the factor markets, and in the noneconomic sphere of community life. The process, supported both by demand and supply forces, including Land Development Bank loan facilities to buy tractors, has brought about a significant qualitative change in the resource base of the community.[7] Mechanization's first impact was to increase the intensity of land use by reducing the extent of fallowing, which had been due partly to the inability to plant large areas within the very short wet periods. The increased use of tractors increased the net cropped area on selected farms—from 86% of the total operational area in 1964–65 to 94% in 1973–74.

Before tractors, the cropping pattern used crops like pearl millet and sorghum which were planted during the early wet periods. Toward the end of the wet periods, crops like moth beans, cluster beans (*guar*), and fodder sorghum were raised. Since maturation of late-sown crops was uncertain, farmers preferred the above crops because even when not fully ripe, they ensured at least fodder if not grain. Moreover, they require relatively little moisture. Other crops like sesame and green gram, although higher priced, neither met subsistence needs of the farmer nor ensured partial returns through fodder. Hence they received lowest priority in acreage allocation.

Table 2 shows the changes induced by tractors. For all tractor-using farms (that is, those that used tractors for crop planting, at least), the share of pearl millet increased from 25% of the total crop in 1964–65 to 30% in 1973–74. Sorghum increased its share from 24 to 29%, sesame from 7 to 14%, and green gram from 3 to 12%. Moth beans, cluster beans, and fodder sorghum had their shares reduced from 16 to 5%, from 15 to 9%, and from 10 to 1%, respectively. The changing pattern is also visible across different farm-size groups. That the new crop ratios are for a much larger total area than was cropped before adds to the significance of the changes.

Attributing the changes in cropping pattern to introduction of tractors—a major qualitative and quantitative change in the resource base of the community—is further supported by the lack of similar changes in the cropping pattern of the non-tractor-using farms during the same period.[8] The latter continued to allocate substantial area to the more drought-resistant crops, as they could not plant all of their land during the brief moisture period.

[6] More than 50% of the plots of the area sown after 7 to 15 days of soaking showers required resowing. Pearl millet yields with those delays were 31 to 79% less than the yields of pearl millet sown within 7 days of soaking rains. For details see Jodha (1974).

[7] The process worked so effectively that in an area of just 6 villages, the number of tractors (mostly 35 HP Massey-Ferguson) increased from 10 in 1964–65 to 35 in 1968–69 and 59 in 1973–74 (Jodha, 1974).

CROSS-SECTION ANALYSIS OF IMPACT OF RESOURCE DIFFERENCES

In what follows, I shall use data from six villages in the semiarid tropical areas of India where the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is conducting studies.[9] The results are preliminary; final processing of the data is in progress.

Farm-level resource base. The resource positions of farms in different landholding groups at the beginning of the 1975–76 agricultural year are summarized in Table 3. The average size of operational holdings broadly follows a pattern dictated by rainfall and irrigation. The Sholapur villages, with the lowest rainfall, have operational landholdings averaging 4.5 and 5.8 ha. Corresponding figures for the Mahbubnagar villages, which have slightly better rainfall and substantially higher irrigation, are 1.6 and 2.6 ha. The average size of landholdings in the Akola villages, which have higher and stable rainfall, are 3.7 and 4.3 ha.

Furthermore, owing to the low intensity of land use in low-rainfall areas and the limited capacity of the farmers to maintain bullocks through frequent droughts, the number of bullocks per 10 ha of operational area in the Sholapur villages was almost half that in most of the other villages. Possession of farm machinery and equipment, as indicated by their value per hectare of operational area, was largely dictated by the availability of

[8] Incidentally, 1964–65 and 1973–74 were two of the best rainfall and crop years in the area. Mild droughts occurred in the years immediately preceding them. Hence, the differences in cropping pattern at two times cannot be attributed to impact of weather conditions in the current year or in the preceding year.

[9] For details, see Jodha and Ryan (1975), Jodha (1976b), and Binswanger and Jodha (1976).

Table 3. Some details of the resource base of farms by size of operational landholdings in six villages of semiarid tropical India, 1975–76.[a]

Village landholding size	Range of operational area (ha)	Av. size of holding (ha)	Irrigable area (%)	Bullocks (no./10 ha)	Land area (ha/bullock)	Family workers (no./10 ha)	Land area (ha/worker)	Value (Rs) of farm equipment[b]	
								/farm	/ha
Aurupalle (M)									
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
Total	—	2.6	13.0	4	2.7	8	1.3	1582	325
Dokur (M)									
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
Total	—	1.6	38.3	5	1.9	12	0.8	1403	596
Shirapur (S)									
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
Total	—	4.5	10.1	2	4.5	8	1.2	787	175
Kalman (S)									
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
Total	—	5.8	11.0	2	5.8	4	2.3	985	129

continued on next page

table 3 continued

Village landholding size	Range of operational area (ha)	Av. size of holding (ha)	Irrigable area (%)	Bullocks (no./10 ha)	Land area (ha/bullock)	Family workers (no./10 ha)	Land area (ha/worker)	Value (Rs) of farm equipment[b]	
								/farm	/ha
Kinkheda (A)									
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
Total	—	4.3	2.1	4	3.9	5	2.1	454	71
Kanzara (A)									
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
Total	—	3.7	4.5	3	3.9	9	1.1	724	125

[a] Data in this table and in subsequent ones relate to six villages two each in three regions of semiarid tropical India where the International Crops Research Institute for the Semi-Arid Tropics has been conducting studies since May 1975. Villages 1 and 2 belong to the red soil area with annual average rainfall of 71 cm in Mahbubnagar district, indicated by (M) with village names, in Andhra Pradesh state. Villages 3 and 4 with medium and deep black soils, 69 cm of annual rainfall, belong to Sholapur district (S) in Maharashtra. Villages 5 and 6 belong to Akola district (A) in Maharashtra and have medium black soils and 82 cm of annual average rainfall. The table shows the resource position as of 1 July 1975. Number of sample farms in each group of every village is 10. [b] Includes farm implements, irrigation equipment, hand tools, and other farm machinery.

irrigation. Dokur and Aurupalle villages have more extensive irrigation and more equipment than the other villages. The intervillage, or rather interregional differences in the broad resource positions illustrated by Table 3, may help explain the differences between cropping patterns if they are not explained by the resource position differences among farms of different sizes. The reasons were discussed earlier.

