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AN ECONOMIC ANALYSIS OF FARM RESOURCE USE, JABALPUR DISTRICT, MADHYA PRADESH, INDIA, 1967-68

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Preface

One of the major controversies of a decade ago concerning the economics of agricultural development was that of the extent to which farmers in low income countries made intelligent economic decisions concerning their farming operations. That controversy has been fully resolved by a series of studies carried on here at Cornell and elsewhere. However, several questions remain which relate to farmer's choice of practices and combinations of enterprises. Most important is the need for knowledge concerning the profitability and the effect on choice of practices and cropping combinations of new agricultural technologies. The recent development of new varieties of rice and wheat for Indian conditions has given urgency to this concern. A number of new possibilities for increasing the availability of certain basic resources such as irrigation have also arisen and provide new questions concerning farming practices and resource combinations. Some of the new agricultural technologies interact with resources such as irrigation water and change the rates of return and the optimal input levels for these resources. These same forces have increased the importance of knowledge of weather variability and the effect of weather variability on returns to inputs and levels of output. The development of a dynamic agriculture in India has greatly increased the importance of production economics studies.

V. P. Shukla has attacked the problems indicated above by the application of a linear programming model. Shukla refines his model by applying it to the existing resource and technological situation facing farmers in a specific area of Central India. He then uses this refined model for analysis of the effect of new agricultural technologies, new resource possibilities and weather on resource and crop combinations and the level of farm income. He demonstrates clearly the tremendous importance to agricultural development of the recently developed new technologies and more important he indicates how they interact with the resource base and the steps which must be taken to encourage expanded use of the new technologies and realization of their tremendous potential for benefit.

The data used for V. P. Shukla's study were collected from operating farms in Jabalpur District, Madhya Pradesh, India. He interviewed a substantial sample of farmers to obtain detailed information concerning the actual resource restraints which they face and the input-output relationships which they experience. Thus his study reflects what actually does and will happen under actual operating circumstances. He recognizes that both resource restraints and input-output relationships vary from farm to farm. Thus he divides his sample into groups of farms which differ significantly in these respects. His study also helps us to understand why certain groups of farmers move more quickly than others in accepting new technologies.

The data for this study were collected directly from farmers through an intensive survey carried on over a period of nearly a year. V. P. Shukla, who already was well acquainted with the area of study, directly supervised the work and collected much of the data himself. The care and detail which went into collection of the data and development of the

model provide a basis for future testing of the effects of various changes in input-output relationships arising from new technologies and from new price relationships. Thus the model which V. P. Shukla has developed will have considerable value into the future as well as for this specific study.

V. P. Shukla's study of choice of practices and enterprises in the agriculture of central India is one of a series of studies being carried out at Cornell University as part of a USAID-financed contract for research on agricultural prices. We are grateful for the assistance provided by the Rural Community Development Division of USAID and, in particular to Douglas Caton, Norman Ward and Voyce Mack of that Division.

The broad program of study of which V. P. Shukla's work is one part, covers three major areas of enquiry: the role of prices in intersectoral income and capital transfers; the effect of price relationships on agricultural production and marketings; and the factors affecting urban prices of agricultural commodities. Thus in total, these studies are concerned with the effects of agricultural prices on the nonagricultural sectors of the economy, with their effects in the agricultural sector, and with the manner in which agricultural prices are determined. Over the course of the contract a substantial number of studies will be carried on in various countries and dealing with various aspects of the processes. At the completion of these studies an effort will be made to pull them together into an integrated view of the role and functioning of agricultural prices in the development process.

A basic objective of the contract with USAID for the conduct of this research is not only to produce useful research results but also to provide a structured research experience so as to enlarge the pool of trained manpower for the analysis of such problems. For this purpose, the research in this project is accomplished primarily by Ph.D. candidates at Cornell University who use the specific studies conducted as Ph.D. dissertations. The definition of the overall project has purposefully been kept broad and flexible to facilitate the attainment of this additional objective. This study by V. P. Shukla is part of that program and is drawn from his Ph.D. dissertation, completed at Cornell University in 1969.

