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SOME DIMENSIONS OF TRADITIONAL FARMING IN SEMI-ARID TROPICAL INDIA

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ABSTRACT

This paper summarizes some results of village-level studies conducted since 1975 by ICRISAT in six villages in three agroclimatic zones of peninsular India. Results which are of direct relevance to the research strategy for generating new technology for SAT areas are discussed. The paper analyzes the rationale behind the practices of monsoon fallowing of deep Vertisols and intercropping in rainfed agriculture. Constraints on spread of prospective watershed technology are also discussed. It is concluded that since small farms have a relatively higher extent of monsoon fallowing and intercropping, any low cost technological advance in these research areas may help less-endowed farmers more than the relatively better-endowed ones. Under the existing pattern of land distribution and utilization, prospective watershed technology is likely to face severe institutional constraints.

SOME DIMENSIONS OF TRADITIONAL FARMING IN SEMI-ARID TROPICAL INDIA

N.S. JODHA*

INTRODUCTION

This paper discusses some aspects of traditional farming systems in SAT areas of peninsular India. The discussion is based on data generated by village level studies undertaken by ICRISAT in three agroclimatic zones since May 1975. The principal objective of the village level studies was to understand the constraints and potentials of traditional farming systems and to use this understanding as an input in the process of generation of new technology for SAT agriculture. Guided by this consideration the paper addresses itself to a few key aspects of traditional farming systems which are of direct and immediate relevance from the standpoint of technology generation.

The paper makes use of data for three agricultural years (1975-76 to 1977-78) collected regularly at an interval of about 20 days from 30 sample farms (10 small, 10 medium and 10 large) from each of the six

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villages.[1]

Table 1 provides some information about the selected villages and the sample farms, which also broadly differentiates the three agroclimatic zones. The three zones considerably differ in terms of soil types, rainfall and extent of irrigation. The differences influence the farm level availability as well as pattern of resource use in these regions.[2]

INTENSITY OF LAND USE AND CROPPING

From Table 1 it is apparent that irrigation is associated with reduction in the average size of operational landholding and increase in the cropping intensity. Except in the highly irrigated village Dokur, and to some extent Aurepalle the intensity of land use during the reference period was found to be very high (exceeding 90 percent).

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[1]For sampling procedure and other methodological details of ICRISAT village studies see Jodha *et al.* [1977]. During the period of three years some households belonging to the sample of labor households (10 in each village) acquired land. However, they have not been included in the present analysis.

In keeping with the different land-man ratios prevailing in the villages different ranges of operational land holding (in hectares) to define small, medium and large farms were fixed as indicated below (for details see Ghodake and Asokan, 1978).

Kanzara	0.21-2.25	2.26-5.60	> 5.60
Kinkheda	0.21-3.00	3.01-5.60	> 5.60
Kalman	0.21-6.00	6.01-10.75	>10.75
Shirapur	0.21-2.50	2.51-6.00	> 6.00
Aurepalle	0.21-2.50	2.51-5.25	> 5.25
Dokur	0.21-1.00	1.01-3.00	> 3.00

[2]This paper deals with some aspects of the use pattern of land and water resources and their implications. For a discussion of the labor resource and its use see Ryan *et al.* [1979a].

Table 1. Details of operational land holding and its use pattern on sample farms in six SAT Indian villages during 1975-76 to 1977-78[a]

Village (Location, soils, annual rainfall)	Farm size group[b]	Average size of land holding	Land-use intensity[c]	Cropping intensity[d]	Irrigated area[e]	Rainy Season Fallow[f]	Rainy Season Cropped area[g]
		(ha)	(%)	(%)	(%)	(%)	(%)
KANZARA (Akola Dist.; medium deep Vertisols; 820 mm)	Small	1.4	99	103	6	2	98
	Large	14.2	97	103	5	2	98
	Total[h]	6.5	97	103	5	2	98
KINKHEDA (Akola Dist.; medium deep Vertisols; 820 mm)	Small	1.6	97	104	4	2	98
	Large	13.2	92	106	5	3	97
	Total	6.7	93	106	4	3	97
KALMAN (Sholapur Dist.; deep and medium deep Vertisols; 690 mm)	Small	3.5	98	105	7	66	34
	Large	13.8	95	108	11	59	41
	Total	8.5	98	108	10	61	39
SHIRAPUR (Sholapur Dist.; deep and medium deep Vertisols; 690 mm)	Small	1.7	100	108	22	77	21
	Large	11.3	91	114	11	71	29
	Total	6.5	92	114	13	68	32
AUREPALLE (Mahbubnagar Dist.; shallow and medium deep Alfisols; 710 mm)	Small	1.4	93	104	5	5	95
	Large	12.0	70	119	25	7	93
	Total	5.6	76	114	21	5	95
DOKUR (Mahbubnagar Dist.; shallow and medium deep Alfisols; 710 mm)	Small	0.7	80	120	74	8	92
	Large	8.2	90	113	59	19	81
	Total	3.7	82	113	60	18	82

[a] Based on details from 180 sample farms in six villages. Village level studies have been conducted in these villages since May 1975 (Jodha *et al.* 1977).

[b] For the details of farm size grouping see text (footnote 1). All tables in this paper exclude the labor households even if they have acquired land during the reference period.

[c] Land use intensity = $\frac{\text{Net cropped area}}{\text{Total operational area}} \times 100$

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

[e] Gross irrigated area as proportion of gross cropped area.