Cropping patterns. An important feature of cropping patterns in the semiarid tropical areas in India and elsewhere (Aiyer, 1949; Norman, 1974) is the predominance of mixed cropping. Depending upon the crops and a number of agronomic factors and economic considerations, the crops are mixed in rows or the seeds are mixed in sowing. Patch-cultivation is also practiced; within one plot, small patches are put under different crops because of such special problems as shading, salinity, severe erosion, water stagnation in depressions, and so on.

Mixed cropping. Some details of mixed cropping in the six villages are in table. Table 4 indicates that, in all the villages except Dokur and Shirapur, sole cropping tends to increase with size of operational landholdings, which implies that smaller farms have a stronger preference for mixed cropping. Mixed cropping on the same plots fits well into small farmers' crop diversification strategy against uncertainty and risk. Also,

Table 4. Extent of sole and mixed cropping by size of operational landholdings in six villages of semiarid tropical India, 1975–76.[a]

Village land-holding size	Share of crops in total cropped area (%)[b]				
	Sole crop	2-crop mix	3-crop mix	4- to 5-crop mix[c]	Total
Aurupalle (M)					
Small	30 —	— —	— —	70 —	100 —
Medium	52 (28)	1 —	— —	47 (5)	100 (14)
Large	57 (26)	9 (2)	— —	34 (1)	100 (15)
Total	53 (25)	6 (2)	— —	41 (2)	100 (13)
Dokur (M)					
Small	88 (59)	12 —	— —	— —	100 (52)
Medium	92 (73)	8 —	— —	— —	100 (67)
Large	82 (57)	15 —	3 —	— —	100 (47)
Total	85 (62)	13 —	2 —	— —	100 (53)
Shirapur (S)					
Small	97 (17)	3 —	— —	— —	100 (17)
Medium	93 (12)	7 (9)	— —	— —	100 (11)
Large	82 (14)	14 (6)	4 —	— —	100 (11)
Total	86 (14)	11 (6)	3 —	— —	100 (13)
Kalman (S)					
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)
Total	57 (21)	27 (2)	14 (11)	2 —	100 (14)
Kinkheda (A)					
Small	6 (40)	31 —	53 —	10 —	100 (2)
Medium	12 (19)	27 —	57 —	4 —	100 (2)
Large	19 —	28 —	46 —	7 —	100 —
Total	16 (5)	27 —	50 —	7 —	100 (1)
Kanzara (A)					
Small	12 (44)	27 —	39 —	22 —	100 (5)
Medium	26 (11)	30 —	39 —	5 —	100 (3)
Large	32 (8)	49 —	17 —	4 —	100 (3)
Total	30 (10)	40 —	24 —	6 —	100 (3)

[a]See note [a], Table 3. [b]Figures in parentheses indicate the extent (%) of irrigated crops in the respective categories. [c]5-crop mixes occur only in Aurupalle village.

Table 5. Important crop mixtures and number of crop combinations characterizing mixed cropping in six villages of semiarid tropical India 1975–76[a].

Crop mixture codes[b]	Share of crop mixtures (%) in villages					
	Aurupalle (M)	Dokur (M)	Shirapur (S)	Kalman (S)	Kinkheda (A)	Kanzara (A)
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 + Gg + S	—	—	—	—	7	—
C + B + P + S	—	—	—	—	—	16
W + Ch	—	—	7	—	—	—
Cr + V	12	—	—	—	—	—
G + P	—	40	—	—	—	7
Sc + V	—	—	18	—	—	—
Others	13	3	15	50	9	16
	Crop combinations in villages (no.)					
Crop mix (Types)						
2-crop mix	6	2	10	26	6	9
3-crop mix	—	1	2	22	6	7
4 + 5-crop mix	2	—	2	12	9	9

[a]See note [a] under Table 3. [b]B = Black gram; C = Cotton; Cp = Chick-peas; Cr = Castor; G = Groundnut; Gg = Green gram; Mm = Minor millets; Oc = Other cereals; Op = Other pulses; Ov = Other fiber-cum-vegetable crops; P = Pigeonpeas; Pm = Pearl millet; S = Sorghum; Sc = Sugarcane; Sf = Safflower; Sn = Sunflower; V = Vegetables; W = Wheat.

