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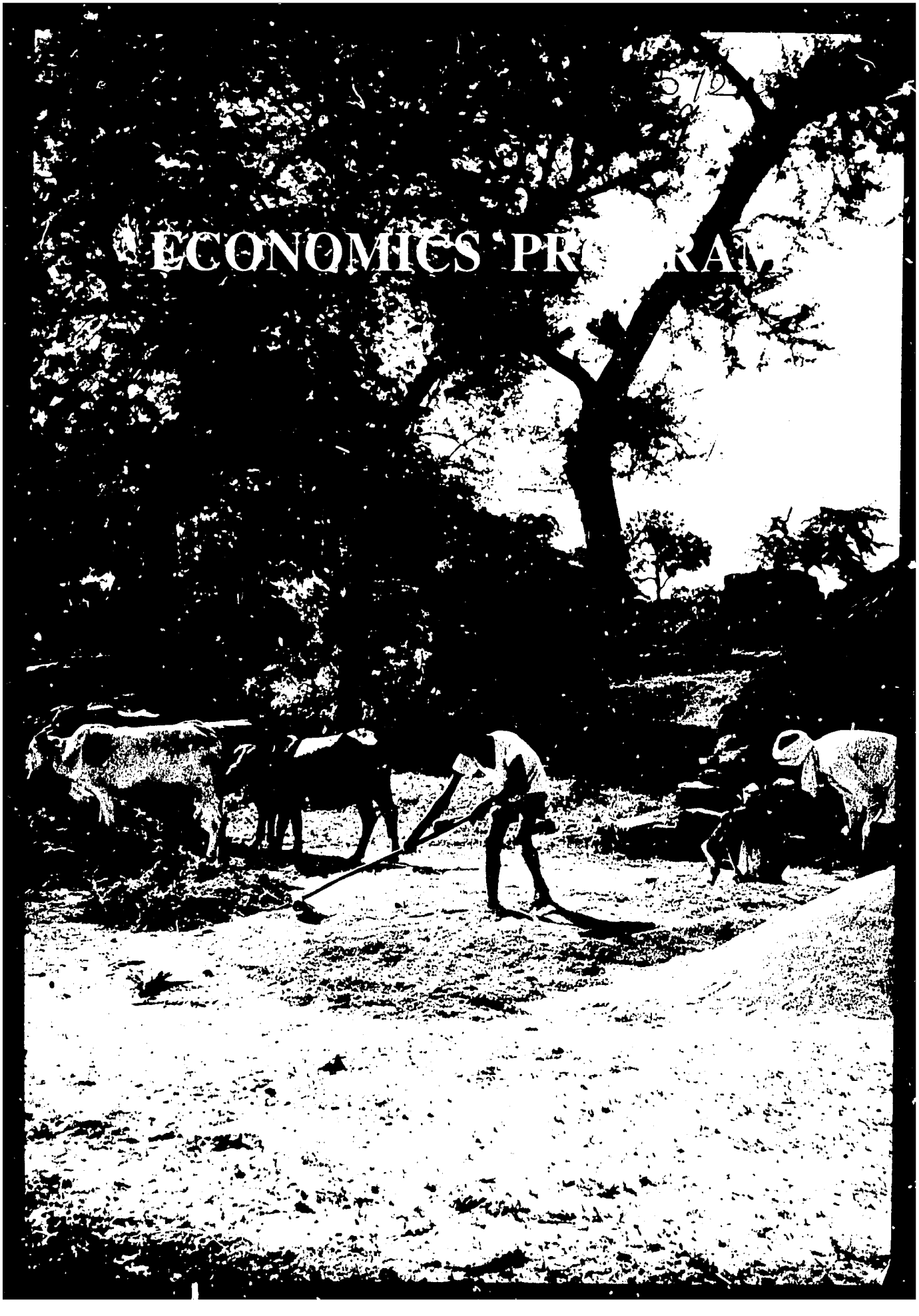
ECONOMICS PROGRAM



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ECONOMICS PROGRAM

The Economics Program conducted in 1978–79 a variety of studies designed to increase understanding, and to help solve problems in production and marketing economics and in the social organization of SAT agricultural production. The results of these studies are presented below.