[f] Proportion of total net sown area fallowed during rainy season and planted in postrainy season. In Dokur and Aurepalle the rainy season fallow lands consist of tank beds where runoff collection is during rainy season. These areas are available for planting crops only in the postrainy season once tank water is used up for irrigation.

[g] Proportion of gross cropped area. It covers all area planted during rainy season including the double cropped area.

[h] Totals include medium farms besides small and large farms in each case.

Land-use intensity was higher on small farms than on large farms. This is quite understandable as the smaller the land holding the less the scope for resting land through periodical fallowing.[3] Though the land-use intensity was lower on large farms, the cropping intensity on the cultivated area showed the opposite trend. In all villages except Dokur the cropping intensity was higher on large farms. This indicates that resource-rich farmers, instead of spreading their nonland resources thinly all over their land, try to concentrate their cropping efforts only on part of the total holding. Furthermore, taking farms as a whole group the gap between intensity of land use and intensity of cropping widened with the extent of irrigation available. The Mahbubnagar villages (particularly Dokur) clearly demonstrate this phenomenon.[4] Since the payoff from irrigated land is much higher farmers prefer not to plant any crop on part of the dry land, and instead concentrate their attention on wet land. The low land-use intensity in Dokur, especially on small farms, is thus largely explained by extensive irrigation in the

[3]This has been observed at macro-level also in the case of the arid region of Rajasthan, where the extent of periodical fallowing has declined with a decrease in the farm size. Such increased land use intensity unaccompanied by measures to protect and conserve the submarginal lands have accentuated the process of desertification in the region (Jodha 1977b).

[4]The extent of irrigation reported in Table 1 does not take into account the intensity of irrigation. If this is done the extent of irrigation in Mahbubnagar villages will further increase substantially. See Table 8.

village. This has implications for rainfed agriculture. Because of the low and uncertain payoff characterizing rainfed agriculture only reduced attention is paid to rainfed agriculture and resources are, if possible, diverted to irrigated farming.[5] More about this later.

RAINY-SEASON FALLOWS

Another feature of traditional farming is the seasonal distribution of cropping (Table 1). In the two Sholapur villages which have a high proportion of deep Vertisols and a bi-model pattern of monsoon rains, 61 and 68 percent of the net cropped area was kept fallow during the rainy season and planted in the *rabi* or postrainy season.[6] This practice, known as *kharif* (rainy season) fallowing or rabi (postrainy season) cropping, is widespread in the deep Vertisol region of semi-arid tropical (SAT) India.[7]

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[5]It has been observed in the study villages and elsewhere that several farmers usually ignore operations like weeding, interculturing, etc. at crucial time on dry land crops and opt for wage employment on irrigated farms at times by temporary outmigration. In such circumstances at least a part of the low productivity of rainfed agriculture could be attributed to back lash effect of neighboring irrigated farming.

[6]In Dokur the rainy season fallowing was more than 18 percent. But this represented a situation different from Sholapur villages. The rainy season fallow areas in Dokur and Aurepalle largely consisted of tank-beds where runoff collection took place during the rainy season. Once the water was used up for irrigation, these tank beds became available for cultivation. This, incidentally, reduces the land lost due to traditional runoff collection tanks.

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

The important reasons advanced by farmers for fallowing the deep Vertisols during the rainy season and then planting in the postrainy season, were as follows:

i) In the absence of good soaking rains, the deep Vertisols are too hard to work; once substantial rains begin, it is difficult to enter such soils.

ii) Even if some crops are dry sown in deep Vertisols prior to rains, the management of the crop during the subsequent wet period is difficult. Weeds may ruin the crop before the soils are dry enough to permit entry of labor.

iii) The rains received during the early phase of the monsoon are less dependable than the ones received during the later phase. According to the farmers' experience and meteorological data, they are inadequate to fully saturate the profile of deep Vertisols. The crops planted during the first phase of the monsoon are exposed to the risk of drought in a prolonged midseason dry spell, and to water-logging as well as increased disease incidence caused by occasional continuous rains in the second phase of the monsoon when they are at the flowering or ripening stages.

At present farmers--not aware of crop varieties or land management practices which can reduce the aforementioned hazards of the rainy-season cropping in the deep Vertisols--continue to follow the traditional practice of fallowing land in the monsoon season. Given the hazards of rainy-season cropping and the nonavailability of viable technology to counter them, the farmer probably makes a rational choice in leaving the deep Vertisols fallow during the monsoon. The irrationality of rainy-season fallow can be demonstrated only by providing a viable alternative, and this precisely constitutes the challenge for agricultural research.[8]

[8]The All India Coordinated Research Project for Dryland Agriculture, ICRISAT and several others are currently engaged in developing technology for traditionally monsoon-fallow areas. Besides the work at experimental stations, ICRISAT initiated in 1977-78 diagnostic experiments on farmers' fields in three of the villages to which this study refers.

Even if one ignores the benefits of reduced soil erosion when Vertisols are planted in rainy season (Kampen *et al.* 1974), the potential payoff from a breakthrough in technology for monsoon-fallow areas, facilitating raising kharif crop besides the rabi crop, will enhance the gross cropped area to an extent equal to nearly one-fourth of the current net sown area in SAT India.

Furthermore, as shown by Table 1, since small farmers have a higher proportion of their land fallowed during the monsoon than do large farmers, the prospective low-cost technology for such areas may help the small farmer more than large ones. This indicates one possible direction for achieving egalitarian goals through technological, as opposed to institutional, means in the SAT areas.