Table 6. Cropping pattern by size of operational landholdings in six villages of semiarid tropical India, 1975–76.[a]

Village, landholding size	Share of major crops (%) in total cropped area[b]										
	Sorghum	Paddy	Wheat	Other cereals[c]	Pigeonpeas	Chickpeas	Other pulses[d]	Groundnuts	Other oilseeds[e]	Vegetables	Cotton and other crops[f]
Aurupalle (M)											
Small	— (100)	—	—	—	—	—	8 —	— —	92 —	— —	— —
Medium	1 (98)	25 —	—	—	—	—	1 —	— —	53 —	20 (2)	— —
Large	4 (80)	35 —	—	2 —	—	—	5 (15)	— (1)	50 —	4 (4)	— —
Dokur (M)											
Small	3 (47)	97 —	—	—	—	—	—	— (53)	—	—	—
Medium	16 (27)	56 —	—	3 —	—	—	—	25 (73)	—	—	—
Large	19 (42)	53	—	12 —	—	—	—	15 (58)	—	1 —	—
Shirapur (S)											
Small	42 —	—	12 —	4 (14)	7 (32)	15 —	— (19)	4 —	9 (22)	3 (13)	4 —
Medium	26 (18)	4 —	4 (27)	1 (8)	21 (31)	12 —	14 (6)	4 (5)	7 —	1 (5)	6 —
Large	36 (35)	1 —	6 —	3 (12)	15 (36)	14 —	8 (11)	1 (1)	2 (5)	4 —	10 —
Kalman (S)											
Small	61 (30)	8 (2)	3 —	3 (2)	3 (45)	4 (9)	— (9)	1 —	15 (3)	1 —	1 —
Medium	64 (43)	6 (2)	5 (3)	5 (2)	5 (39)	3 (3)	4 (7)	3 —	1 —	3 (1)	1 —
Large	65 (32)	6 (2)	7 (2)	4 (1)	1 (50)	7 (4)	4 (6)	3 —	1 (2)	1 (1)	1 —
Kinkheda (A)											
Small	— (53)	9 —	36 —	—	—	13 —	26 —	— —	— —	16 —	— (47)
Medium	— (50)	2 —	8 —	—	—	21 —	7 —	25 —	6 —	10 —	21 (50)
Large	18 (46)	4 —	5 —	—	—	33 —	23 —	3 (5)	— —	— —	14 (49)
Kanzara (A)											
Small	46 (22)	—	43 —	—	—	—	—	11 (19)	—	—	— (59)
Medium	45 (13)	4 —	18 —	—	—	12 —	14 —	4 (17)	—	3 —	— (70)
Large	23 (20)	5 —	17 —	1 —	—	3 (4)	—	18 (5)	1 —	1 —	31 (71)

[a] See [a] under Table 3. [b] Figures outside the parentheses indicate the share (%) of each crop in total area under sole crops. Figures in parentheses indicate the share of crop mixtures dominated by the same crops in the total area under mixed crops. [c] Includes maize, finger millet, and pearl millet. [d] Includes green gram, black gram and moth beans. [e] Indicates castor in Aurupalle and safflower, [illegible] in other villages. [f] [illegible]

small farmers resort to mixed cropping to achieve diversification because they do not have many plots on which to plant different sole crops. Large farmers, on the other hand, are able to diversify by using their more numerous plots.

The possibility that the risk factor[10] influences the extent of mixed cropping in different landholding-size groups is supported by other details in Tables 4 and 6. For instance, the greater the certainty of the crop (through germination, early growth, and so on), the less should be the need for crop diversification through mixed cropping. The bulk of the irrigated (and therefore less risky) crops were raised as sole crops on farms of most sizes.

Extent of irrigation ranges from 1% (Kinkheda) to 53% (Dokur) of the total area cropped in different villages (Table 4). Further, barring the small-farm group in Kalman, the proportion of irrigated crops is higher in the case of sole crops. If irrigated crops alone are considered, 83 to 100% of the irrigated acreage is occupied by sole crops in different villages (Table 7). The greater 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 the extent of 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-based argument about mixed cropping. Shirapur and Kalman villages are characterized by deep, black soils and a bimodal rainfall pattern. Two rainfall peaks occur in June and September, separated by a phase of low and variable rainfall. Not only are deep, black soils difficult to work after the onset of the monsoon, but the soil profile is not fully recharged by the first rains. Consequently, most farmers with deep, black soils 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, crops planted after the monsoon can mature. The soil profile is full of moisture in a broad qualitative sense; it offers usually lower but assured crop prospects similar to those of irrigated farms. The need for guarding against risk through mixed cropping is reduced. Moreover, the large farmers have more land—some

[10] Other factors may influence the extent of mixed cropping. They include the self-provisioning character of subsistence farming which induces the farmer to add a few rows of crops like chillies, coriander, oilseeds, or tobacco to the main crop; possibility of increased and more evenly distributed utilization of family labor through mixed cropping; relative economics of specialized versus diversified cropping in different categories of farms, and so on. However, in the absence of usable data at this stage, it is difficult to discuss those factors meaningfully.

Table 7. Crop distribution in irrigated area by size of operational landholdings in six villages of semiarid tropical India, 1975–76.[a]

Village, landholding size	Share of crops (%) in total irrigated crops									Total area irrigated (ha)
	Paddy/ Wheat[b]		Sugar cane	Vege- tables	Ground- nuts	Maize	Sor- ghum	Other sole crops[c]	All mixed crops[d]	
Aurupalle (M)										
Small	—	—	—	—	—	—	—	—	—	—
Medium	72	(29)	—	—	—	—	2	11	15	4.8
Large	88	(62)	—	2	—	—	4	3	3	13.2
Total	85	(53)	—	2	—	—	2	5	6	18.0
Dokur (M)										
Small	100	(90)	—	—	—	—	—	—	—	3.4
Medium	68	(63)	—	—	32	—	—	—	—	16.3
Large	90	(85)	—	1	8	—	—	1	—	26.9
Total	83	(78)	—	—	17	—	—	—	—	46.6
Shirapur (S)										
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
Total	12		23	19	9	8	12	11	5	17.1
Kalman (S)										
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
Total	19	(1)	3	5	4	6	35	12	15	27.8
Kinkheda (A)										
Small	92	(92)	—	8	—	—	—	—	—	0.5
Medium	44	(44)	—	56	—	—	—	—	—	0.9
Large	—	—	—	—	—	—	—	—	—	—
Total	62	(62)	—	48	—	—	—	—	—	1.4
Kanzara (A)										
Small	100	(100)	—	—	—	—	—	—	—	0.8
Medium	100	(100)	—	—	—	—	—	—	—	1.2
Large	87	(43)	4	9	—	—	—	—	—	3.3
Total	92	(65)	3	5	—	—	—	—	—	5.3