Agricultural Development in the Indian SAT

To summarize major aspects of agricultural development in the Indian SAT, we carried out a detailed comparative study of the region. A total of 190 Indian districts fall in the areas having an annual rainfall range between 500 and 1500 mm. These districts comprise over three-quarters of the area sown to ICRISAT mandate crops in India. Irrigation in the Indian SAT is relatively uncommon. Up to now, in areas where irrigation has increased, cropping patterns have changed in favor of rice, wheat, and sugarcane.

In India, farmers have been slow to adopt high-yielding varieties (HYVs) of pearl millet and sorghum compared with the progress made by HYVs of wheat and rice (Table 1). HYVs of pearl millet spread rapidly for a few years after their initial introduction, until struck by downy

Table 1. Percentage area in selected states and throughout India under high-yielding varieties for different crops in 1974–75.

State	Sorghum	Pearl millet	Wheat	Rice	Maize
Andhra Pradesh	7	33	NA	68	30
Gujarat	2	65	81	26	15
Haryana	NA	33	89	50	12
Karnataka	20	18	29	31	100
Madhya Pradesh	10	13	26	20	8
Maharashtra	8	33	43	27	23
Punjab	NA	25	83	84	17
Rajasthan	1	4	51	21	2
Tamil Nadu	8	39	NA	83	NA
Uttar Pradesh	NA	4	69	32	1
All ten States	8	23	61	43	12
India	8	22	62	29	18

Source: *Fertilizer Statistics*, 1976–77, Fertilizer Association of India, New Delhi.
NA = Not applicable.

mildew disease in many areas. Statistics indicate that they have continued to be successful where the crop is grown with good soil moisture or irrigation or where the varieties in question are relatively well adapted to local conditions. HYVs of sorghum seem to have been less successful due to several factors including harsh crop environments, susceptibility to diseases and pests, and difficulties in meeting consumer requirements for grain quality and fodder. These hypotheses regarding adoption of HYVs of both pearl millet and sorghum in India need to be tested with detailed and extensive farm-level data.

Most of the fertilizer used by SAT Indian farmers is for irrigated crops such as wheat, paddy, and sugarcane, or for high value non-irrigated crops such as cotton and groundnut. High-yielding varieties of pearl millet and sorghum are fertilized at fairly high rates under irrigated conditions, but the area so treated is small. There is some evidence to show that farmers have started applying fertilizers to some pulse crops. In this context, we note that grain legumes have witnessed sharp price rises in recent years.

It seems that SAT Indian farmers are aware of the potential of fertilizers and that their actual use of fertilizers is influenced by size and certainty of returns. There would be good scope for improvement in production of the ICRISAT mandate crops in India if more, better-adapted HYVs were available, if market demand increased leading to higher profits to farmers from growing these crops, and if measures to reduce risk were devised, including conservation of moisture and improvements in its use.

Market Channels of ICRISAT Crops in India

Our estimates of market arrivals in 29 selected markets sampled in SAT India showed that in the mid-1970s only 22% of sorghum was marketed and 78% was retained on farms or in the village. About 26% of pearl millet was marketed. Higher percentages of the grain legumes were marketed: 35% of pigeonpea, 45% of chickpea, and 80% of groundnut. Interregional trade in sorghum and pearl millet is concentrated within the SAT areas of India where these crops are used as staple food. The major producing areas for sorghum (Maharashtra State) and pearl millet (Gujarat State) are also the major importing regions for these crops. The pulses flow into other non-SAT areas (Figs. 1 and 2).

