Human Labour use with Existing and Prospective Technologies in the Semi-Arid Tropics of South India

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This study, based on work in six villages, seeks insights into the likely effect of the introduction of prospective land-, water-, and crop-management technologies, being researched at the International Crops Research Institute for the Semi-Arid Tropics, on the existing village labour-use patterns in one major relevant region: peninsular India. Explicit attention is given to the similarities and differences between small and large farms and their relevance to the adoption of the prospective new technologies.

Regional variation in labour utilisation reveals a tremendous employment-creating potential in the existing tank and well irrigation systems in the Alfisols of peninsular India. The prospective technologies should increase employment, compared with existing technologies, by at least 100 per cent in the Alfisols and by over 300 per cent in the deep Vertisols — but with some increase in the seasonal variability of labour demand. Given the existing availability of labour, there will be, with the improved watershed technologies, major farm labour bottlenecks. These should eventually generate increased wage rates and employment potentials. However, even temporary adverse effects on the timelessness of operations could be critical to the success of a double-cropping and/or intercropping technology aiming at greatly increased yields. This would create demands for selective mechanisation, for example, of threshing.

Human labour is a key resource in the agriculture of most developing countries, especially in the semi-arid tropical (SAT) regions where more than 600 million people eke out a livelihood from the meagre resources of land and capital in a risky

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climate.[1] Substantial efforts are presently underway to develop improved agricultural technologies for these SAT regions, involving both national and international programmes. In many of these programmes the research thrusts involve development of technologies that will be viable for all farmers, including the small landholder, and which will have potential for augmenting rural employment, particularly in the Asian context.

Experience with the modern varieties of wheat and rice in Asia, which were introduced in the mid-1960s, suggests that new seed/fertiliser/irrigation technology, being basically land-augmenting and labour-using, does have scope for creating employment and benefiting small farmers [*Hayami and Ruttan, 1970: 1125-1127; Hanumantha Rao, 1975: 155, 195*]. However, there is evidence that tractor mechanisation which occurred at the same time in south Asia may have led to labour displacement with little, if any, increase in the productivity of land [*Binswanger, 1978: 51-53*].

It was against this background that the present study was initiated. The aim was to obtain insights into the likely effect of the introduction of prospective improved land-, water-, and crop-management technologies being researched at ICRISAT on existing village labour-use patterns in semi-arid south India. Inter-regional and inter-village differences in labour-use patterns are explored and their agro-climatic and socio-economic determinants discussed. In addition, explicit attention is given to the similarities and differences between small and large farms within villages and their relevance to the adoption of the prospective new technologies being developed at ICRISAT.

THE DATA

Data for the study were derived from the ICRISAT's studies in six villages of semi-arid south India since 1975.[2] The villages were selected to represent three broad agro-climatic zones. Aurepalle and Dokur villages (Mahbubnagar District, Andhra Pradesh) represent the Alfisol, low (713 mm average anual rainfall) and uncertain[3] rainfall areas in Andhra Pradesh, Karnata and Tamil Nadu. Shirapur and Kalman (Sholapur District, Maharashtra) represent the deep and medium-deep Vertisol, low (691 mm) and uncertain rainfall areas of Maharashtra, Karnataka and Madhya Pradesh. Kanzara and Kinkheda (Akola District, Maharashtra) typify the relatively high (819 mm) and more-assured rainfall areas of northern Maharashtra and Madhya Pradesh, having medium-deep Vertisols.

VILLAGE CHARACTERISTICS

The average operated farm size ranged from 3.37 ha in Dokur to 6.75 ha in the Sholapur villages (Table 1).[4] In Aurapalle and Aloka landless households represented about one-third of the total. In Sholapur they comprised almost half; Dokur had fewest, at one-quarter.

More than 75 per cent of the operated land was cultivated. The proportion was lower in Mahbubnagar than Akola and Sholapur. Almost 45 per cent of Dokur farms were irrigated, but in Akola villages, only two per cent; irrigation is more prevalent in the Alfisol than in the Vertisol villages. Villages in the more-assured rainfall Vertisol areas of the Akola region had a lower percentage of irrigation than

TABLE 1

SOME SOCIOECONOMIC CHARACTERISTICS OF SELECTED SAT VILLAGES IN INDIA (1975-76)

District/Village	Operational farm size group	Av. operated land (ha)	Family human labour per 10 ha of operated land (man-equiv.)	No. of bullocks per 10 ha of operated land	Av. irrigated area (%)	Av. intensity of cropping (%)
MAHBUBNAGAR VILLAGES						
Aurepalle	Small	1.33	27.67	5.03	0.0	100
(Alfisols)	Medium	3.09	12.12	2.58	15.19	102
	Large	12.52	5.65***[a]	3.19*	10.77***	118***
	All farms	5.79	8.41	3.21	10.82	113
Dokur	Small	0.69	54.50	2.91	69.25	130
(Alfisols)	Medium	1.90	14.90	2.64	60.64	127
	Large	7.53	6.27***	3.98	39.19	111
	All farms	3.37	11.17	3.65	45.25	116
SHOLAPUR VILLAGES	Small	2.63	13.33	2.10	11.25	107
(Deep Vertisols)	Medium	6.84	6.32	2.00	13.52	112
	Large	10.96	4.06***	1.44	7.49	109
	All farms	6.75	6.05	1.71	9.95	110
AKOLA VILLAGES	Small	1.52	21.33	2.63	3.84	105
(Medium-deep	Medium	3.92	7.98	2.56	1.03	105
Vertisols)	Large	13.41	3.66**	2.43	2.26	106
	All farms	6.29	5.97	2.47	2.15	106

[a] Asterisks indicate large-farm figures are significantly different from small-farm figures of the respective village/region.

***, ** and * represent significant differences at 1, 5 and 10% levels, respectively.

did those in the Sholapur Vertisols. Partly because they have more irrigation, the Mahbubnagar Alfisol villages have a higher cropping intensity (around 114) than those in either Sholapur (110) or Akola (106).[5] Another contributing factor to lower cropping intensity in the Akola villages is the large area under long-duration cotton. This cropping intensity index does not take the duration of a crop into account, and must, for that reason, be interpreted carefully.

Some of the differences between small and large farms are illuminating.[6] The average large farm is about ten times larger than the average small farm in Mahbubnagar; in Akola, nine times; in Sholapur, only four times. This suggests more equal operational landholding distributions in areas with low and variable rainfall and without substantial irrigation. Large farms tend to cultivate a slightly lower percentage of their operated land than small farms, especially in Mahbubnagar, where more non-cultivable land seems to exist.