[a]See note [a] under Table 3. [b]Indicates paddy in Aurupalle and Dokur villages and wheat in the remaining villages. Figures in parentheses indicate the shares of high yielding varieties of the respective crops in total irrigated area. [c]Other sole crops include cotton, fodder crops, garden crops in total irrigated area. Other sole crops include cotton, fodder crops, garden crops and in some cases chick-peas, sunflower, and castor. [d]Mixed crops mainly include vegetables, wheat, chick-peas and oil seeds.

of it relatively shallow—on which they plant during the monsoon. They use mixed cropping to alleviate risk.[11] Kalman village, in the same region, does not compare with Shirapur village largely because it has much greater proportion of medium, black, shallow soils which are usually cropped

[11]Yet another set of data not presented in the tables showed that the area kept fallow during kharif (monsoon season) and put under rabi (winter season) crops constituted 78, 50, and 55% of the total cropped area on small, medium, and large farms respectively in Shirapur. The corresponding extent of rabi cropping in Kalman village was 50, 60, and 64%.

only in the monsoon season. Moreover, Kalman has more bunded plots,[12] which allow more opportunities for small-patch cropping involving coriander, linseed, vegetables, and paddy near the bunds where water stagnates. These small-patch crops also add to the extent of mixed cropping.

In view of the extent of mixed cropping, and lacking information about the proportions of individual crops in the crop mixtures, it is difficult to discuss areas of individual crops in the cropping patterns.[13] In most of the subsequent tables, data about a particular crop raised as a sole crop and as a main crop of the mixture (without specification of its actual share in the mixture) have been presented side by side. Table 6 presents the details of individual crops in the manner indicated above.

Mixed cropping characterizes all the villages, but there is considerable difference in the number as well as in the types of crop combinations (Table 5). For instance, Kalman village has 26 and 22 different crop mixtures in two-crop and three-crop patterns, respectively. Dokur, on the other hand, has only one or two crop combinations. Other villages fall between those extremes. In Kalman, the heterogeneity of circumstances, such as availability of deep black, medium black, and shallow soil permitting raising of both rabi and kharif crops in different areas, small-patch cultivation due to bunding, and so on, seems to be responsible for the large number of crop combinations.

Regardless of the number of crop combinations, the inclusion of relatively drought-resistant and relatively drought-sensitive crops such as sorghum, cotton, and pigeon peas is significant in all villages except those in Sholapur. In the Sholapur villages, the reduced number of drought-sensitive crops, combined with drought-resistant crops, is partly due to the delayed 1975 monsoon. When the rains are late and inadequate to start with, drought-sensitive crops like sesame and groundnuts are seldom planted even as mixed crops.

Regardless of the total availability of irrigation in different villages, more than 50 to 100% of the irrigated area is devoted to high-value sole crops like paddy, wheat, sugarcane, groundnuts, vegetables, and others (Table 7). That pattern persists when different landholding-size groups are considered. The Sholapur villages (particularly Kalman) are the exception, where low-value crops like sorghum, maize, and chick-peas also

[12]In Kalman village as a whole, nearly 84% of the farm households have 90 to 100% of their land area bunded. In Shirapur, with extensive areas of deep black soils, only 25% of the farm households have bunded land. Deep black soils make it difficult to maintain bunding. Bunds can cause damage to crops (Jodha, 1976b).

[13]Data collection involved recording the main crop in crop mixtures as first crop. Other components depending upon their declining share in the mixture, were recorded as second, third, fourth crop, and so on, for the same plot (Binswanger and Jodha, 1976). The share of the main crop (or first crop) in the crop mixture could range from 50 to 90% of the total acreage under that mixture.

account for a substantial proportion of irrigated area. The difference is due to the low and undependable extent of recharge in most of the wells, which could not facilitate raising of high water-consuming (high-value) crops in those villages, compared with, say, tanks and wells in Mahbubnagar villages, which ensure intensive irrigation during different seasons. In view of the differing quality of irrigation systems, high-value crops probably utilize a much higher proportion of the available irrigation facility than what is suggested by the irrigated area under them.

Table 7 indicates that paddy occupies most of the irrigated land in the Mahbubnagar villages, unlike the other villages. The situation is largely due to differences in the irrigation systems. In Mahbubnagar, community tanks that collect the runoff water during the monsoon are the major source of irrigation. Historically, tank irrigation is used for paddy cultivation only. In Sholapur and Akola, wells with varying depths and stability of recharge are the only sources of irrigation. Crops are chosen according to water availability. Vegetables are preferred in small or bigger measure everywhere because they (1) are more labor absorbing, early maturing, and an almost perennial source of cash income during the season, and (2) can be marketed with no institutional restriction.