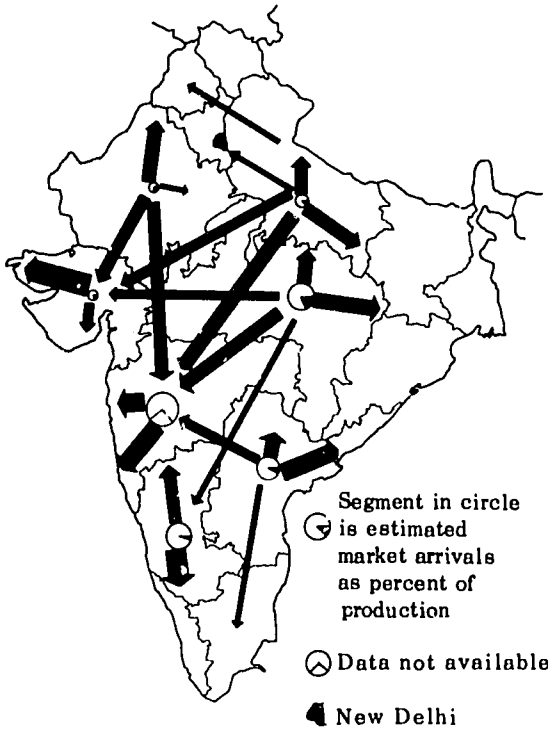
In all the markets studied, large farmers participated more than small farmers. Generally, small farmers seemed to produce for home consumption. When they did sell part of their produce, small farmers usually used only nearby markets, possibly because of small quantities of produce for sale and transportation problems. Relative access to product markets and participation in these is an important area for further research. Means to increase small farmer participation in markets need particular attention.

Estimates based on marketing costs and margins in three representative markets indicated that these markets were operationally efficient for all five ICRISAT crops. The margins obtained by delears in the different channels were consistent with overhead costs and services rendered. The farmer's share in the final retail price paid by the consumer varied between 74% for groundnut and 85% for sorghum, net of marketing costs but not of production costs.

Economic Assessment of Technologies for SAT India

From 1975 through 1978 experiments were conducted at ICRISAT to test improved methods of soil, water, and crop management for increased food production in the SAT. We carried out an economic analysis of the data from these experiments, with the following conclusions:

- A complete improved technology package generated maximum profits per hectare in small plot experiments at ICRISAT Center.



Name of state	Production (1000 metric ton)	Estimated market arrivals as % of production
Andhra Pradesh	1571	8
Madhya Pradesh	1869	18
Maharashtra	3622	NA
Rajasthan	306	31
Gujarat	320	16
Karnataka	1815	5
Uttar Pradesh	397	12

NA = Not available

Arrows across state borders represent flows to markets in other states.

Medium length arrows represent flows to markets in other districts within the state.

Short arrows represent flows to other markets within the district.

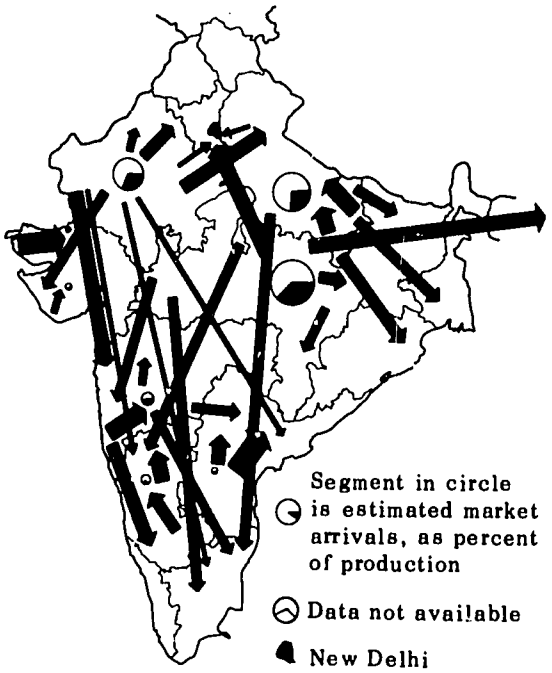
Width of arrow represents relative proportion of flow.

Figure 1. Sorghum marketing in India: market arrivals as percent of production and total flows as percent of market arrivals, 1974–75.

The package, tested on both Vertisols and Alfisols, utilized improved seed varieties, fertilization, plant protection and soil management and employed an improved, bullock-drawn wheeled tool carrier for all operations.

- Maximum profits were achieved with risks that seemed well within tolerances revealed by the Indian SAT farmers.
- On deep Vertisols at ICRISAT Center the broadbed-and-furrow system of soil and water management plus improved crop management was highly profitable in the large-scale experiments.
- On Alfisols at ICRISAT Center profits from improved soil and crop management were also attractive in the small plot experiments although 60% less than on the Vertisols.
- A profit could not be shown for improved soil and crop management on medium-deep Vertisols in the larger-scale trials at ICRISAT Center.
- Traditional cultivation and crop management was more profitable than broadbed-and-furrow cultivation in the large-scale Alfisols experiments.