Aurepalle is the only village where large farmers have a significantly higher percentage of the land irrigated than do small farmers. In all other villages the difference was not statistically significant.[7] The only case where there was statistically significant difference between farm sizes in cropping intensity was in Aurepalle where large farms had a much higher intensity (118) than small (100) ones. The reverse was true in Dokur, although not significant statistically.

Available family labour per 10 ha ranged from a high of 11 man-equivalents in Dokur to only 6 in both Sholapur and Akola.[8] In all villages, small farms had a statistically greater availability of family labour per 10 ha than did large farms. Only in Aurepalle was there a statistical difference in the bullock/land ratio, with small farms having more (5 per 10 ha) than large farms (3 per 10 ha).

PRESENT VILLAGE LABOUR-USE PATTERNS

Regional Variations

Intensity of labour utilisation reveals as much regional variation as was observed, (Table 2) in resource endowments. Dokur village, primarily due to the extent of irrigation there (45 per cent), used an average of 1,156 man-equivalent hours per hectare of net cropped land: more than 4 times Sholapur villages (274), and more than double Aurepalle (540), which has soils and climate similar to that of Dokur, but only 11 per cent of its land under irrigation.[9] This demonstrates the employment-creating potential of the existing tank and well irrigation systems in the Alfisols of south India. A study of tank irrigation there [*von Oppen and Subba Rao, 1980: 21-22*] has also indicated that in Alfisol situations tank irrigation is beneficial to the farmer. Thus new technologies for the rain-fed portions of such villages will have to compete with these irrigation systems for labour use at strategic times in the crop growing season.

The two villages in Akola used about 60 per cent more labour per hectare than the two Sholapur villages. The higher proportion of irrigation in the Sholapur villages did not lead to greater labour use, because agro-climatic differences outweighed the irrigation differences. Around 60 per cent of the cropped area of the two Sholapur villages is left fallow during the June to September rainy season, and then sown. (In the two Akola villages, fallows are negligible during the rainy season [*Jodha, 1977: 14-17*].) Post-rainy season crops require much less labour for weeding and interculture than do rainy season crops. This largely explains why

TABLE 2

PATTERN OF HUMAN LABOUR USE BY FARM SIZE GROUPS IN SELECTED SAT VILLAGES (1975-76)

District/ Village	Operational farm size group	Annual labour use per ha (ME/ha)[a]		Coefficient of variation of fortnightly labour use (%)	Av. number of crops per farm[b]
		Net cropped land	Gross cropped land		
MAHBUBNAGAR VILLAGES					
Aurepalle	Small	242	242	154	1.8
	Medium	320	313	150	2.5
	Large	650***[c]	551***	97***	7.1***
	All farms	540	479	133	3.9
Dokur	Small	2093	1566	151	1.6
	Medium	1252	989	175	3.2
	Large	1022**	920**	142*	4.0***
	All farms	1156	994	156	2.9
SHOLAPUR VILLAGES	Small	356	356	180	4.6
	Medium	317	283	135	9.2
	Large	227*	227*	118***	9.8*
	All farms	274	250	145	7.8
AKOLA VILLAGES	Small	522	498	142	2.3
	Medium	459	439	121	2.9
	Large	445	419	95***	6.4***
	All farms	455	429	119	3.8

[a] All labour is measured in man-equivalent (ME) hours.

[b] These are average number of different sole crops and/or different crop mixtures per farm.

[c] Asterisks indicate that large farm figures are significantly different from small farm figures in the same village/region.
***, ** and * represent significant differences at 1, 5 and 10% levels, respectively.

less labour is used per hectare in Sholapur than in Akola. Furthermore, in 1975-76, the two Sholapur villages averaged 960 mm of rainfall – 30 per cent above normal – mostly in September-October, the busiest months. This led to even less labour use than normal. In Akola, on the other hand, rainfall was just below normal.

Another factor leading to greater labour use in the Akola villages is the predominance of mixed cropping. Mixed crops require more labour than sole crops.[10] Cotton, grown extensively in Akola, also demands much more labour than the foodgrain crops which predominate in Sholapur.

The ranking of villages was the same whether labour utilisation was expressed on a net cropped or a gross cropped area basis (col. 4, Table 2). The ratios of per hectare labour use between villages were also similar. The gross cropped area labour-use measure implicitly adjusts for the effect of cropping-intensity differences. The fact that cropping intensities are generally low in these villages, together with the similar ranking and proportionalities in labour use (whether on a gross or net cropped area basis), sugests that the intensity of cropping does not contribute substantially to differences in labour-use intensity in these villages. Other factors such as cropping pattern and resource endowment differences must be the primary determinants of labour intensity differences.

Size of Farm and Labour Use

The size of farm is often found to be negatively related to the use of total human labour (family plus hired) per unit of land. Three explanations are generally given: (i) higher crop intensities on small farms; (ii) more labour-intensive crops on small farms; (iii) greater labour use per hectare on individual crops grown on small farms.

Using farm data from Hooghly District in West Bengal, a significant negative correlation between labour use per acre of net cultivated land and the size of farm was found [*Rudra, 1973: 971*]. On the same farms use of material inputs per acre and intensity of irrigation were also inversely correlated with farm size. Farm management data, particularly for the earlier periods in the fifties, indicated that the larger inputs of labour on smaller farms were associated with a greater intensity of cropping and more irrigation per acre [*Bharadwaj, 1974: A-16; Bardhan, 1973a: 1384*]. When one adjusted for the differences in irrigation (or cropping intensity), the inverse relationship between farm size and labour-use per unit of land was much weaker [*Bardhan, 1973a: 1383-1384*]. Village studies from Asia and Africa confirmed this higher labour intensity on small farms [*Srivastava, 1966: 89, Norman 1967*].

Bardhan [*1973b: 949*], using National Sample Survey data of the 25th round (1972), found that the average rate of daily wage earnings for hired-out adults per day of work was higher in the households that relied solely on wage earnings for their income compared to small farm households. In the villages of the present study there was some evidence that probabilities of employment were lower for workers from small farms than those from labour households [*Ryan et al., 1980a: 369*]. Others have found that for family labour the probability of employment is less than 1 in general [*Agarwal, 1964: 1850-1851; Mazumdar, 1965; and Sen, 1966: 443*]. These reasons are also cited as explanations for a greater intensity of family labour use on small farms. As family opportunity wages are less than the actual wages of hired landless labour, small farmers tend to employ a higher percentage of family labour (so the argument goes). Wherever this occurs, it also leads to more total labour use per hectare. This latter step in the argument is, however, a little questionable, as probabilities of employment can also be less than one for those members in medium and large farm households [*Ryan et al., 1980a: 369*].