Further examination of Table 6 reveals that a clear-cut relationship between farm size and extent of individual crops obtains mainly in the cases of sorghum, paddy, wheat, other cereals, groundnuts, and cotton in some of the villages. More importantly, the relationship in most cases is not uniform. For example, the acreage of sorghum (sole crop) increases with size of farm in Dokur and Kalman, but the opposite is true in Kanzara.

This is maybe partly due to the fact that farmers' cropping preferences (for instance, large farmers going in for drought-sensitive risk crops and small farmers allocating more area to food grain crops) are based on groups of crops with common attributes (drought-resistance and others) rather than on individual crops. The relationship between farm size and cropping patterns can be seen better if crop groups are considered. Table 8 presents the relevant data. In keeping with the complex of goals that govern farmers' decisions about allocation of area to different crops, the crops have been put into two categories: food-grain crops and cash crops. They have further been broadly subclassified into drought-resistant crops and drought-sensitive crops.[14]

The conventional presumption is that the small farmer devotes a greater proportion of his land to food-grain crops and to drought-resistant crops because of his subsistence requirements, inability to take risks, and so on. Preferences of the larger farmer should be the opposite, as the maximization of profits is presumably his main goal, and he is presumed to be able to

take the greater risk involved in drought-sensitive crops.[15] These hypotheses will now be further examined.

In Aurupalle village (Table 8), if mixed crops alone are considered, the hypothesis of small farmers' concern for subsistence and risk is supported by the increase in area under both food-grain-crop-dominated and drought-resistant-crop-dominated mixtures with the decline in size of operational holding. The support for the hypothesis is strengthened by Table 5 which indicates that most mixtures in Aurupalle consist of food-grains, and almost all the mixtures consist of drought-resistant crops.

When sole crops are considered, paddy and castor distort the trend. The area under food-grains increases with the size of holding. In fact, paddy is more a cash crop than a subsistence crop and implies no violation of the food-grain-based hypothesis. Similarly, the increase in proportion of cash crop mainly due to castor with decline in size of holding does not go very much against the expected behavior of small farms, as castor has numerous virtues like low input cost, drought resistance, long duration of crop conducive to a dispersed pattern of labor use, and supply of fuel materials as a byproduct. The greater extent of drought-resistant crops in large farms than in medium farms is largely due to castor and to kharif pulses, which could be described as large farmers' "subsidiary crops."

In Dokur village, lying in the same tract as Aurupalle but having significantly better irrigation, the situation is quite different. The proportion of drought-sensitive crops declines with the size of landholding. In other respects, such as the area of food-grain crops (raised either as sole crop or the main crop of a crop mixture), the area of cash crops, and the area of drought-sensitive crops, the table does not suggest any clear trend. The principal reason for the above situation is the greater extent of irrigation (Table 3, 4, and 7) on small farms and consequent higher area allocation to paddy and groundnuts as the main crops of mixtures (Table 6). The higher proportion of food-grains and drought-resistant crops on large farms than on medium farms may be attributed to the "subsidiary crops",[16] as Dokur is one village where land concentration is high (Jodha, 1976b).

[14]Categorization of crops as food-grain and cash crops has lost much of its sharpness with the increased commercialization of agriculture, as food-grains in many cases are raised not only for subsistence but also for cash marketing. However, in the absence of a more convenient alternative, this classification has been used. Accordingly, the crops falling in each subcategory are as follows:

a) Drought-resistant food-grain crops: pearl millet, sorghum, finger millet, other minor millets, pigeonpeas, chickpeas, black gram, and other pulses except green gram.
b) Drought-sensitive food-grain crops: paddy, wheat, maize, green gram.
c) Drought-resistant cash crops: castor, sunflower, safflower.
d) Drought-sensitive cash crops: groundnuts, sesame, mustard, linseed, cotton, sugarcane, vegetable crops (except rainfed).

[15]For a discussion of the conventional presumptions and empirical work supporting or contradicting them, see Krishna (1963). Also see Bharadwaj (1974).

Table 8. Relative share of drought-resistant and drought-sensitive crops in total crop acreage by size of operational landholding groups in six villages of semiarid tropical India, 1975–76.[a]

Village, landholding size	Relative share (%)							
	Food-grain crops			Cash crops			All crops	
	Drought-resistant[c]	Drought-sensitive	Total	Drought-resistant	Drought-sensitive	Total	Drought-resistant	Drought-sensitive
Aurupalle (M)								
Small	8 (100)	— —	8 (100)	92 —	— —	92 —	100 (100)	— —
Medium	2 (99)	25 —	27 (99)	53 —	20 (1)	73 (1)	55 (99)	45 (1)
Large	11 (80)	35 —	46 (80)	50 (15)	4 (5)	54 (20)	61 (95)	39 (5)
Total	9 (88)	30 —	39 (88)	53 (9)	8 (3)	61 (12)	62 (97)	38 (3)
Dokur (M)								
Small	3 (47)	97 —	100 (47)	— —	— (53)	— (53)	3 (47)	97 (53)
Medium	19 (27)	56 —	75 (27)	— —	25 (73)	25 (73)	19 (27)	81 (73)
Large	34 (42)	53 —	87 (42)	— —	13 (58)	13 (58)	34 (42)	66 (58)
Total	27 (40)	58 —	85 (40)	— —	15 (60)	15 (60)	27 (40)	73 (60)
Shirapur (S)								
Small	65 —	16 —	81 —	5 —	14 (100)	19 (100)	70 —	30 (100)
Medium	72 (55)	10 (27)	82 (82)	4 —	14 (18)	18 (18)	76 (55)	24 (45)
Large	76 (89)	8 —	84 (89)	1 (5)	15 (6)	16 (11)	77 (94)	23 (6)
Total	73 (83)	10 (3)	83 (86)	3 (4)	14 (10)	17 (14)	76 (87)	24 (13)
Kalman (S)								
Small	69 (96)	14 (4)	83 (100)	15 —	2 —	17 —	84 (96)	16 (4)
Medium	77 (93)	16 (6)	93 (99)	1 —	7 (1)	8 (1)	78 (93)	22 (7)
Large	77 (92)	18 (4)	95 (96)	— (3)	5 (1)	5 (4)	77 (95)	23 (5)
Total	76 (93)	17 (6)	93 (99)	3 (1)	3 —	6 (1)	79 (93)	21 (7)