John W. Mellor

Ithaca, New York
January, 1970

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CHAPTER I

INTRODUCTION

This study analyzes the organization of medium size farms in the Jabalpur District, Madhya Pradesh, to assess the economics of present resource use and the requisites for increasing agricultural output and farm incomes. Data on the existing resource structure, cost and income were obtained through a farm survey. The sample consisted of irrigated and unirrigated farms, which was further subdivided into farms with traditional and advanced techniques of farming. Thus, four technological categories of farms were studied; namely, traditional unirrigated, traditional irrigated, advanced unirrigated and advanced irrigated.

Linear programming was the basic analytical technique used. The programming was based on the actual resource restrictions and input-output relationships from each of the four categories of farms studied. Data were obtained from farmers by personal interview using a pretested, structured questionnaire. For each category of farm, the possibility of increasing income by reallocation of existing resources was studied. The effect on income of increasing resources such as operating capital and irrigated area was examined within each of the four technological categories. The effect of change in weather was examined in relation to present and programmed allocation of resources. Finally, the extent of income gain by technological change and the necessary resource expansion required was determined.

Salient Characteristics of Sample Area

Jabalpur is one of the 43 districts of the central Indian state of Madhya Pradesh. The state is the largest in India, and has a low density of population at about half the all-India average. It is predominantly an agricultural state with 86 percent of the people living in rural areas. More than half of the state's income is derived from agriculture. The per capita income of the state in 1965-66 was Rs. 357 whereas the national average was Rs. 430.

Although the yield levels of most of the crops are quite low compared to all-India, the state has been traditionally a surplus state in the production of food. The two important crops of the state are rice and wheat. Jabalpur District is situated in the rice-wheat zone where both these crops have equal importance.

In Jabalpur District the annual rainfall in 1967 was 87 centimeters of which monsoon accounted for 77 centimeters. The number of rainy days in this district were 45. The rainfall in the agricultural year of 1967-68 was extremely favorable to rabi crops due to winter showers.

The irrigated area in Madhya Pradesh is only a little over one million acres. A little less than 6 percent of the cultivated area is irrigated compared with 44 percent in Punjab and 45 percent in Madras. The intensity of cropping in the state is low at 111.

The chemical fertilizers used per hectare in 1967-68 were about 1.95 kilograms as against an average of 11.25 for India or 23.24 for Kerala and 36.14 for Madras. The yield of wheat in the year 1966-67 was only 505 kilograms per hectare and rice was 480 kilograms per hectare. These yields are only about half those obtained in states like Madras and Punjab.

Prices of farm commodities in Madhya Pradesh are substantially lower than those in the rest of the country. This is in part because it is a surplus producing state distant from major markets and has a poorly developed transportation system. The result is discouraging to heavy use of inputs and intensive farming.

The all-India figure for commercial crops is 21 percent of the total cropped area. Madhya Pradesh has only 15 percent area under commercial crops.

Features of the Sample

The data were collected in three sampling units to incorporate different influences. Jabalpur, adjacent to the first sampling unit, is a big industrial city, which may affect farm attitudes and practices in nearby areas. In Sehora sampling unit, the influence of the extension work of the nearby agricultural university may have brought about some change. In Shahpur sampling unit, neither the Jabalpur city nor the Agriculture University are likely to have had any impact.

Jabalpur city sampling unit has 52 farms whereas the other two units had 60 farms each. Farms in each unit were subdivided into two groups, unirrigated and irrigated. The resource position of the Sehora sampling unit farms appears to be better as reflected by acres owned, investment in land buildings and machinery and numbers of man equivalent and bullocks. The average size of irrigated farms was smallest in Jabalpur sampling unit, but the size of family supported was largest on these farms. The fertilizer use on unirrigated farms was highest in Sehora unit but was lowest in Shahpur. However, Shahpur unit was highest in fertilizer use for irrigated farms. The lowest use of fertilizer on irrigated farms was found in Jabalpur unit. The averages per farm for such features as land use, labor inputs, livestock numbers, etc., are reported in Table 1.