In the cases of Dokur and Sholapur villages small farms used significantly more labour per hectare of net cropped land than did large farms (Table 2). In Akola villages there was no significant difference, and in Aurepalle large farms used significantly more labour per hectare than did small farms. The picture is similar when labour use is expressed per hectare of gross cropped land.

The Aurepalle result seems to be because the extent of irrigation was significantly higher on large farms (Table 1). This leads to higher land values and cropping intensities. In addition large farms in Aurepalle also had more bullocks and implements per hectare. All these factors complemented labour, resulting in a greater use of this resource per hectare.

Seasonality of Labour Use

The utilisation of labour over the agricultural year was calculated on a fortnightly basis for each region and farm-size group. The coefficients of variation (CVs) of seasonal labour use per hectare were significantly higher on the small than on the large farms (Table 2). One important reason for this seems to be the number of different crops grown on farms of different size. As more crops are cultivated in various seasons more continuous use of labour ensues, resulting in less seasonal variability. Generally, small farmers concentrated on simple and limited crop combinations to meet their subsistence needs. Large farmers seemed to prefer to grow a wider variety of crops to meet their own as well as their servants' consumption needs [*Jodha, 1977: 20*].

Another reason for greater seasonal variability of labour use on small farms may be that they concentrate only on 'key' operations on their own farm, such as sowing and harvesting. They may largely ignore their crops in the interim to free themselves for work off their farms. There may hence be a linkage between seasonal labour variations on small farms and the release of labour to, and absorption of labour by large farms, leading to mutual seasonal compensation. If the work available off the farm is mainly agricultural, it has been implied that a synchronous seasonality pattern causes total annual employment to be low [*Bharadwaj, 1974: A-18*]. The lack of continuous and guaranteed employment might compel small operators to adopt a cropping pattern that eases the seasonality factor. Several types of crops and/or crop combinations will help reduce the seasonal variability of labour use and thus help avoid likely seasonal labour bottlenecks.

In the ensuing section the village seasonal labour-use pattern is compared with the pattern which is emerging from the prospective watershed-based land- water-management technologies being researched at ICRISAT. Although it is recognised that the prospective technologies may still be modified prior to their eventual adoption, a comparison with existing village labour-use patterns can assist in delineating potential bottlenecks on which attention can then be focussed.

LABOUR USE WITH EXISTING AND IMPROVED WATERSHED-BASED TECHNOLOGIES

The Farming Systems Research Program at ICRISAT has been conducting research aimed at increasing and stabilising crop production for rain-fed areas of the SAT since 1974. One of the basic concepts involves management of the soil and water on a small catchment or watershed basis, ranging in size from 1 to 30 ha. High-yielding crop cultivars are sown with improved fertilizers and crop management on broadbed established between furrows. The broadbeds and furrows are formed with improved animal-drawn implements on a graded slope of between 0.4 and 1.0 per cent. This is to enable excess run-off generated from the heavy rainfall storms of the monsoon to be guided slowly across the natural grade (usually 1.5 to 2 per cent). In this way rainfall penetration into the root profile for use by crops is increased.

We have selected several of the experimental treatments which have been found promising at ICRISAT Center to compare with the village data [*Farming Systems Research Program, 1977*]. The experimental treatments have been matched with villages having similar soil types in the manner shown in Table 3. Threshing at ICRISAT Center has mostly been done using stationary combines and/or stationary threshers. Hence to enable a more valid comparison of the labour use under new technology we adjusted the ICRISAT Center labour requirement for threshing to reflect those in a current village situation.

TABLE 3

EXPERIMENTAL TREATMENTS AT ICRISAT CENTER USED FOR LABOUR COMPARISONS WITH THE VILLAGES

District	Experimental treatments used for comparison
MAHBUBNAGAR	Alfisol watersheds with: (i) Bed planting on a 0.6% grade, and hybrid sorghum followed by its ratooning (ii) Bed planting on a 0.6% grade and pigeonpea intercropped with setaria
SHOLAPUR	Deep Vertisol watersheds with: (i) Bed planting on a 0.6% slope and hybrid maize followed by sequential chickpea (ii) Bed planting on a 0.6% slope and pigeonpea intercropped with hybrid maize
AKOLA	Medium-deep Vertisol watersheds with: (i) Bed planting on a 0.6% slope and hybrid maize followed by sequential chickpea (ii) Bed planting on a 0.6% slope and pigeonpea intercropped with hybrid maize

Farm Labour Utilisation

The labour use per hectare of net cropped land under the prospective broad-bed-and-furrow, improved crop management technologies was 100 to 370 per cent greater than the existing labour utilisation observed in three of the four village situations (Table 4).[11] The exception was the highly irrigated Dokur village where existing average labour use slightly exceeded projected requirements of the new technology under Alfisol conditions. This was not the case in Aurepalle, which is in the same broad agro-climatic region as Dokur but has much less irrigation. The new technology almost has double the present village labour requirement in Aurepalle.

TABLE 4

COMPARISON OF LABOUR REQUIREMENTS WITH EXISTING VILLAGE TECHNOLOGY AND PROSPECTIVE WATERSHED-BASED TECHNOLOGY AT ICRISAT CENTER

District/ Village	Existing village technology		Improved technology on ICRISAT Center watersheds	
	Annual labour use per ha of net cropped land (ME/ha)[a]	Coefficient of variation of fortnightly labour use per ha (%)	Annual labour use per ha of net cropped land[b] (ME/ha)	Coefficient of variation of fortnightly labour use per ha (%)
MAHBUBNAGAR VILLAGES				
Aurepalle	540	133	1048[c]	135
Dokur	1156	156	1048[c]	135
SHOLAPUR VILLAGES	274	145	1287[d]	[illegible]
AKOLA VILLAGES	455	119	1345[d]	106

[a]All labour is measured in man-equivalent (ME) hours.

[b]These are the average of two cropping patterns used in each soil and water management system.

[c]The two crops on Alfisols were hybrid sorghum/ratoon sorghum, and pigeon-pea intercropped with setaria.