INTERCROPPING*

Intercropping, or growing crops in a mixture, is an important feature of traditional farming in SAT areas of India and elsewhere. The superiority of intercropping, in terms of higher gross returns, as well as higher and more evenly-spread employment of labor when compared to sole cropping, has been documented by Mathur [1963], Norman [1974, 1978]. Additional reasons for this are given below.

*This discussion on intercropping draws heavily from the discussion presented elsewhere; see Jodha [1979a].

As shown by Table 2, the extent of intercropping as a proportion of gross cropped area (average of three years) varied from 18 to 83 percent in the six villages under study. The intervillage or interregional differences in the extent of intercropping can be attributed primarily to differences in agroclimatic and related conditions.

Factors which explain the differences in extent of intercropping in these villages were the amounts of irrigation, postrainy (rabi) season cropping, and extent of HYVs, as well as the extent of some specific crops like paddy, castor bean and sugarcane (rarely grown as mixed crops in these villages) (Table 2). Table 3 illustrates that the above factors lead to greater emphasis on sole cropping.

Diminution, if not complete disappearance, of intercropping with an increase in irrigation, observed also in the command area of new irrigation projects, e.g. Chambal canal (Bapna, 1973), is not difficult to understand. To the extent that intercropping is a strategy against weather-induced risk, the availability of irrigation reduces the need for such strategy (Jodha 1977). The same reasoning applies to the situation where postrainy (rabi) season discourages intercropping. Unlike the rainy season (kharif) crops the postrainy (rabi) crops, largely in deep Vertisol unirrigated areas, are grown on the basis of moisture stored in the soil profile. Planting of crops in such situation begins with a known state of soil moisture; hence the need for intercropping to adjust to eventual fluctuations in the soil moisture situation becomes less important.

Table 2. Extent of intercropping and related details in six SAT Indian villages during 1975-76 to 1977-78.[a]

Village	Farm size groups	Proportion of gross cropped area devoted to: Inter-cropping*	Irri-gated crops	HYVs[b]	Specific crops[c]	Postrainy season cropping[d]
		(%)	(%)	(%)	(%)	(%)
Kanzara	Small	87	6	13	-	2
	Large	70	5	16	2	2
	Total[e]	73	5	16	2	2
Kinkheda	Small	91	4	4	2	2
	Large	82	5	7	2	3
	Total	83	4	7	2	3
Kalman	Small	60	7	-	3	66
	Large	41	11	1	5	59
	Total	47	10	1	4	61
Shirapur	Small	11	22	-	5	77
	Large	19	10	1	7	71
	Total	18	13	-	7	68
Aurepalle	Small	44	5	3	41	5
	Large	34	25	15	57	7
	Total	35	21	12	54	5
Dokur	Small	5	74	77	82	8
	Large	21	59	43	45	19
	Total	21	60	44	50	18

[a]Based on details from 180 sample farms in six villages. Village Level Studies have been conducted in these villages since May 1975 (Jodha *et al.* 1977).

[b]High yielding varieties mainly include hybrid sorghum and hybrid cotton in Kanzara and Kinkheda, and HYV paddy in Aurepalle and Dokur.

[c]Includes crops like paddy, castor bean, and sugarcane more than 90 percent of which are grown only as sole crops.

[d]Net area of postrainy season (or rabi) cropping as a proportion of total net sown area.

[e]Total includes medium farms besides small and large farms in each case. For the basis of farm size classification, etc., see text (footnote 1).

*The small and large farm differences in the extent of intercropping were found to be statistically significant at one percent level.

Table 3. Proportions of postrainy season net sown area (NCA) gross irrigated area, high yielding varieties (HYVs) area, and specific crops area devoted to sole cropping in six SAT Indian villages during 1975-76 to 1977-78.[a]

Village	Proportions of sole cropping in the total of:			
	Postrainy season NCA	Gross irrigated area	HYVs' area	Specific crops[b]
	(%)	(%)	(%)	(%)
Kanzara	99	100	77	-
Kinkheda	100	74	73	-
Kalman	65	83	61	93
Shirapur	79	90	100	91
Aurepalle	100	94	100	95
Dokur	99	100	100	100

[a]Based on details from 180 sample farms in six villages. Village Level Studies have been conducted in these villages since May 1975 (Jodha *et al.* 1977).

[b]Specific crops are sugarcane in Kalman and Shirapur; paddy in Dokur; and paddy and castor bean in Aurepalle.

To the extent that HYVs and intercropping are not incompatible[9], the limited use of HYVs in intercropping systems may hopefully be regarded as a transitional phase. But the real issue is not the technical suitability of HYVs for intercropping.[10] The farmers' decision is largely guided by economic costs involved. From the standpoint of the majority of SAT far-

[9]This has been amply demonstrated by experimental evidence. See papers presented at Intercropping Workshop, ICRISAT [1979].

[10]Of course there is one technical possibility of HYVs discouraging intercropping. HYVs are generally earlier maturing crops which facilitate sequential relay cropping, i.e. planting second crop after harvesting the first crop. Any intercropping which may obstruct sequential or relay cropping may be rejected by the HYV-grower (J.G. Ryan, personal communication).

mers in India, the HYV technology is a high-cost technology as it needs costly inputs like fertilizers, pesticides, and better management of the crop. The farmer does not want to divert costly inputs meant for HYVs to intercropped non-HYV crops.[11] The same consideration tends to discourage the mixing of other crops with high water-requiring, high payoff crops like paddy and sugarcane. Furthermore, crops like paddy, castor bean and sugarcane may lack strong technical complementarity with other crops. Villages with a high proportion of these crops correspondingly had a lower extent of intercropping (Table 2). On the other hand, villages (particularly Kanzara, Kinkheda) with substantial area under crops like pigeonpea, cotton or rainy-season sorghum (largely grown as intercrops), had a higher extent of intercropping.[12]

FARM SIZE AND INTERCROPPING

Largely because of its risk-reducing potential, intercropping is a more popular system among small farmers.[13] Both because of his poor capacity to take risk and the paucity of land to sow sole crops in different plots, the small farmer often resorts to intercropping as a defense against

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[11]The difficulty of incorporating HYVs into intercropping systems could be one of the factors responsible for a limited spread of HYVs in areas as well as farming groups (i.e. small farmers) where intercropping receives higher priority (Table 2).