On ICRISAT Center Vertisol watersheds, a maize/pigeonpea intercrop system generated substantially higher profits, with less variability, than did a maize-plus-chickpea sequential system, especially on medium-deep Vertisols. The likelihood that water harvesting and supplementary irrigation will prove viable is much higher on ICRISAT Center Alfisols than Vertisols, due to the greater runoff-generating potential and scope for profitable crop responses to irrigation on Alfisols. It is unlikely that this technology will be viable on deep Vertisols in a climate similar to that of Sholapur District



Name of state	Production (1000 metric ton)	Estimated market arrivals as % of production
Andhra Pradesh	28	NA
Madhya Pradesh	1147	37
Maharashtra	146	46
Rajasthan	794	31
Gujarat	15	NA
Karnataka	66	NA
Uttar Pradesh	1048	26

NA = Not available

Arrows across state borders represent flows to markets in other states.

Medium length arrows represent flows to markets in other districts within the state.

Short arrows represent flows to other markets within the district.

Width of arrow represents relative proportion of flow.

Figure 2. Chickpea marketing in India: market arrivals as percent of production and total flows as percent of market arrivals, 1974–75.

in India, where the early monsoon is very sparse and undependable and overall rainfall levels are low. Optimum small watershed sizes seemed to be between 8 and 16 ha for the situations tested.

Model to Predict and Evaluate Runoff

We used data from ICRISAT Center and from Sholapur District of India to develop a model to predict and evaluate runoff from rainfall. The data from Sholapur, a particularly drought-prone area, were made available through the cooperation of the local station of the All India Coordinated Research Project for Dryland Agriculture. The range of variables tried in the various regression equations was as follows: daily runoff, daily rainfall, antecedent rainfall, peak rainfall intensity, average rainfall intensity, vegetative cover, soil type, type of cultivation, type of bunding, area of runoff plots or watersheds, soil depth, years after initial land shaping on watershed, and mulching.

Results suggest that the empirical models derived for determining runoff on Vertisols and Alfisols in these two areas of India will enable predictions for these areas to be made with quite a high degree of accuracy. This accuracy will increase the more one moves away from daily predictions and sums predictions into weekly, monthly, and annual totals. In some cases, annual runoff totals can be predicted on average with less than 10% error.

Economics of Improved Bullock-drawn Tool Carriers

A study at ICRISAT Center by scientists of the Economics Program and the Farming Systems Research Program shows that on Alfisols and Vertisols significant increases in returns from

SAT crops can be realized by the use of a wheeled, bullock-drawn tool carrier with attachments to carry out improved soil management practices along with improved levels of plant protection. We find that these returns are attributable inter alia to the relatively high efficiency and precision with which certain traditional and improved practices can be carried out with the aid of such frame and set of implements (Fig. 3).

A simple way to examine the economics of the wheeled tool carrier is to compute a contract hire rate that an entrepreneur would have to charge to make a profit from investment on the tool carrier, implements, and a sturdy pair of bullocks. This calculation can be made under various assumptions about machine costs, profit rates, and utilization rates of the bullocks and the tool carrier. These rates can then be compared with existing bullock hire rates in the central peninsular SAT Indian villages studied by ICRISAT.

One finding from these calculations and comparisons is that the equivalent rental rate for traditional implements of Rs 37 per day cannot be achieved even under the most favorable assumptions of a low-cost machine and a 10% profit rate, although the difference in this case is only Rs 2. The calculations also show that increases in utilization rates allow for large reductions in rental rates; the machine thus must be made to work for nonagricultural purposes such as hauling as well as for field use. The costs of bullocks and the wages of the driver form the larger portion of the cost of the package under nearly all assumptions. Because of this, reduction in machine costs by about 50% only reduces the rental rate of the entire package by approximately 27%.

In future, research attention should be focused on how to increase bullock utilization rates. Efficiency increases for the machine itself are also of prime importance since these would allow operation with smaller and cheaper bullocks. Reductions in machine costs will be helpful only if they do not require design changes that reduce the efficiency of the machine, thus increasing the bullock cost component.