continued on opposite page

Table 8 continued

Village, landholding size	Relative share (%)							
	Food-grain crops			Cash crops			All crops	
	Drought-resistant[c]	Drought-sensitive	Total	Drought-resistant	Drought-sensitive	Total	Drought-resistant	Drought-sensitive
Kinkheda (A)								
Small	3 (53)	82 —	85 (53)	— —	15 (47)	15 (47)	3 (53)	97 (47)
Medium	21 (50)	17 —	38 (50)	— —	62 (50)	62 (50)	21 (50)	79 (50)
Large	51 (45)	32 —	82 (45)	— —	16 (55)	16 (55)	51 (45)	49 (55)
Total	44 (47)	32 —	76 (47)	— —	24 (53)	24 (53)	44 (47)	56 (53)
Kanzara (A)								
Small	45 (21)	44 —	89 (21)	— —	11 (79)	11 (79)	45 (21)	55 (79)
Medium	56 (13)	37 —	93 (13)	— —	7 (87)	7 (87)	56 (13)	44 (87)
Large	36 (24)	13 —	49 (24)	1 —	50 (76)	51 (76)	37 (24)	63 (76)
Total	40 (21)	19 —	59 (21)	1 —	40 (79)	41 (79)	41 (21)	59 (79)

[a]See note [a] under Table 3. [b]For details of drought-resistant and drought-sensitive crops, see the text. [c]The two sets of figures under each column give details of sole crops and mixed crops at one place. The figures outside the parentheses indicate the percentage share of different crop groups (sown as sole crops) in the total area under sole crops. The figures within the parentheses indicate the share of crop mixture dominated by the corresponding crops in the total area under mixed cropping. Thus the figures in parentheses do not indicate the extent of area under particular crop groups but under the crop mixes dominated by the said crops.

The cropping pattern in Shirapur reveals trends that are completely contrary to the ones hypothesized. Accordingly, the extent of both drought-resistant crops and food-grain crops increases with farm size. That applies to both sole crops and mixed crops.

The trends can be explained in terms of the extent of rabi cropping in the deep, black soils which varies considerably among different farm-size groups in the village. As mentioned earlier, the extent of rabi cropping declined with size of holding in Shirapur. That implies that the larger the farm, the greater is the extent of kharif cropping. This is due partly to the fact that larger farms have some lands that can be planted to drought-resistant crops in the kharif season, and partly to their ability to take added risk. Hence, in terms of risk behavior, growing kharif crops (regardless of type) is comparable to using drought-sensitive crops and is thus in keeping with the risk-related hypothesis about crop preferences of large and small farms.[17]

Rabi cropping, on the other hand, usually provides more assured moisture prospects. The actual choice of rabi sorghum versus wheat, safflower, chick-peas, and so on, during 1975 was influenced by the continuation of monsoon till early November. Most small farmers could not plant sorghum during the short period available, hence, the greater use of crops like wheat (which fall into the drought-sensitive category) and safflower (Table 6).

The situation in Kalman village is fairly different from that in Shirapur. In the case of mixed crops, which have more use in Kalman and the use of which increases as the size of farm declines (Table 4), the cultivation of food-grain crops is inversely related to farm size. There are also more drought-resistant mixed crops on small farms than on farms in other size groups, though there is no clear trend. But there is a clear inverse relationship between farm size and drought-resistant crops when sole crops are considered. The positive relationship between farm size and the extent of cultivation of food grain (sole crops), which contradicts the subsistence-related hypothesis, is largely due to the greater use of drought-resistant (sole) crops like safflower and sunflower on small farms.

In Kinkheda village, if mixed crops are considered, the proportion of

[16] When resources of large farms are not suited to uniformly intensive use, farmers may concentrate their efforts on their better lands (in terms of fertility, irrigation facility, and so on). The remaining lands are used for "subsidiary crop enterprises." If the proportion of inferior lands in total operated area is large, the "subsidiary crops" may dominate the cropping patterns of large farms. Moreover, the large farmers' preferences for particular cash crops may be neutralized by the unavailability of timely and adequate rains. For instance, in Sholapur villages, in medium black soils groundnuts and sesamum crops are replaced mainly by pulse crops in such a situation.

[17] Moreover, delayed and inadequate rains in the early part of monsoon season (1975–76) favored more drought-resistant food-grain crops rather than cash crops like sesame and groundnuts, which further led to more use of food-grain crops on large farms.

food-grain crops declines with the size of holding. In constrast, the share of drought-sensitive cash crops increases with size of holding. Those trends support the subsistence and risk-related hypotheses.

In the case of sole crops, the extent of food-grain crops on small farms is greater than that of other groups, but there is no clear trend. The extent of drought-sensitive crops declines with the size of farm. This is mainly due to higher extent of wheat crop on small farms.

In Kanzara, another village from the cotton tract, however, 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 larger proportions of food-grain crops and smaller proportions of drought-sensitive crops.