[12]For details of major sole crops and crop combinations in mixed crops see Jodha [1979a].

[13]The analysis of data for precise qualification of the extent to which intercropping reduce risk is still in progress.

risk[14] to a larger extent than the large farmer. The preliminary results on this aspect reported earlier (Jodha 1977) are confirmed by data for three crop years (Jodha 1979a); small farmers consistently used intercropping to a higher extent than large farmers in all the villages except Dokur and Shirapur. The difference between proportions of intercropping on small and large farms (average of three years) ranged from 9 to 18 percent in different villages and was found statistically highly significant. The highly significant greater use of sole cropping than intercropping on small farms in Dokur and Shirapur was explained by the fact that small farmers had more irrigation and postrainy-season cropping, which for the reasons discussed earlier, discouraged intercropping.

An implication of this result is that any advance in intercropping technology may benefit less well-endowed farmers (and areas) more than the relatively better-endowed ones. This once again offers another opportunity of explicitly incorporating equity considerations into an agricultural research strategy by means of greater resource allocation to this area of research.

COMPLEXITY OF TRADITIONAL INTERCROPPING SYSTEM

Complexity and diversity is another feature of traditional cropping systems (Table 4). If sole crops and number of crop combinations in crop mixtures

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[14]Another reason for higher proportion of intercropping on small farms is the fact that the small farmer tries to satisfy his profit, subsistence and security-oriented needs from the same small piece of land. Intercropping serves this purpose better.

Table 4. Number of sole crops, crop combinations in crop mixtures, and their (%) share in gross cropped area in six SAT Indian villages during 1975-76 to 1977-78.[a]

Village	Sole crop	Intercrops with mixtures of				Total
		2 crop	3 crop	4 crop	5-8 crop	
	(no)	(no)	(no)	(no)	(no)	(no)
Kanzara	22 (27)[b]	17 (26)	13 (24)	11 (19)	4 (4)	67 (100)
Kinkheda	19 (17)	15 (24)	14 (41)	11 (17)	1 (1)	60 (100)
Kalman	34 (53)	40 (24)	28 (15)	13 (6)	3 (2)	118 (100)
Shirapur	44 (82)	23 (15)	3 (2)	1 (1)	-	71 (100)
Aurepalle	21 (65)	4 (6)	2 (10)	-	11 (19)	38 (100)
Dokur	17 (79)	4 (5)	3 (2)	2 (7)	1 (7)	27 (100)

[a]Based on details from 180 sample farms in six villages. Village Level Studies have been conducted in these villages since May 1975 (Jodha *et al.* 1977).

[b]Figures in parentheses indicate the percentage share of crop/crop combination in gross cropped area during the 3-year period.

are considered together, their number ranges from 27 to 118 in different villages. Two crop mixtures were popular in most villages, but mixtures involving five to eight crops were not uncommon.[15] There were considerable

[15]Mathur [1963] recorded more than 100 crop combinations in fields of crop mixtures in Vidarbha region of India; Norman [1978] recorded 230 different crop combinations used in intercropping in villages of northern Nigeria. This indicates that complexity of traditional intercropping is a general phenomenon.

interregional differences in terms of the importance of major intercrops. For instance, in Kanzara and Kinkheda (Akola District) cotton-based and sorghum-based intercrops were dominant. In other villages (except Dokur where groundnut-based intercrops dominated) sorghum-led intercrops were more important. Pigeonpea was an important component of mixtures in all villages (Jodha 1979a).

The complexity of traditional intercropping systems is partly an outcome of farmers' informal experimentation with crops which satisfy their requirements and also fit the agricultural environment of the region. The farmer is engaged in agriculture with multiple objectives related to subsistence and employment of his family and cattle, profit from farming adjustment to drought risk, as well as potential and limitations of his land.

As the specific crop or a group of crops have comparative advantage in satisfying only specific objectives, owing to their physiological, economic and other characteristics, the farmer likes to grow all of them to satisfy his multiple objectives. However, in densely-populated countries farm size is not large enough to devote an area to each crop separately. Consequently, the farmer finds it convenient to intercrop in order to satisfy his multiple objectives simultaneously.

To illustrate the points mentioned above, crop mixtures observed in the villages were classified into six categories on the basis of the specific characteristics of the crops included in each intercrop combination. The categories were defined on the basis of objectives they could fulfill and are briefly described under Table 5, which presents the proportions of intercropped area covered by mixtures aimed at different objectives. Since a given mixture may satisfy several objectives the six categories of crop mixtures are not mutually exclusive,[16] and the percentages in Table 5 do not add to 100%.

In the six villages the most important categories of crop mixtures (indicated by their share in total area of intercrops) were as follows:

(C) Mixtures of different maturity length - involving crops of different maturity cycle to evenly distribute the labor requirements of cropping and making fuller use of crop-related environment (e.g. sorghum and pigeonpea).