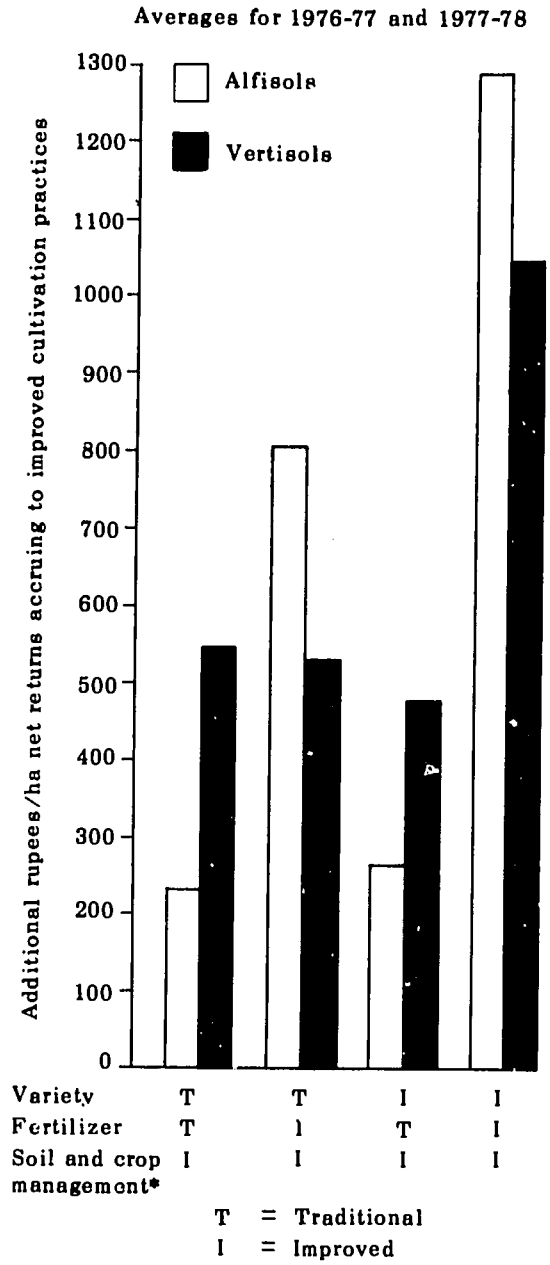


Figure 3. Increased net returns per hectare attributable to improved soil and crop management practices with wheeled tool carrier at ICRISAT Center.

Field Studies of Watershed Development and Group Action

Experiments were initiated during 1978–79 to test in farmers' fields systems of watershed development evolved at ICRISAT Center. The experiments are being conducted in cooperation with farmers from three villages, with member institutions of the Indian Council of Agricultural Research, and with the Farming Systems Research Program of ICRISAT.

The watershed areas being studied involve groups of from 5 to 15 farmers and are located in each of the three central peninsular Indian agroclimatic and soil subregions under study since 1975 in ICRISAT's Village-Level Studies (VLS). Farmers are protected against failure of the experiment for its 3-year duration, and they provide substantial amounts of the labor and bullock power used.

During the 1978-79 crop season small plot experiments covering approximately 4 ha in each village were laid out on individual fields to test different possible cropping patterns. A 3-day workshop involving all the farmers from each of the three watersheds proposed for development and study was held in August 1978. During this workshop, farmers were able to examine a range of agricultural innovations and to test for themselves the improved, bullock-drawn wheeled tool carrier used in ICRISAT's watershed development experiments. During the dry, premonsoon season of 1979, integrated, watershed-based development involving improved drainage structures and the formation of graded beds for planting was begun on several farmers' fields on each watershed.

The farmers' reactions to the technologies and to the types of group action involved are being monitored at present; they will also be observed when the present management assistance and financial aid end with the completion of the 1980–81 crop season. Concurrent, supplementary studies on the social organization and the economics of watershed-based agricultural development are being undertaken.