The sample farms were mainly analyzed on the basis of technological categories and the allocation of resources for increasing returns to fixed resources was derived by linear programming. Since decision-making may also be influenced by such variables as caste, education, age

Table 1. Salient Features of the Farms in Three Sampling Units
172 Farms, Jabalpur District (M.P.), India, 1967-68

Features	Jabalpur Unit		Sehora Unit		Shahpur Unit		All
	30 Farms unirrigated	22 Farms irrigated	30 Farms unirrigated	30 Farms irrigated	30 Farms unirrigated	30 Farms irrigated	172 Farms
Land Use							
Acres Owned	20.3	19.5	23.1	30.4	21.7	22.5	23.0
Number of plots	2.1	2.6	2.0	2.1	2.0	3.5	
Investment in land, buildings, machinery (Rs.)	12257	16121	12364	35680	14146	21216	185551
Labor Inputs							
Members in family	5.7	6.7	5.2	6.4	5.6	5.9	5.8
Working man equivalent	3.5	3.8	3.4	5.4	2.7	3.8	3.7
Casual man days hired	34	58	35	76	37	44	47
Casual woman days hired	84	60	79	107	90	103	88
Livestock Numbers							
Cows	2.3	1.6	1.4	2.2	2.3	2.3	2.0
Buffaloes	0.6	1.9	1.0	1.7	1.2	1.4	1.3
Bullocks	3.1	3.5	5.0	6.0	3.8	4.2	4.3
Fertilizer Inputs							
Value of fertilizer (Rs.)	79	132	132	476	45	538	243
Value of Food and Fodder							
Home produced food consumed (Rs.)	1848	1892	1540	1750	1370	1860	1775
Home produced fodder used (Rs.)	965	1004	1040	1149	900	1002	1010
Total fodder used (Rs.)	1058	1138	1113	1257	1035	1190	1166

of operator and level of leadership in the community, the sample was classified accordingly. The irrigated farms were classified on the basis of mode of irrigation. Their variability was studied by employing analysis of variance on the basis of gross income per acre. The basis of gross income was chosen because in a traditional agriculture the purchased inputs are relatively small.

The age of operator and level of leadership of the farmer in the community did not significantly affect the income of the farm (Table 2). However, caste, educational level and modes of irrigation had significant effects on gross income per acre. There appears to be an interaction between caste and education. The third caste group (Vaish) has the highest mean income. This group had the highest percentage of farmers with higher education. The lowest income was obtained by Shudra group which had the smallest percentage of farmers in higher education.

Table 2. Analysis of Variance of Gross Income
172 Farms, Jabalpur District (M.P.), India, 1967-68

	Caste	Educational Level	Age of Operator	Leadership Level	Mode of Irrigation
Per acre	Brahmin (309)	College (379)	Twenties (360)	Cooperative (336)	Electric Pump (429)
Mean gross	Kshatriya (339)	High School (359)	Thirties (272)	Panchayat (305)	Oil Pump (334)
Income in	Vaish (336)	Primary (333)	Forties (334)	School (290)	Tube Well (404)
Rupees in	Shudra (292)	None (292)	Fifties (310)	None (309)	Charas (323)
			Sixties (329)		
Observed F ratio	2.79	4.84	2.28	0.50	4.15
Critical region	2.6	2.6	2.37	2.6	2.76
Hypothesis of equal means	Rejected	Rejected	Accepted	Accepted	Rejected

The rest of the analysis, assessment and projections are carried in terms of the 4 technological categories. In Chapter II the present resource use, cropping pattern, yields, cost and income are analyzed. In Chapter III the effect of reorganization of the existing resources is examined to see its possible effect on income. In Chapter IV certain

limited resources are moderately increased to see the changes in income and production. The effect of differences in weather is also examined in this chapter. Finally, in Chapter V, the impact of technological change on production and income together with returns to irrigated advanced technology are examined.