(D) Mixtures of drought-sensitive and drought-resistant crops - involving drought-resistant and less drought-resistant (or drought-sensitive) crops such as pearl millet with groundnut, or pigeonpea with cotton, to guard against moisture risk without losing the option of benefitting from expected good rains.

(E) Cash crop - food crop mixtures - involving crops traditionally described as cash crops and food grain crops, e.g. cotton with sorghum or pearl millet with groundnuts, in order to simultaneously satisfy cash and subsistence requirements.

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[16]It may be noted that in a number of situations a crop whether grown as sole or as part of mixture can satisfy the same objectives. But besides the land constraints there are a few other factors which favor the latter. The convenience of management (watching, supervision) technical complementarity of crops, gain in yields, risk reduction, etc., are a few examples.

Table 5. Proportions of different categories of crop mixtures in the total area of intercropping in six SAT Indian villages (Average of 1975-76 to 1977-78)[a]

Crop mixture Categories[b]	Proportion of different categories of crop mixtures in total area of intercropping in					
	Kanzara	Kinkheda	Kalman	Shirapur	Aurepalle	Dokur
	(%)	(%)	(%)	(%)	(%)	(%)
A. Special situation	2	3	15	12	3	2
B. Self provisioning	9	11	18	14	36	29
C. Different maturity periods	58	84	46	32	71	79
D. Drought sensitive - Drought resistant	72	81	18[c]	25	13[c]	41
E. Cash crop - food crop	73	59	44	61	53	50
F. Legume - Nonlegume	88	77	59	40[d]	84	38[d]

[a]Based on details from 180 sample farms in six villages. Village Level Studies have been conducted in these villages since May 1975 (Jodha *et al.* 1977).

[b]The crop-mixture categories are not mutually exclusive. Therefore the percentages are not additive. The basis of crop-mixture categorization is as follows:

Category A - Special Situation: Mixture resulting from adding to the main crop of the plot a few other crops in order to adjust to the physical factors like patches with salinity, depressions, infertile, gravelly soil, etc. (e.g. paddy combined with sorghum or pigeonpea).

Category B - Self Provisioning: Mixtures having in addition to main crops of the mixtures, some crops like seasonal vegetables, tobacco, fiber crops, etc., seldom grown for the purpose of final harvests. They are harvested as and when family "self provisioning" demands.

Category C - Different Maturity Lengths: Mixtures involving crops with different growth periods facilitating spread of peak (harvest) period labor requirement (e.g. sorghum and pigeonpea).

Category D - Drought Sensitive and Drought Resistant Crops: Mixtures involving drought resistant and drought sensitive (or less drought resistant) crops (e.g. groundnut and pearl millet).

Category E - Cash crop - Food Crop : Mixtures involving cash crops and foodgrain crops (e.g. sorghum and cotton, castor bean and pigeonpea).

Category F - Legume - Nonlegume: Mixtures involving legumes and nonlegumes (e.g. sorghum, pigeonpea, or greemgram).

[c]Bulk of the other mixtures consisted of only drought-resistant crops.

[d]Bulk of the other mixtures consisted of only legumes.

(F) Legume - nonlegume mixture - involving nonlegume and legume crops, e.g. sorghum or pearl millet with mung bean or pigeonpea to fulfill fertility and rotation requirements without sacrificing nonlegume crops and for balancing the diet.

The other two categories of mixtures *viz.,* A and B induced by self-provisioning requirements and the need for adjustment to problems of soils, though important in themselves, are relatively less important as indicated by their share in the total area of intercrops.[17]

While the analysis of data to quantify the extent to which the farmer actually achieves his goals by growing the six categories of crop mixtures is still in progress, the above picture demonstrates that traditional intercropping systems are complex and diverse because they involve a conscious and rational attempt by the farmer to adjust his cropping pattern according to his need and resource base. An important implication for research on intercropping follows from the above. Even while trying to generate new, simple and more productive intercropping systems, other considerations indicated by mixture categories C, D, E, and F should not be completely ignored. Ignoring these would mean ignoring the very client for which intercropping technology is being generated.

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[17]It may be mentioned that cropping patterns in villages are not rigidly fixed. Depending on the quantum and timing of rains and rotation requirement farmers do adjust their crops and crop combinations. An analysis of relationship between rainfall and cropping decisions using village level daily rainfall record and cropping patterns on sample farms, is currently under progress.

WATER RESOURCE : THE KEY VARIABLE

Without belittling the rationale of farmers' wisdom underlying the traditional system of farming in SAT areas, it is clear the system seems to operate more as an adjustment mechanism against factors causing low and unstable production rather than a dynamic enterprise showing possibilities for sustained growth. The circumstantial evidence in terms of asset depletion/replenishment cycle (Jodha 1978) and aversion to risk associated with investment (Binswanger 1978), indicates the possibility of permanent underinvestment in SAT agriculture. The scope for dynamizing SAT agriculture is limited for want of viable technological options. The new element which in recent years has led to a rise in production in traditional agriculture in some areas is the fertilizer-responsive HYVs. But HYV-based technology also works best when complemented by the requisite amount of moisture. This brings us to a key physical factor which can make traditional agriculture in SAT areas more dynamic. Farmers and policy-makers, of course, are not unaware of this.