Labor Availability and Allocation

Attempts are under way at ICRISAT to develop technologies that will be viable for all SAT farmers, including the small landholder, and have potential for augmenting rural employment. Recent experiences with modern varieties of wheat and rice in Asia suggest that new seed/fertilizer/irrigation technology does have scope for creating employment and for benefiting small farmers. However, there is evidence that some of the mechanization that occurred with introduction of the new varieties may have led to labor displacement with little gain in productivity. In view of this, a study was initiated to obtain insights into the likely effects that prospective improved land-, water-, and crop-management technologies being studied at ICRISAT would have on existing village labor-use patterns in peninsular India, one of the major SAT regions of concern. It was also thought that with a thorough understanding of existing labour patterns it would be possible to design technologies that would capitalize on periods when opportunity costs of labour are relatively low.

The data for analysis were drawn mainly from the six VLS villages in SAT peninsular India. Details from sample households on utilization of the labor of each family member and of hired personnel were obtained and related to both on- and off-farm activities as well as to household work. Labor-use data from the watershed-based research being conducted at ICRISAT Center by the ICRISAT Farming Systems Research Program were used for a comparison with the village situation.

Major results from this research project to date are as follows:

- There is a tremendous employment-creating potential in existing tank and well irrigation systems in the Alfisols of peninsular India, and new technologies for the rainfed portions will have to compete with these systems for labor at strategic times.
- Factors including rainfall patterns, crop-

ping patterns, the extent of mixed cropping, and the extent and quality of irrigation all play important roles in determining the intensity of labor use.

- Employment potential for women seems greatest in the highly irrigated and cotton-growing villages (Dokur and the Akola villages).
- There is a substantial contribution of female labor in the crop agriculture of SAT peninsular India.
- Males contribute substantially more of the total family labor, while females contribute substantially more of the total hired labor.
- Females from the poorest socioeconomic group are at the greatest disadvantage in terms of employment opportunities, since they must seek work throughout the year, and not just at peak periods.
- Average opportunity costs of male labor (Rs 2.26 per day) were about 90% greater than those of female labor (Rs 1.20) in these villages.
- Coefficients of variation of opportunity cost were quite large throughout the season (12 to 47%). Hence, there seems to be good scope for design of technology that strategically uses low opportunity costs periods; this would also generate additional income for disadvantaged groups at times when job opportunities and/or wages are low.
- The prospective technologies being evaluated at ICRISAT offer scope for increased employment compared with existing technologies, ranging from at least 48% more employment in Alfisols to more than 150% in deep Vertisols. If traditional threshing methods are utilized, the potential employment increases could be much higher (Figs. 4 and 5).