[d]The two crop systems on Vertisols were hybrid maize followed by sequential chickpea, and pigeonpea intercropped with hybrid maize.

Under the Vertisol situations the potential for increased labour demand with the new technology seems greater than on Alfisols, particularly in the Sholapur situation where labour use could increase by more than four and a half times.[12] In the Akola Vertisol region there is scope to almost triple labour demand with the new technology. These increased demands apparently will occur without substantially affecting the CVs of fortnightly labour use per hectare throughout the year, providing, as was the case here, that it is based on more than one cropping system.

The CVs of the labour requirements of individual cropping systems with the new technology (not reported here) were generally much higher than those presently existing in the villages. This clearly demonstrates the complementarity that can exist between enterprises in their seasonal demands on labour. Hence new technologies involving improved land and water management should not be evaluated only on the basis of a limited range of cropping systems, but should embrace as many options as feasible to enable individual farmers to select those combinations which suit their particular labour availabilities and commitments. Unless this is done the risk will be that the new technology will exacerbate labour peaks and will not be adopted. Farmers in these villages have a multitude of cropping patterns evolved over long periods by trial and error [*Jodha, 1977: 49-50*]. This will not easily be changed unless of course a single cropping pattern proves to be so vastly superior in terms of profitability and risk that it dominates all others.

Seasonality

By examining the timing of the various peaks and slacks in seasonal labour use throughout the year, one can identify strategic periods when apparent under-use of labour exists, and this could conceivably be capitalized upon in evolving new technology. This is particularly relevant in the context of the research underway at ICRISAT on improved soil and water management techniques which entail creation of capital by such operations as land shaping, establishing broadbeds and furrows, bunds, and possibly reservoirs to store run-off. Making use of labour for these tasks at times when its opportunity costs are lowest can substantially improve the benefit/cost calculus of the technology. It can also augment incomes of hired labourers. New cropping systems requiring changes in the timing of labour-intensive operations, such as sowing, weeding, harvesting, and threshing may need to allow for existing seasonal labour distributions if they are to be adopted.

Figures 1-4 show the seasonal patterns of labour use with existing village technology and prospective watershed-based technology from the 6th standard fortnight (commencing 12 March) of the first year to the 7th standard fortnight (to 8 April) of the next year. This period essentially covers the agricultural year from preparatory tillage to post-harvest ploughing.

The estimates of total supply of labour for crop production were obtained firstly by calculating average total time spent by a particular labour category (male, female, child) in all types of activities in each fortnight. Labour and cultivator households are both considered in this calculation. From these figures estimates of average time spent in all non-crop production activities (animal husbandry, building, other construction, repairs and maintenance, trade, marketing, transport, domestic work, food processing, fuel gathering, and regular jobs) were subtracted to arrive at the time available exclusively for crop production work. These effective labour availabilities in different periods have also been adjusted for in- and out-migration, sickness, festivals and holidays. The final total labour availability figures are expressed in man-equivalent hours by assigning weights of 1, 0.75 and 0.5 to adult male, adult female and child, respectively. The labour availability estimates thus obtained also include voluntary and involuntary unemployment days. Hence we assume in subsequent analysis these latter days are potentially available for crop production activities.

In general, the labour available from the labour households increases overall availability per hectare by between 22 and 47 per cent above that provided by family farm labour alone, depending on the village. In Aurepalle village with existing technology two to three moderate labour peaks followed by small slack periods occurred in the months of June, July, and August, when sowing of sorghum, pearl millet, and castor took place (Fig. 1). These moderate peaks were followed by a somewhat longer slack period in September and the first week of October, after which the harvest of sorghum, pearl millet, and castor caused a second sharp peak in November and December, with 52 man-hours per hectare being the highest level in early November.

In contrast to Aurepalle, Dokur village with its extensive irrigation, experienced slightly longer slack periods (Fig. 2). Three distinct peaks occurred in the months of May, October, and December-January. The last peak required as many as 117 man-hours per net cropped hectare from mid-January to the end of the month, while the first and second peaks, in May and October, required 83 and 72 man-hours per hectare, respectively. The important operations performed in August, September, and October were irrigation, nursery raising of paddy, transplanting, weeding and harvesting of paddy, and harvesting of groundnut. The harvesting of sorghum, nursery raising, transplanting, etc. caused the second peak labour-use period in October. These peak periods were then followed by small slack periods. The differences between slack and peak period labour use were large in this village compared with Aurepalle, as reflected in CVs of 156 and 133, respectively (Table 2). It seems that the predominance of paddy (in most cases two paddy crops in a year and in some cases up to three crops) on the irrigated areas in Dokur, which have a set labour use pattern affecting peaks and slacks, largely contributed to the highly variable intra-seasonal labour use pattern in that village.

A comparison of the seasonal labour distribution in Aurepalle with that of the new technology shows that there were approximately the same number of peaks. Compared with Dokur the new technology had slightly fewer peaks. However, the amplitude of labour fluctuations with the new technology was much greater than at present in these villages. On many occasions labour requirements fell to zero with the prospective technology. With the combination of sorghum ratoon and pigeonpea/setaria crop technologies, the major peaks occurred in July-August and September-October. Presently in Aurepalle the major peak occurs in October-November. In Dokur it occurs in January. The new technologies in Alfisols hence would shift the peak labour periods back into the monsoon.[18] When the present average labour availabilities per hectare in the two villages of Mahbubnagar are compared with the requirements of the new technologies in Figures 1-2, it seems clear that there will be major farm-labour bottlenecks in July-August, October and January.