At the cost of a little digression, the following can be mentioned.[18] Even during British Colonial rule, the traditionally drought-prone areas in India started receiving priority in terms of irrigation projects, largely based on import of water from other catchments. The substantial

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[18]For a detailed review of various technological approaches and policies to reduce instability and ensure growth of rainfed agriculture in India see Jodha [1979b].

irrigation investment in SAT areas since the early 20th Century did not help beyond creating a few pockets of prosperity within SAT regions where irrigation schemes, intended to irrigate and protect dry crops against drought ended up being used to irrigate sugarcane and paddy. The realization of limits on 'imported water' as a solution to the problems of low rainfall areas induced a search for technologies which would ensure maximum conservation and efficient use of available moisture. The limited research effort of the 1930s, generated what is commonly known as the Bombay Dry Farming Technology. More concentrated efforts were initiated during the early 1970s when organizations like the All India Coordinated Research Project for Dryland Agriculture and ICRISAT came into existence to generate relevant technological options for SAT farmers. Of the several approaches being tried, the principal one heavily emphasised by ICRISAT is management of soil and water on a watershed basis.

WATERSHED BASED SYSTEM OF FARMING

The basic philosophy behind the resource centred (as against crop centred) approach to technology research is that the resource use in SAT agriculture should be environment-based rather than individual holding-based. For this purpose ICRISAT considered a watershed or catchment to be the appropriate unit of resource management and utilization (Krantz *et al.* 1976). To ensure conservation and effective utilization of water--the most scarce of natural resources for agriculture in SAT areas--a variety of measures are considered. Depending upon soil type and slope, these measures broadly include, necessary land shaping; semi-permanent to permanent graded broad-beds and furrows--to ensure full penetration of moisture, reduce erosion and regulate runoff; grassed water ways for drainage; and tanks to collect run-off water to be used for life-saving irrigation during midseason droughts or for irrigating crops in the postrainy season. The land and water management measures are complemented by improved agronomic inputs (Krantz *et al.* 1977). Devoid of its detailed technicalities, the key elements of the watershed-based system of farming relevant to the present discussion are two. First, if the land management is attempted on a watershed basis it can ensure higher availability of moisture which when complemented with improved agronomy can ensure much higher and stable production from the same land resources.[19] Second, since water is the most limiting natural factor in SAT agriculture, it should be used most efficiently--i.e. on crops which are low water-consuming--so that the maximum area could be covered with the limited water available from runoff collection tanks in the watersheds.

The full-scale watershed technology is yet to be tried in the villages. However, juxtaposition of some factors characterizing traditional agriculture and the elements of prospective watershed technology can give some idea of the potential constraints on the prospective technology.[20]

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[19]For economic analysis of field-scale watershed experiments see Ryan *et al.* [1979b].

[20]For a detailed discussion of these issues see Jodha [1975].

PROBLEM OF GROUP ACTION

The first problem arises from the existence on every miniwatershed in the villages of several plots owned/operated by different owners (Table 6). The watersheds actually surveyed in ICRISAT study villages, as well as the DPAP (Drought Prone Area Programme) districts of different states, suggest that the number of farmers involved in a single miniwatershed ranged from 7 to 93 and there was considerable variation in the size of different holdings within the watershed. Similar variation could be expected in terms of other resource positions of the farmers involved in the watershed. In the context of rather disappointing experience of cooperatives in India obtaining the agreement of all farmers in a watershed to its common and integrated use poses a question of group action among the farmers in order to adopt the prospective watershed technology.

The scope for adoption of full watershed based technology on an individual farmer's land, as against the contiguous plots owned by several farmers involving group action has certain limitations. The important being the fragmentation of holdings, small size of plots, practical difficulties of consolidating the small plots into land parcels large enough to satisfy the requirements of integrated watershed development.[21] Somewhat clearer idea of the above problems can be had from the following Tables 6 and 7.

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[21]Of course, some components of prospective watershed technology could be adopted in parts, the total impact in terms of resource productivity and conservation can be realized only if whole package of the technology is adopted (Krantz *et al.* 1977).

Table 6. Details of land holdings on small watersheds in eight SAT Indian villages[a]

Village	District (State)	Total area	Farms repre-sented on water-shed	Average size of farm holding on given water-shed	Range of hold-ing size on water-shed	Farm hold-ings smaller than average	Soil types on water-shed[b]	Annual rain-fall
		(ha)	(no)	(ha)	(ha)	(%)		(mm)
Kanzara	Akola (Maharashtra)	19.9	13	1.5	0.4-4.5	69	MDV	819
Shirapur	Sholapur (Maharashtra)	16.9	13	1.3	0.2-3.9	77	DV	636
Darphal	Sholapur (Maharashtra)	70.5	30	2.4	N.A.	N.A.	MDV,SV	600
Khanderajani	Sangli (Maharashtra)	35.4	10	3.5	N.A.	N.A.	MDV,SV	425
Krishnapur and Takli	Dharwar (Karnataka)	43.4	29	1.5	0.3-4.0	N.A.	MDV	606
G.R. Halli	Chitradurga (Karnataka)	116.0	93	1.3	0.4-6.0	47	DA,SA	612
Bayanapalle	Mahbubnagar (Andhra Pradesh)	20.0	30	0.7	N.A.	N.A.	DA,SA	710
Aurepalle	Mahbubnagar (Andhra Pradesh)	26.7	7	3.8	1.3-10.0	57	DA,SA	710

[a]Details summarized from Sharma and Kampen (1977) and unpublished reports prepared during Training Program for DPAP Officers, organized jointly by All India Coordinated Research Program for Dryland Agriculture, Central Soils and Water Conservation Research and Training Institute and ICRISAT, April 10-17, 1977.