Besides subsistence and risk considerations that have been examined in these six villages, a few more variables have an important influence on the land allocation to food-grain crops and drought-resistant crops. Large farms depend on hired labor to a great 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 devote considerable area to such crops, not only for their own subsistence purposes but also for the production needs of the farm enterprise.

At times institutional factors, like the custom of releasing water from irrigation tanks during specific times to irrigate paddy crops, may make cropping decisions or cropping patterns different from those that the households' own resources would suggest.[18] Also, to avoid problems with land reform laws, a large farmer may plant low-cost, drought-resistant crops rather than let land go unused.

The fact that cropping patterns vis-a-vis size of farm do not reveal uniform trends in different villages suggests that, influenced by numerous complex factors, the cropping pattern cannot be fully explained by using landholding size. Furthermore, the factors which convincingly explain the cropping pattern in one situation prove utterly ineffective in another. The diversity of both the cropping patterns and the factors underlying them magnifies one dimension of the problem of cropping systems research for rainfed areas.

CONCLUSIONS

My discussion, based on microlevel details from different locations in arid and semi-arid areas of India, may lead to the following inferences.

[18] For instance, farmers with sufficient irrigation from tanks in Dokur village cultivate paddy. In Sholapur, farmers with dependable irrigation from wells plant sugarcane.

Cropping patterns are affected by a multiplicity of factors of which resource position is one. Within the resource base, the land type, irrigation and rainfall play the most important roles. Those basic resources, together with the availability of plant varieties, determine the comparative advantages of different crops and crop mixes on the various soils. They also determine the rate of return to investment for other components of the resource base. In the long run, the availability of resources of capital (and of labor) are also determined by the land and water resources and the state of technology.

Massive resource transformation that relaxes major constraints (as indicated by canal irrigation and tractorization) and overshadows the impact of other resource differences can lead to shifts of cropping patterns on farms of all categories. Such resource improvements orient the cropping patterns towards high-value crops and reduce the importance of mixed crops.

Major resource shifts may have a stronger and quicker impact on cropping patterns than marginal improvements of various cultural practices or even of crop mixes.

Similarly, introduction of new varieties tends to change the comparative advantages of different crops and may lead to massive shifts in cropping patterns as well as in incentives for investment in other capital items.

The more heterogeneous the resource base, mainly in terms of soil types, the more complex and heterogeneous will be the cropping pattern and the more numerous the crop mixtures observed. That tendency is reinforced by quantum, temporal, and spatial variability of rainfall. The feasible choices in such cases are limited, yet to adjust for uncertainty and risk caused by variability, the farmer tries to multiply his alternatives (through crop combinations) within the limited possibilities. Kalman village illustrates the situation.

On the other hand, greater uniformity of the resource base leads to simple, one- or two-crop-based cropping patterns, even under rainfed conditions. The castor crop in the Mahbubnagar area or sole crops of sorghum and wheat in rabi (winter) cropping in deep-black soil areas of Sholapur are illustrations.

Irrigation imparts uniformity and stability to the resource base and opens a wide range of cropping options. Nevertheless, the cropping pattern tends to become less and less heterogeneous, partly because the uncertainty–induced need for diversification has disappeared. More importantly, the stable cropping environment generated by irrigation permits clearer perception of the comparative advantages of different crops; crop

preferences are more easily narrowed down to the few that are clearly most profitable.

Where overall cropping options are limited, the cropping patterns are varied and complex. Where cropping options are numerous, the tendency is toward simple and one- or two-crop-based patterns. In the former, the farmer is forced to multiply cropping options within narrow limits; in the latter it becomes easy for him to select a few from the large number of options. The size of landholding seems to matter little.

The situation has a number of implications for agricultural research.

First, in view of the association between mixed cropping and poverty of resource base, e.g., smallness of farm, any breakthrough in intercropping research is likely to help the poor more than the rich. This is a unique instance where research can be deliberately biased in favor of the poor.

Second, where cropping options are numerous, as in better watered areas, the crop breeders have greater flexibility and opportunity for crop or variety selection. Even where the environment is not so favorable as in the irrigated areas, but where the resource base is more homogeneous, their task may be less difficult, as the evolved crops do not have to be tested under many different microlevel situations within the same region. Serious problems arise once crops or cropping systems are to be generated for a very heterogeneous resource base. The thought of generating a cropping system to incorporate as many as 26 crop combinations for the micro-units of a heterogeneous tract (as illustrated by mixed cropping in Kalman village) is quite demoralizing. It may create numerous problems even in simple designing of experiments and their replication.

The problems faced in any effort to generate cropping systems for rainfed areas where, in the absence of irrigation, the inherent micro-level heterogeneity of the resource base persists, are the following.

First, the logistics of multilocation and multicrop combination experimentation, to capture the total cropping possibilities to satisfy the varied timing and site requirements of the rainfed areas, is tremendous and costly. Further, it is difficult to avoid the location specificity of experimental results.

Second, the realism and relevance of a new cropping system depends largely upon the extent to which it has been rigorously compared with farmers' prevailing systems. But that poses more serious problems than do multilocation trials. The complexity of the farmer's system stems from his adjustments to diminish the instability and uncertainty of rainfed agriculture. Unless the adjustment mechanism is fully understood and replicated in some form by researchers, injecting the desired degree of diversity and complexity in the prospective cropping system may prove impossible. Understanding and replicating farmers' adjustments are difficult; the systems are sensitive to small changes which are difficult even to perceive at the research farm.

Moreover, the farmers' own cropping systems are a result of informal experimentation over a long period.[19] Given the resource base and varieties, how far formal experimentation can improve upon the cropping system evolved by the farmer is an open question.