In the Sholapur villages, not many sharp peak periods were observed, but two moderate peaks with reasonably long intervals between them seemed to exist (Fig. 3). The first peak was in September-October and the second in January-February. There was a steady increase in labour use from April, when land preparation began, up to the middle of October when sowing of sorghum, chickpea, wheat, and safflower were the important operations. This period was followed by a short period of moderate slack. The predominance of post-rainy season cropping in these villages is reflected in increased labour demand from August-September to January-March. The second peak in January-February, occurred because of har-

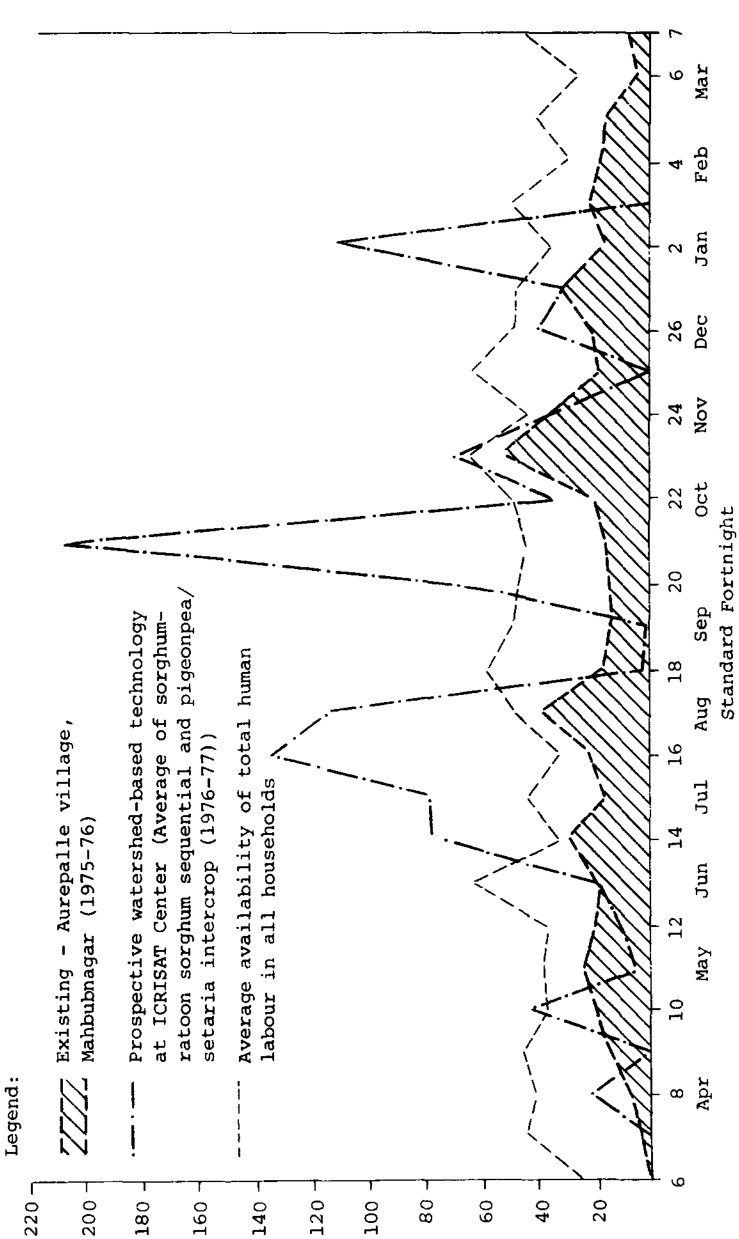

Figure 1. Average seasonal human labour availability and use with existing and prospective watershed-based technology on Alfisols

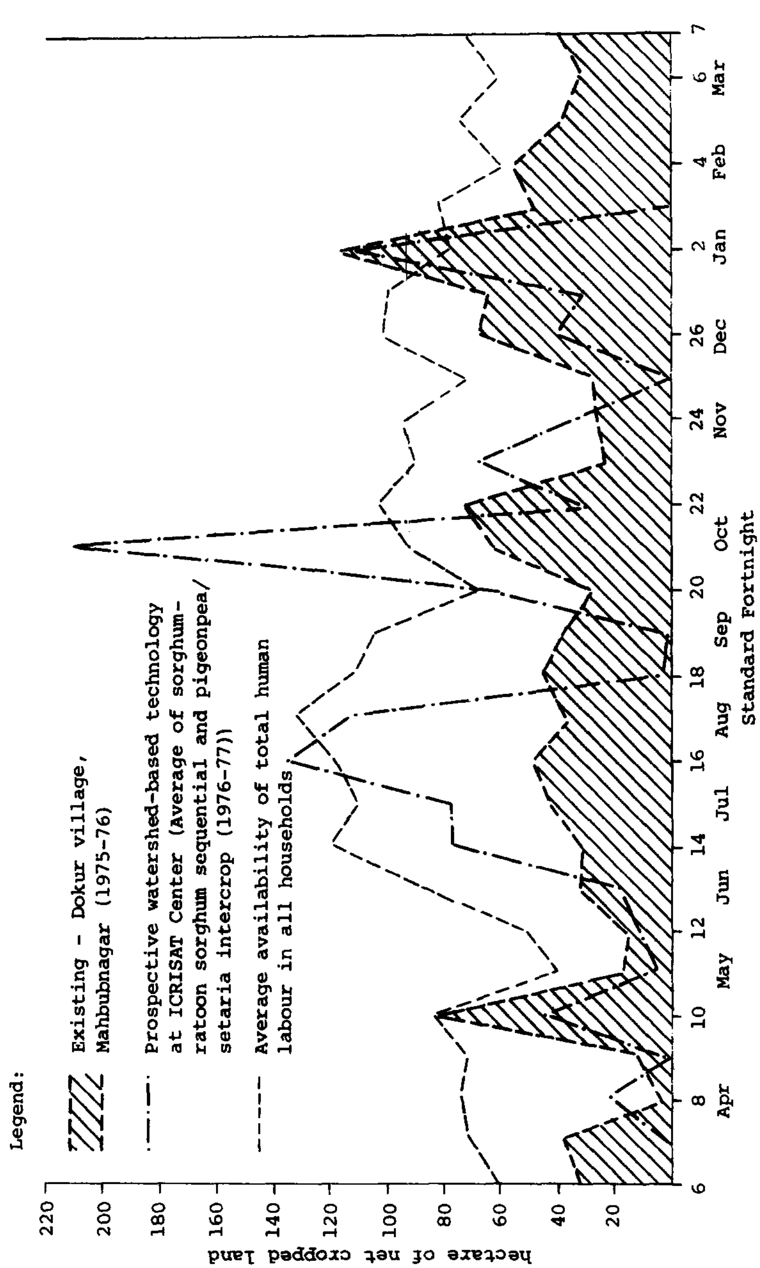

Figure 2. Average seasonal human labour availability and use with existing and prospective watershed-based technology on Alfisols