[b]<u>Soil types</u>: MDV = Medium Deep Vertisols; DV = Deep Vertisols; DA = Deep Alfisols; SA = Shallow Alfisols; SV = Shallow Vertisols.

Using different parameters of prospective watershed technology, Ryan *et al.* (1979b) have estimated that the optimum economic size of catchment or watershed in parts of peninsular India would seem to be between 8 to 16 hectares. The size distribution of individually-owned land parcels or fragments (Table 7) in the six villages indicates that there are literally no plots with any farmer which could satisfy the economic (8 to 16 ha) requirements of a miniwatershed for the individual farmer. Even if the size requirement is reduced to 4 to 6 ha, in four out of six villages one does not find more than seven percent of individually-owned land parcels which could, at least on an area basis,[22] qualify for a miniwatershed. Topographic information about the plots may probably further reduce the percentage of fragments suited for treatment on whole watershed basis. Furthermore, practically all the large plots under consideration were owned by large farmers. Hence, for the small and medium farmers (and to a greater extent for large farmers too), there is no alternative to group action, if the complete watershed-based technology including provision for runoff collection tank, is to be adopted.

A review study of several agricultural group-organizations by Doherty and Jodha (1977) suggested that besides several other factors, an easily perceivable, clear-cut, and higher economic payoff is one

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[22]It is not area alone but also topography of the plot which determines its suitability as an integrated miniwatershed. However, such information about land parcels (Table 7) is not available at present.

Table 7. Distribution of land fragments by size on the sample farms in six SAT Indian villages during 1975-76[a]

Village	Total fragments/ land parcels	% distribution of fragments in the ranges (ha) of <0.8	0.1 - 2.8	2.8 - 4.1	4.1 - 6.1
	(no)	(%)	(%)	(%)	(%)
Kanzara	100	28	57	9	6
Kinkheda	71	21	44	15	20
Kalman	216	48	50	2	-
Shirapur	112	53	39	4	4
Aurepalle	87	37	40	9	14
Dokur	83	68	26	4	2

[a]Based on details from 180 sample farms in six villages. Village level studies have been conducted in these villages since May 1975 (Jodha *et al.* 1977).

condition which can induce farmers to participate in a gorup action. It seems from the analyses performed on the research watersheds at ICRISAT Center from 1975-76 that the new watershed technology does offer considerable additional profits, particularly on deep Vertisols.[23]

ALLOCATION OF WATER RESOURCE

The next problem relates to use of runoff collection in watershed tanks. Even if one ignores the issues relating to cost- and benefit-sharing by the farmers who are spatially separated vis-a-vis the tank, there is a major problem of water use for ID (irrigated dry) crops like sorghum, mil-

[23]See Ryan *et al.* [1979b] for economics of watershed technology.

let, pigeonpeas versus the high water-consuming crops like paddy and wheat. Farmers have a tendency to use water for high-water requiring crops which usually are high-valued crops also. This phenomenon is universally visible in all irrigation systems, be it public canals, small runoff collection tanks or even the dug wells (Jodha 1979b).

As Table 8 shows, in the villages of Dokur and Aurepalle, where traditional runoff collection tanks are a principal source of irrigation, around three-quarters of their gross irrigated area was occupied by paddy alone. Even in the villages where the extent of irrigation was only 5 to 13 percent of gross cropped area the bulk of the irrigation was devoted to high water-consuming crops like wheat, sugarcane, cotton, vegetables, etc. If the case of Kanzara, where hybrid sorghum was irrigated is excluded, Kalman is the only village where sorghum received substantial proportion (30%) of the irrigation. This was because wells did not have sufficient recharge to support paddy or sugarcane. Intercrops did not receive more than 10 percent of irrigation in any village, once again confirming the results mentioned earlier. Furthermore, if the extent of irrigation is defined in terms of intensity of irrigation (area irrigated multiplied by number of irrigations), the tendency towards concentration of the water resource on high water-consuming crops, particularly in low irrigation villages, becomes more clear. For instance, in Shirapur the share of sugarcane in irrigation increased from 22 to 39 percent once intensity of water use was considered. Correspondingly, shares of sorghum and mixed crops declined from 9 to 3 and 6 to 3 percent, res-

Table 8. Percentage share of different crops in the gross irrigated area in six SAT Indian villages (Average of 1975-76 and 1976-77)[a]

Crops	Proportion of different crops in gross irrigated area in:[b]											
	Kanzara		Kinkheda		Kalman		Shirapur		Aurepalle		Dokur	
Sorghum	28[c]	(26)	-	-	30	(28)	9	(3)	5	(6)	-	-
Wheat	56[d]	(58)	44[d]	(45)	19	(23)	15	(14)	3	(2)	-	-
Paddy	2	(2)	1	(1)	6	(5)	1	(1)	73	(78)[e]	79[e]	(74)
Groundnuts	6	(5)	10	(9)	4	(4)	10	(10)	-	-	20	(24)
Pulses[f]	5	(4)	25	(27)	9	(5)	2	(1)	-	-	-	-
Vegetables	4	(4)	2	(1)	7	(11)	12	(13)	5	(6)	1	(1)
Sugarcane	-	-	-	-	3	(6)	22	(39)	-	-	-	-
Cotton/Castorbean[g]	-	-	9	(13)	-	-	-	-	5	(2)	-	-
Other Sole Crops[h]	-	-	-	-	13	(13)	23	(17)	-	-	1	(1)
All Mixed Crops[i]	-	-	9	(4)	10	(7)	6	(3)	10	(6)	-	-
Total	100	(100)	100	(100)	100	(100)	100	(100)	100	(100)	100	(100)
Total as % of GCA	5	(22)	3	(6)	8	(21)	13	(42)	19	(66)	60	(307)

[a]Based on details from 180 sample farms in six villages. Village level studies have been conducted in these villages since May 1975 (Jodha *et al.* 1977). The sources of irrigation are tanks and wells in Mahbubnagar and Aurepalle and only wells in other villages.