The formal research to evolve new cropping systems may have very limited payoff unless what goes into the prospective cropping systems is radically new. The new elements can be new crop varieties, or improvements (including better management) in the land and water resources.[20] The research directed toward generating these new elements obviously should get high priority. As and when the new elements become available, it will be the principal function of cropping systems research to indicate broadly the alternative ways in which farmers' crops can be tied to them. The detailed evolution of cropping systems to suit microlevel heterogeneity may be conveniently left to the informal experimentation of the farmers.

Finally, in the whole process, it is critically important to coordinate the cropping systems research with prior research in adapting varieties to local conditions, and with the research aimed at finding efficient ways to conserve and improve the land and water resource base.

ACKNOWLEDGEMENT

The author wishes to thank Dr. Hans P. Binswanger and Dr. James G. Ryan for their valuable comments and suggestions during the preparation of the paper. They of course are absolved of any blame for errors of omission or commission which remain. The author is grateful to the ICRISAT for providing research facilities and permission to use preliminary results of their studies in this paper. However, the views expressed do not necessarily reflect those of ICRISAT.

[19] The choice of 26 crop combinations in mixed cropping planted in a single village like Kalman is a result of such informal experimentation.

[20] For a detailed discussion of such issues, see Binswanger et al. (1976).

REFERENCES

AERC. 1970. A study of high yielding varieties programme in the Kota districts, Rajasthan. Agro-Economic Research Centre, Vallabh Vidyanagar, India. (mimeo.)

AIYER, A.K.Y.N. 1949. Mixed cropping in India. Ind. J. Agric. Sci. 19:4–15.

BAPNA, S.L. 1973. Economic and social implications of green revolution—a case study of Kota district. Research study no. 28, Agro-Economic Research Centre, Sardar Patel University, Vallabh Vidyanagar, India. (mimeo.)

BHARADWAJ, K. 1974. Production conditions in Indian agriculture: a study based on farm management surveys. Cambridge University Press: 61–84.

BINSWANGER, H.P., and N.S. JODHA. 1976. ICRISAT village level studies manual of instructions for economic investigators (revised). Economics Department, ICRISAT, Hyderabad, India. (mimeo.)

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 bahra. Econ. Pol. Weekly, Rev. Agric. 8:A145–A150.

JODHA, N.S. 1974. A case of process of tractorization. Econ. Pol. Weekly, Rev. Agric. 9:A111–A118.

JODHA, N.S. 1976a. Dry farming technology: achievements and obstacles. *In* C.N. Vakil, C.H. Shah, and U.S. Mohan Rao, ed. Agricultural development in India: policy and problems. Orient Longman Ltd., Bombay. (forthcoming)

JODHA, N.S. 1976b. 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., 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.)

KRISHNA, RAJ. 1963. Rapporteur's report on economics of the cropping pattern. Indian J. Agric. Econ. 18:170–181.

NORMAN, D.W. 1974. Rationalizing mixed cropping under indigenous conditions: the example of northern Nigeria. J. Dev. Stud. 11:3–21.

DISCUSSION

ZANDSTRA: Cropping systems research needs to go beyond the description of different cropping systems encountered in farms with given resource bases. Given an alternative (new) system, how would you evaluate its fit or lack of fit to a given resource base? What criteria would you use in this evaluation?

Jodha: To my mind, description of the existing cropping pattern and its rationale is essential as an input for evolving new cropping patterns. Further, unless there is something new in a new cropping system, the farmer may not accept it. For more about this, see the last two pages of my paper.

HOQUE: How do you account for a definite trend for the percentage of mixed cropping to be determined by the number of plots?

Jodha: Large farms have more land and more plots. By putting in crops as sole crops in more plots, they are able to achieve a degree of crop diversification which small farms with small land cannot. Hence, small farms achieve a degree of crop diversification through mixed cropping on the same plots.

BOWRING: Is there any evidence of cropping systems being adopted on tenant farms that are different from those on owned farms—given of course, that other factors such as farm size are equal?

Jodha: From ICRISAT studies we do have data about each plot—owned or leased. Details are available not only for crops, but for inputs and outputs. As the processing of the data is still in progress, no answer is possible at this stage. However, we will look into it.

FARMER'S DECISION-MAKING BEHAVIOR WITH REGARD TO CROPPING SYSTEMS RESEARCH

W.H. Vincent

This paper introduces a farmer-behavior dimension into the discussion of cropping systems research. An appreciation of the process of decision-making and its role in the total farm-management task is presumed to contribute to an understanding of whether or not farmers will adopt partially or totally, quickly or slowly, the results of research on improved cropping systems.

The paper will first present a conceptualization of the decision-making aspect of management from a systems point of view; second, it will review briefly a few research efforts which suggest alternative approaches to the problem; and finally, it will draw implications from the preceding sections for analyzing the management-behavior aspects of a cropping systems research program.

CONCEPTUALIZATION OF DECISION-MAKING IN MANAGEMENT

I was instructed to identify in my contribution to this part of the program the determinants of farmers' choices among alternative cropping systems. Previous papers have stressed the importance of natural resources and their use for predicting cropping systems' performance. Introducing the human being into the system now makes it more difficult to keep our attention solely on cropping systems.

Household decisions to use resources in crop production are conditioned upon decisions to use resources in other activities. Hence, it seems appropriate to look at general decision-making activity by managers before setting up decision criteria for cropping systems in particular. I will use Figure 1 as a guide.

W.H. Vincent, Professor, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, USA.