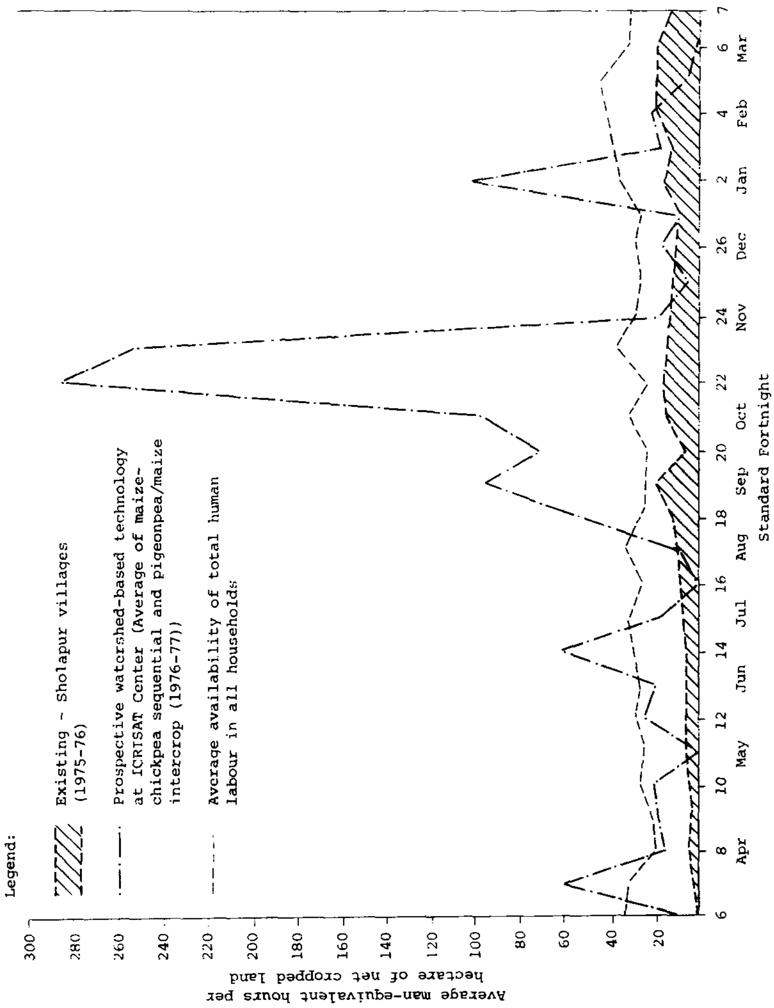

Figure 3. Average seasonal human labour availability and use with existing and prospective water-shed-based technology on deep Vertisols

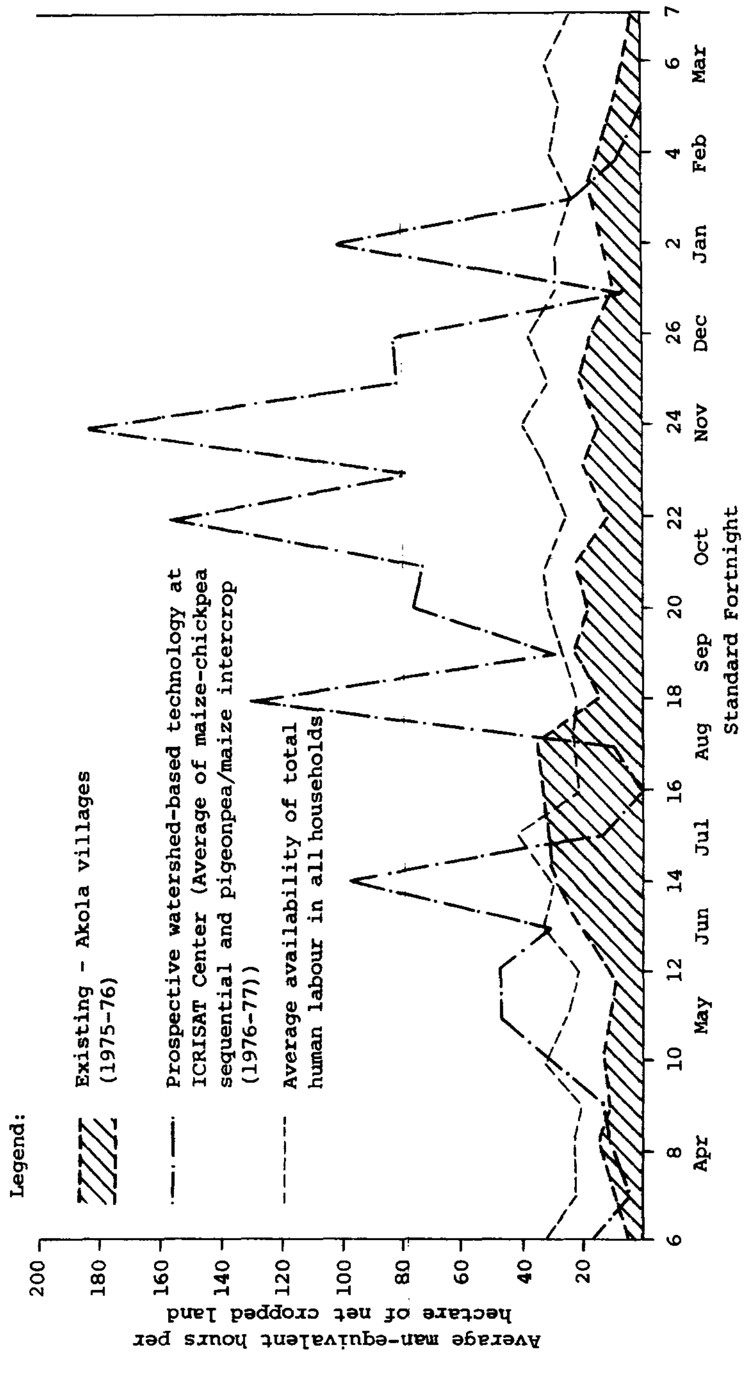

Figure 4. Average seasonal human labour availability and use with existing and prospective watershed-based technology on medium-deep Vertisols

vesting of sorghum, pigeon-pea and chick-pea.

The improved technology on deep Vertisols would alter the present labour-use patterns in the Sholapur area to a more unimodal shape. There would be a substantial peak with the new technology in September, October, and November due to weeding prior to chick-pea sowing, and the harvesting and threshing of maize. This would be in contrast to the more or less steadily rising labour demands from June to March experienced at present in the Sholapur villages. Present average labour availabilities in these villages would be insufficient to meet the demands of the new technologies during April, July, September, October, November, and January.