[b]Figures in parentheses indicate the proportion of each crop in the gross irrigated area recalculated using the intensity of irrigation. The recalculated gross irrigated area is based on area irrigated multiplied by number of irrigations given to the same (whole) plot. While doing so all irrigation operations for a given plot taking place within the intervals of 10 days have been treated as one irrigation operation. This avoids the possibility of partial coverage of a plot by water being treated as its full coverage. The partial coverage may result from poor and slow recharge in the irrigation well as well as the water-spreading methods used in the paddy fields. Furthermore, in the case of paddy this method tends to under estimate the irrigation intensity because watering of paddy is almost continuous as the field is always kept wet.

[c]Hybrid Sorghum.

[d]Kanzara over 60 percent and Kinkheda over 60 percent HYV wheat.

[e]HYV-paddy over 60 and 90 percent respectively in Aurepalle and Dokur.

[f]Mungbean in Kanzara and Kinkheda; chickpea in Kalman and Shirapur.

[g]Hybrid cotton in Kinkheda; castorbean in Aurepalle.

[h]Includes maize, sunflower, garden crops in Kalman and Shirapur villages, and finger millet in Dokur.

[i]Excludes all vegetables, mixtures and a limited extent of sugarcane-vegetable mixtures, included with respective main crops.

pectively. Similar was the case in Kalman where sugarcane, vegetables and wheat gained at the cost of sorghum, mixed crops, etc. The inter-village comparison further highlights the concentration of water on high water-requiring crops. Among the six villages Dokur had highest extent (60 percent) of gross cropped area receiving water. Once water use intensity was considered, the gross irrigated area exceeded three times the gross cropped area. Practically all of this area was devoted to high water-requiring crops, particularly paddy. Furthermore, one can expect a similar pattern in the allocation of other inputs among different crops.

This raises a basic question about priorities in resource use on wet crops and ID crops within SAT areas. On the basis of social justice the benefit of water can be spread over larger area thus benefitting more farmers, stabilizing agriculture and increasing productivity per unit areas as well as per unit water. However notwithstanding the sacrifice of potential social gains, the farmers guided by private benefit allocate water and other resources to high value high water requiring crops. Under such circumstances, coarse grains like sorghum and pearl millet (two of the five crops researched by ICRISAT) will always suffer neglect unless their low value status is centred by reduced cost of production and institutionally determined rise in their relative price. This constitutes a challenge for both researchers and policy makers. Any breakthrough in crop technology of SAT-crops reflected through low cost and high yield as well as their improved competitiveness with other crops, besides being an achievement in itself, could serve as means of shifting resources (e.g. water) allocation in favor of these crops. The policy makers through price incentives as well as social control of water distribution to different crops also could encourage adoption of such technologies by farmers. It may be mentioned that institutional support through price incentives and water use regulation farming of coarse grains and the areas growing these crops will involve certain direct and indirect costs. But that should be treated as price of social justice and development. Similar price the nation has usually paid for helping other endowed areas while creating public irrigation schemes, etc. most of which have not proved profitable if judged by narrow commercial yardstick. Furthermore, the initial impetus to develop and spread new technology can more than offset the initial costs involved.

CONCLUSIONS

The results, based on data from three crop years in village level studies in three agroclimatic zones in peninsular India, have revealed the rationality behind some of the traditional farming practices. The important results which could help in designing research strategies for evolving a relevant technology for these areas are as follows.

In the deep Vertisol areas the practice of fallowing land during rainy season and planting it in postrainy season is very important. This is more so in the case of small farmers than large ones. Hence any technological advance facilitating rainy season crops in monsoon-fallow tracts, besides substantially adding to double-cropped area, can probably help small farmers more than large ones.

In the largely rainfed areas (other than those with extensive deep Vertisol areas) the traditional practice of intercropping covers 35 to 73 percent of gross cropped area. The extent of intercropping declines with increase in irrigation. The small farmers again have a significantly higher extent of intercropping than large farmers. This indicates that generation of a low-cost new technology for intercropping may help less-endowed areas and farmers more than the relatively well-endowed ones. This suggests yet another of the few opportunities where egalitarian objectives could be achieved by technological means as opposed to institutional means in the SAT areas. This has significant implication for research resource allocation.

As revealed by the number of crop combinations (as high as 84 in a single village), the traditional intercropping is highly complex. This is partly an outcome of farmers' informal experimentation with crops which could satisfy their requirements and also fit to agricultural environment of the region. While evolving new intercropping technology the multiple objectives of the farmer such as security, profitability, employment and subsistence requirements of his family members and cattle etc., should be taken into account.

The juxtaposition of requirements of prospective watershed-based technology and the features of the traditional system of farming--particularly land ownership and usage pattern-gives an idea of the institutional constraints the technology is likely to face. Owing to indivisibility of integrated watershed-based technology, nonavailability of individually-owned land parcels to constitute a composite miniwatershed, there seems no alternative to a group action which can ensure management of land for higher productivity and conservation on a watershed basis. In order to induce group action among farmers for prospective watershed technology, the latter will have to be highly profitable.

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