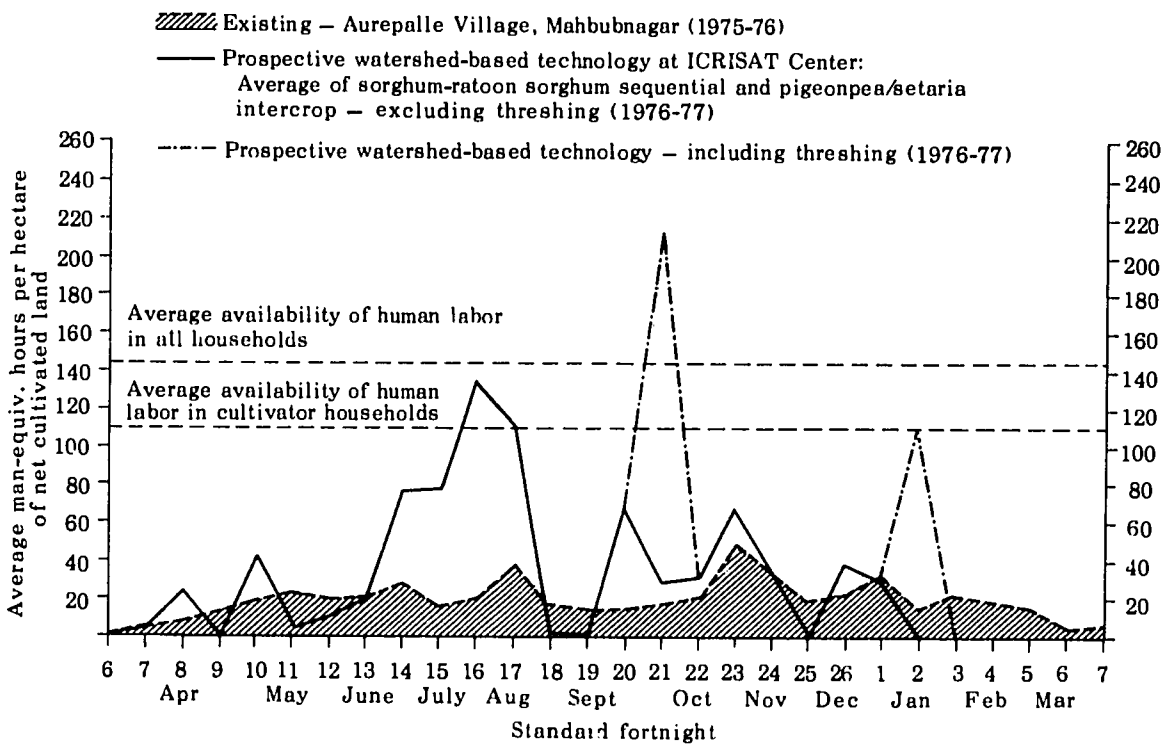


Figure 4. Average seasonal human labor availability and use with existing and prospective water-based technology on Alfisols.

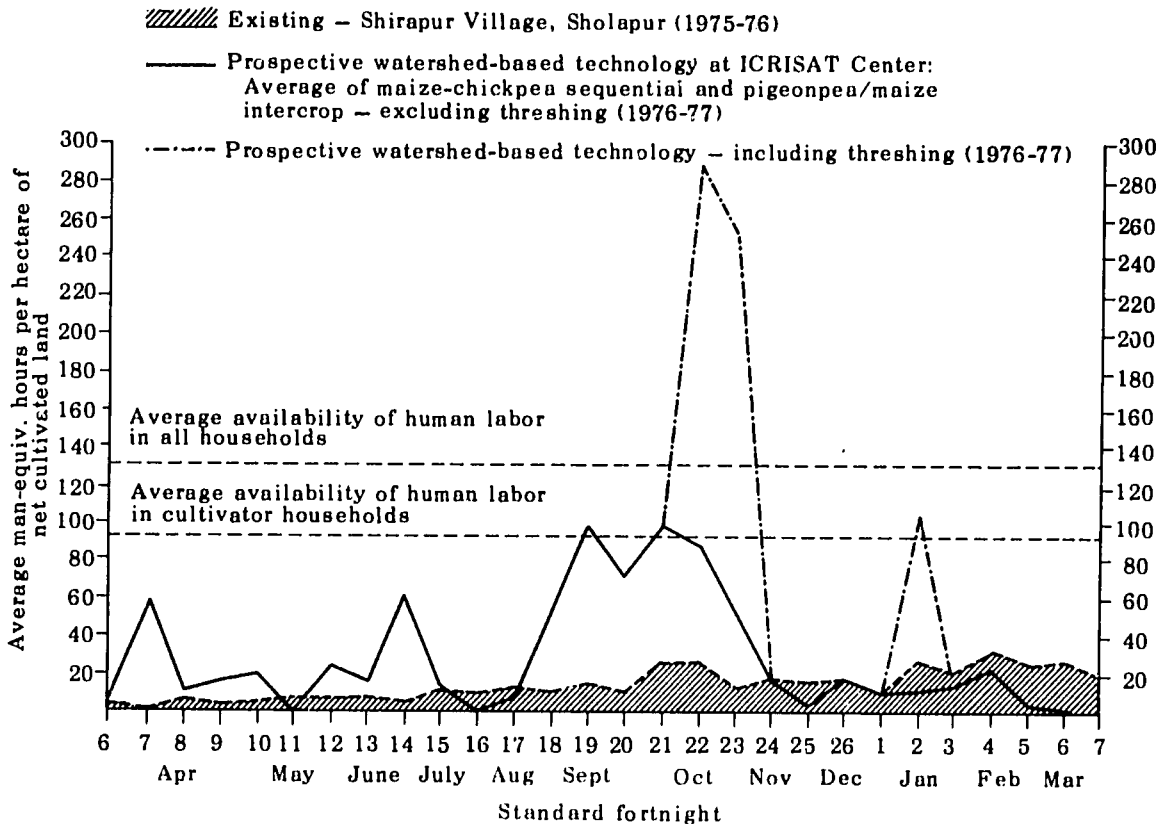


Figure 5. Average seasonal human labor availability and use with existing and prospective watershed-based technology on deep Vertisols.