CHAPTER II

ANALYSIS OF SAMPLE FARMS BY TECHNOLOGICAL CATEGORIES

Technological Categories

Unirrigated farms with fertilizer used on less than 25 percent of the acreage were defined as "unirrigated traditional farms." Irrigated farms with fertilizer used on less than 25 percent of the acreage were defined as "irrigated traditional farms." Unirrigated farms with at least 25 percent of the area receiving fertilizer were defined as "unirrigated advanced farms," and similarly, irrigated farms with over 25 percent of the acreage receiving fertilizer were defined as "irrigated advanced farms."

The number of farms in each category were:

Category	Description	Number of Farms
1	Unirrigated traditional	69
2	Irrigated traditional	27
3	Unirrigated advanced	21
4	Irrigated advanced	55
		172

Resource Use

Land Use

The 19.1 acres owned per farm in category 1 (traditional unirrigated) was smaller than the averages for the other categories which were 25.2, 28.5 and 24.7, respectively (Table 3). The acres owned in category 3 were about 50 percent larger than in category 1.

By definition categories 1 and 3 had no irrigation while 2 and 4 did. The irrigated crop acres for categories 2 and 4 were similar with 7.5 and 8.0 acres, respectively. For both the traditional farms (categories 1 and 2) and the advanced technology farms (categories 3 and 4) the farms with irrigation had more total crop acres than the unirrigated farms with 32.0 versus 24.1 and 32.8 versus 29.0.

The advanced technology farms in categories 3 and 4 had fewer plots 2.0 and 1.9 than did the traditional farms with an average of 2.5 and 2.7 plots per farm (Table 3). This in turn means that the advanced technology farms had larger plots than the traditional farms.

Permanent Labor Force

More than half of the permanent labor force was provided by the family (Table 4). The irrigated farms had larger families than the unirrigated farms. The total permanent labor use on irrigated farms as

Table 3. Land Use by Technological Categories
172 Farms, Jabalpur District (M.P.), India, 1967-68

Item	Category			
	Traditional		Advanced	
	1	2	3	4
	Unirrigated	Irrigated	Unirrigated	Irrigated
	per farm			
Acres owned	19.1	25.2	28.5	24.7
Acres cultivated	18.1	24.6	24.3	23.0
Irrigated crop acres	—	7.5	—	8.0
Unirrigated crop acres	24.1	24.6	29.0	24.9
Total crop acres	24.1	32.1	29.0	32.9
Acres current fallow	12.1	17.2	19.7	13.1
Number of plots	2.5	2.7	2.0	1.9
Acres owned per plot	7.6	9.3	14.2	13.0

Table 4. Labor Force by Technological Categories
172 Farms, Jabalpur District (M.P.), India, 1967-68.

Item	Category			
	Traditional		Advanced	
	1	2	3	4
	Unirrigated	Irrigated	Unirrigated	Irrigated
	Average per farm			
Members in family	5.6	6.1	5.3	6.2
Men in family working	1.5	1.7	1.4	1.6
Women in family working	1.0	1.1	0.8	1.0
Hired men working	0.7	1.5	1.0	1.4
Hired women working	0.2	0.4	0.5	0.6
Man equivalent[a]	3.0	4.3	3.4	4.2
Man equivalent per cultivated acre	.16	.17	.14	.18
Man equivalent per crop acre	.12	.13	.12	.13
Crop acres per man equivalent	8.0	7.5	8.8	7.8
Cultivated acres per man equivalent	6.3	5.7	7.1	5.5

[a]For computing man equivalents one woman was treated as equal to 0.75 man equivalent and a boy equal to 0.50, ratios similar to those of the wage rate.