The first peak in the Akola villages occurred in June, July, and August, which is the busy period for sowing and weeding most of the rainy season crops like groundnut, sorghum, cotton, pigeon-pea, mungbean and pearl millet (Fig. 4). This period was followed by a short slack period in September, but then there began a continuous labour demand for harvesting of sorghum and groundnut and the sowing of chick-pea and wheat in October and November, followed by harvesting of pigeon-pea and cotton in December, January, and February.

The maize-based improved systems on the medium-deep Vertisols generally involved less labour use during the late July-August period than presently in the villages in Akola. On the other hand, the demands for sowing after the onset of the rainy season followed by weeding under the existing cropping patterns in these villages, created a labour peak in this July-August period. With the new technology, rainy season crops are dry-sown in June, prior to the onset of the monsoon. This is the main reason for the late-June labour peak. Again the new technology involves much more prolonged labour peaks with greater amplitudes than with the existing systems during the harvesting and threshing periods for maize from September to December. The present labour availability in the villages with medium-deep Vertisols would become a major limitation with these new technologies in the months of June, September, October, November, December, and January.

The three major peak periods would hence shift under the prospective technology in the villages (Figs. 1-4). In Aurepalle they would move from July, August and November to August, October, November and January. In the case of Dokur the move would be from May, October and January to August, October and January. In Sholapur the existing moderate peaks in September, October and February-March would change to September, October and January. In Akola they would move from July, August, October and November to September, October, November and January.

In Aurepalle and Sholapur villages the total labour supply appeared to be generally above the present requirement for crops throughout the year (Figs. 1, 3). However, in Dokur village there presently are two critical periods when crop labour requirements seem to be in excess of labour availability (Fig. 2). The first period was during mid-May, when nursery raising of paddy becomes a priority task; the second is for transplanting of post-rainy season paddy in the month of January. In the Akola villages, the main present labour bottleneck observed was in July-August, mostly for sowing of rainy season crops (Fig. 4).

Labour Bottlenecks

Estimates of total village surplus labour over and above farm labour requirements were calculated (Table 5). The annual total labour available from crop production in each region was estimated using figures of fortnightly labour supply from all households using the sampling fraction weights for each respondent category. This facilitates comparisons of the present average regional estimates with the prospective watershed-based technology.

There was a wide variation in annual labour availability, ranging from 791 hours per net cropped hectare per year in Akola, to 2,381 hours in Dokur. The annual surplus labour figures with existing technology ranged from 43 per cent in the Akola villages to 66 per cent in the Sholapur villages, indicating that a considerable proportion of the total labour available is used for the purpose of direct farm work. However, a major portion still remains surplus, possibly in the form of involuntary unemployment, voluntary unemployment, and under-employment.

The pressures on available annual village labour from the prospective technologies would appear to be greatest in the Vertisol villages of Sholapur and Akola. In the former region, the annual surplus of 66 per cent would change to a net deficit of 36 per cent with the prospective technology. In Akola it would change from a 43 per cent surplus to a 41 per cent deficit. There would be substantial reduction in the labour surplus in Aurepalle village. On the surface, prospective technology would not substantially change the Dokur village labour situation. However, recall that Dokur has almost half of its land irrigated (Table 1). Hence if the prospective technologies evaluated here were adopted only on the unirrigated lands there would still remain the substantial labour use from the irrigated portions.

Focussing only on the three peak fortnights, with existing technology Aurepalle village generates a 13 per cent labour surplus while for Sholapur the figure is 54 per cent (Table 5). Dokur and Akola villages have present deficits of 2 and 13 per cent, respectively, indicating that existing technologies in highly irrigated Dokur and the cotton-growing villages of Akola create labour bottlenecks in peak periods.

From a peak surplus labour position of 13 and 54 per cent presently in Aurepalle and Sholapur villages, introduction of the prospective technology could involve deficit situations of 25 and 85 per cent, respectively. The deficit in Dokur village could increase from 2 to more than 73 per cent while it could rise from 13 to 82 per cent in the Akola villages. Hence the excess labour demands would be a maximum in the Sholapur deep Vertisols and a minimum in the Mahbubnagar Alfisols.

The major bottlenecks with the prospective technology would appear to be at harvest and threshing time of the first crop. In addition, there would be bottlenecks at weeding and sowing time. These arise primarily because we have compared the present village situations involving numerous crops, with the prospective systems embracing only two cropping patterns. The extent to which farmers adopt the prospective technology using many more cropping patterns than employed in this analysis will alleviate the potential labour bottlenecks derived here.

So far the analysis has been carried out using only comparisons of human labour use with existing technology and the prospective watershed-based technologies. We have not considered the relative impacts of the new technologies on use of other resources such as bullock power. It may well be that bottlenecks would arise in use of resources other than human labour.

TABLE 5

ESTIMATES OF VILLAGE LABOUR SURPLUS IN EXCESS OF FARM REQUIREMENTS UNDER TRADITIONAL AND IMPROVED WATERSHED-BASED TECHNOLOGIES

District/village	Present labour availability per ha of net cropped land (ME/ha)	Percent surplus (+)/deficit (-) labour with[a]:	
		Traditional technology	Watershed-based technology[b]
	Annual		
MAHBUBNAGAR VILLAGES			
Aurepalle	1227	56	15
Dokur	2381	51	56
SHOLAPUR VILLAGES	821	66	-36
AKOLA VILLAGES	791	43	-41
	Three peak periods		
MAHBUBNAGAR VILLAGES			
Aurepalle	145 (344)[c]	13	-25
Dokur	264 (125)	-2	-73
SHOLAPUR VILLAGES	120 (95)	54	-85
AKOLA VILLAGES	86 (86)	-13	-82

[a]Calculated as the sum of the difference between estimated supply of able -bodied village workers (males, females and children) available for crop production and the requirements for farm labour expressed as a percentage of estimated supply in the case of surplus and expressed as a percentage of requirements in the case of deficits. It is the area between total labour availability line from all the households in Figures 1-4 and the labour-use lines, expressed as a proportion of the total area enclosed by the availability line in the case of surplus and as a proportion of the total area enclosed by the labour use line in the case of deficits.

[b]Average of two watershed cropping patterns on same type of soil.

[c]Figures in parentheses are total labour availabilities in the 3 peak labour use fortnights under improved technology, while figures next to them relate to labour available in peak fortnights with existing village technology. The peak fortnights differ in these two cases.