- Given the existing availabilities of labor in these villages the watershed-based technologies would be expected to encounter major farm labor bottlenecks in July, August, and October on Alfisols, and in September, October, November, and January on deep Vertisols. Medium-deep Vertisols would experience major bottlenecks in two periods: in June and from September to January. Such bottlenecks would be expected to create demands for selective mechanization of operations such as threshing at some periods.

Factor Proportions and Technology Development

Farm data from village-level studies conducted in the Indian states of Andhra Pradesh, Maharashtra, and Himachal Pradesh were analyzed to determine the extent to which small and large farms differed with respect to their resource endowment ratios.

From the evidence examined it seems that for such regions there is no basic reason why the type of technology relevant for small farms should be substantially different from that for large farms with respect to its resource-saving or resource-using characteristics. The differences in the average resources endowment ratios between the small and large farm groups seem to be too minor for separate large-farm and small-farm developmental pathways to exist, at least under present conditions. The difference in factor ratios between the extremities of the farm data analyzed was minor compared with that between the U.S. and Japan,

countries which are often cited as the prime examples of induction of different technological growth paths. The heterogeneity in resource endowment ratios within the farm-size groups studied also makes it impossible to identify a unique target such as "small farms" for technology design.

The relevant technology for both small and large farms in these regions of India is one that is land-saving and/or labor-using. This will be of benefit to large and small farmers alike.

Intercropping

Our data from the central Indian SAT suggest that intercropping in this area is highly complex and diverse because farmers attempt to achieve multiple objectives simultaneously through intercropping. Research cannot and need not generate equally complex new intercropping systems. Instead, research could concentrate on generating simple systems that satisfy key objectives like profitability and stability, without completely ignoring the other objectives that underlie traditional intercropping systems. Such a research strategy could realize relatively quickly the great potential of intercropping for higher and more dependable gross returns per hectare and per unit of peak period labor use.

Socioeconomics Workshop

A successful international workshop was held on the socioeconomics of agricultural development in the SAT. This is reported in more detail in the section "Conferences, Workshops, and Seminars."

Looking Ahead

Scientists of the Economics Program posted in West Africa will establish initial research priorities in production and marketing topics. Steps will also be taken leading to the early initiation of field research at the farm level in major SAT areas of West Africa. The sites for this research will be chosen so as to be useful to ICRISAT's biological and physical scientists for field observations and experiments, as has been the case with the present VLS. These West African studies will provide important data for comparison with those from the continuing central Indian VLS, and from the expansion of the Indian VLS into major chickpea, pearl millet, and groundnut growing areas of northern India.

Building on the results of our studies of risk in our central Indian VLS sample of farmers and laborers, further experiments and analysis will be undertaken. It is proposed to analyze the relationship of experimentally-measured risk aversion with actual agricultural decisions taken by the respondents. Furthermore, the impact of credit market imperfections on risky decisions will receive increasing attention.

Field experiments to test watershed development technology developed at ICRISAT will continue in cooperation with VLS farmers, Indian Council of Agricultural Research scientists, and ICRISAT scientists of the Farming Systems Research Program.

In order to assess further the feasibility and likely consequences of new land- and water-management technologies, activities analysis models are being developed that will try to incorporate all the possible alternatives available in improved as well as traditional technologies and most of the constraints present in semi-arid tropical regions. In order to evaluate the economies of the use of runoff from small watersheds for life-saving irrigation in the rainy season, the derived equations used to predict runoff will be employed in simulation exercises.

As part of a strategy to test hypotheses regarding supplementary irrigation and its social organizational requirements, studies of the ownership and management of existing irrigation sources including wells and tanks will be carried out.

We plan to utilize central Indian VLS data and intensive special interviews with respondents to describe the socioeconomic conditions

that structure this area's daily and long-term agricultural labor markets.

We will attempt to quantify the effects of market infrastructure and market regulation policies on aggregate agricultural productivity in major SAT states in India. Grain quality indices based on general consumer preferences are being developed to aid in efficient selection of breeding material for good consumer acceptance.

Publications

Institute-level Publication

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