CONCLUSIONS

Examination of regional variation in the intensity of labour utilisation reveals that there is a substantial employment creation in the existing tank and well irrigation systems in the Alfisols of south India. New technologies for the rain-fed portions of such villages will have to compete with these irrigation systems for labour at strategic times. Besides irrigation, other factors like the extent and distribution of rainfall, the extent of rainy and post-rainy season cropping, cropping patterns, and the extent of inter-cropping, also play an important role in determining the intensity of labour use.

Previous literature suggests that size of farm is usually inversely related to the amount of human labour use per unit of land. However, no such consistent relationship was found in these villages. Before drawing firm conclusions about this phenomenon, analyses using data for other years are required.

The coefficients of variation of seasonal labour use per hectare were significantly higher on small compared to large farms. The reason for this seemed to be that small farmers grow a much smaller variety of crops than do large farmers. When a greater number of crops are cultivated this generally entails a more continuous use of labour with less seasonal variability. Hence, several differently-timed crops or/and crop combinations grown per farm will help avoid seasonal labour bottlenecks.

The prospective technologies being evaluated at ICRISAT offer scope for increased employment compared with existing technologies, ranging from a 100 per cent increase in the Alfisols to almost 400 per cent in the deep Vertisols.[14] However, there appears to be some increase in the variability of seasonal labour demand as a consequence. The labour CVs of the prospective technologies are higher than those currently in the villages. Combining the two cropping pattern treatments for each soil type demonstrates the complementarities in labour-use patterns of different crops. The CVs of combined cropping systems are always less than those of the individual cropping systems. Hence the new technologies should not be evaluated only on the basis of a limited range of cropping systems, but should embrace as many options as feasible to enable individual farmers to select those combinations which suit their particular labour availabilities and commitments. Unless this is done, the risk will be that the technology will exacerbate labour peaks and will not be adopted.

It is clear that, given the existing availabilities of labour in these villages, there could be major farm labour bottlenecks in August, October and January with adoption of the improved watershed technologies on Alfisols. On deep Vertisols such bottlenecks will be in the months of September, October, November, and January, while on medium-deep Vertisols bottlenecks could occur in June and from September to January. The three peak labour fortnights with the improved technologies could generate labour deficits ranging between 25 per cent on Alfisols to 85 per cent on deep Vertisols.

No doubt such bottlenecks would generate increased wage rates and employment potentials for those relying on daily wages for most of their sustenance, which would be desirable from an equity point of view. However, such bottlenecks could adversely effect the timeliness of operations critical to the success of the prospective double-cropping and/or intercropping technology aiming at greatly increased food production. If this is so one may expect to see increased demand by farmers for selective mechanisation of operations such as threshing, where the major bottlenecks would seem to arise. Choice of a wider array of cropping patterns (than used in the experiments analysed here) by farmers to dampen potential labour peaks is another possibility. However, there may not be as many degrees of freedom in crop choice with the new technology as exists with the traditional soil and crop management technologies.

NOTES

1. See Kampen and Associates [*1974: 3*], Krantz and Associates [*1974: 219*], and Ryan [*1974: 389*].
2. Data pertaining to 1976-77 and 1977-78 have also been obtained, but analysis is not yet complete. For a detailed description of the methodology, villages, and the complete range of information, see Binswanger *et al.* [*1977*], Jodha *et al.* [*1977*], and Binswanger and Jodha [*1978*].
3. The coefficients of variation of rainfall in the June to September rainy season are 29 per cent, 34 per cent and 28 per cent in Mahbubnagar, Sholapur and Akola districts, respectively.
4. The two villages in each of Sholapur and Akola districts have been combined while the Mahbubnagar villages have been treated separately for the subsequent analyses in this paper. This was because of wide socio-economic and resource endowment differences between the Mahbubnagar villages.
5. Per cent cropping intensity is defined as the total gross cropped area divided by the net cropped area, multiplied by 100. We have not attempted to calculate indices which reflect crop duration.
6. Throughout the paper, most comparisons will be limited to those between small and large size farms. Data on the medium size farms will be presented in tables but not specifically discussed to enable us to focus on the other two distinct groups.
7. It is recognised that there may be qualitative differences in the extent of irrigation, but this was not measured here.
8. Man-equivalent family labour has been calculated by considering those members of the household engaged in agricultural occupations partly or fully in the reference year. This includes attached and permanent labourers with the household. The conversion factors used for calculating man-equivalent labour availability were as follows:

Children 6-14 years	=	0.50 man-equivalent
Males 15-64 years	=	1.00 man-equivalent
Females 15-64 years	=	0.75 man-equivalent
Males above 65 years	=	0.50 man-equivalent
Females above 65 years	=	0.50 man-equivalent

9. The results of the studies conducted on Maharashtra villages by the Gokhale Institute of Economics and Politics (1956-58) showed quite considerable differences between partially irrigated and non-irrigated villages in labour use for sorghum (33.1 and 21.4 man-days per acre) and cotton (34.2 and 26.9 man-days per acre).
10. Akola villages had about 77 per cent of their cropped area sown to mixed crops, while Sholapur villages had only 28 per cent [*Jodha, 1977: 22-24*]. While explaining the popularity of intercropping in the African context, Norman [*1967*] showed that the average gross return per man-hour used during the peak labour period was higher for crop mixtures than for sole crops. He further found that total labour input was higher for crop mixtures.
11. 1976-77 was the first year of establishment of the broadbed-and-furrow-system in the Vertisols at ICRISAT Center. Hence labour requirements will be somewhat higher than what may be expected in subsequent years when 'development' is complete. Indications are the reduction may be around 20 per cent. When labour use was expressed per gross cropped hectare, the prospective technologies used between 10 and 160 per cent more labour than traditional village technology. The exception was Dokur village, which had more labour use per gross cropped hectare due to the predominance of irrigated paddy.
12. The Sholapur village comparison with the new technology at ICRISAT Center, Hyderabad should be however viewed with some caution. The probability of successfully growing rainy season crops at Hyderabad is significantly higher than in Sholapur [*Virmani et al., 1978: 2-7*]. As the new technology primarily depends on rainy season followed by post-rainy season cropping for its superiority, it is not clear that in Sholapur this will be possible without considerable risk.

13. As Dokur is highly irrigated and likely to stay so even after introduction of new dryland technology, the labour-use picture would continue to be dominated by irrigated paddy. This would not be nearly as true in Aurepalle.
14. Considerable income gains also seem possible [*Ryan et al., 1980b: 52-72*].

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