measured by man equivalent was also more than on the unirrigated farms. However, the difference appeared to be less when labor use was compared on the basis of per crop acre. The traditional irrigated and advanced irrigated farm required 0.13 man equivalent per crop acre while unirrigated farms in advanced and traditional technologies required 0.12 man equivalent. This shows advanced technology did not use a permanent labor force, but irrigated farms did use somewhat more such labor than unirrigated farms. This is even more apparent if the comparison is made on a "cultivated acre" basis where on advanced farms the irrigated used 0.18 man equivalent compared with 0.14 for the unirrigated. This can also be expressed in terms of area managed per man equivalent. The largest area per man equivalent was managed by advanced unirrigated farms. The irrigated farms had about equal area per man equivalent. The traditional unirrigated farms had considerably less area managed per man equivalent.

Casual Labor

In addition to permanent labor available on the farm, some casual labor was also needed from time to time for seasonal requirements of crop husbandry. There were three periods of busy season for which employment of casual labor in man equivalent days is presented in Tables 5 and 6.

Table 5. Seasonal Distribution of Casual Labor in Man Equivalent
172 Farms, Jabalpur District (M.P.), India, 1967-68

Category	July-Aug.	Oct.-Nov.	March-April
	Man equivalent days		
1 Traditional unirrigated	23.07	37.33	35.10
2 Traditional irrigated	28.90	43.92	43.94
3 Advanced unirrigated	30.29	37.27	38.41
4 Advanced irrigated	37.67	50.31	46.82

Table 6. Man Equivalent of Casual Labor Per Crop Acre by Seasons
172 Farms, Jabalpur District (M.P.), India, 1967-68

Category	July-Aug.	Oct.-Nov.	March-April
	Man equivalent days		
1 Traditional unirrigated	.95	1.54	1.45
2 Traditional irrigated	.90	1.37	1.37
3 Advanced unirrigated	1.04	1.29	1.32
4 Advanced irrigated	1.14	1.53	1.42

Investment and Supplies

The category 1 farms had the lowest investment in land, buildings, and machinery averaging Rs. 12,431 (Table 7). The investment in category 3 which is also unirrigated was higher due to larger size of farm. Total investment and investment per acre is much higher for irrigated than unirrigated farms and highest of all for advanced irrigated farms.

Table 7. Value of Investment* by Technological Categories
172 Farms, Jabalpur District (M.P.), India, 1967-68

Category	Average Investment	Investment per acre	
		Owned	Cultivated
		Rupees	
1 Traditional unirrigated	12,431	651	687
2 Traditional irrigated	19,158	760	779
3 Advanced unirrigated	14,530	510	598
4 Advanced irrigated	28,085	1,137	1,221

*Investment in land, buildings and machinery.

Fertilizer, Seed and Feed Inputs

There was no significant difference in the use of inputs in different technological categories except fertilizer. The inputs were examined on a per farm and a per acre of crops grown basis (Table 8).

The value of fertilizer per acre was highest on advanced irrigated farms, but also was sizeable on the advanced unirrigated farms (Table 8). The use of fertilizer on traditional unirrigated and irrigated farms was negligible. Technological change did not require much change in the value of seed and feed inputs. However, the value of fertilizer represented a cash expense whereas other inputs did not because they were produced mostly on the farm.

Livestock

There were three kinds of livestock on the sample farms, namely cows, buffaloes and bullocks. The smallest number was observed on unirrigated traditional farms. It appears the quality and number was highest on traditional irrigated farms (Table 9).

For feeding the cattle, all the farms indicated that they would like to produce crops that would provide sufficient straw for fodder. However, many farms purchase oil cakes and other concentrates.

Table 8. Fertilizer, Seed, and Feed Inputs by Technological Categories
172 Farms, Jabalpur District (M.P.), India, 1967-68

Input	Category			
	Traditional		Advanced	
	1	2	3	4
	Unirrigated	Irrigated	Unirrigated	Irrigated
	Rupees			
Value of fertilizer:				
Per farm	9	47	334	582
Per acre of crops	.37	1.47	11.52	17.74
Value of seed:				
Per farm	835	1,012	1,017	1,110
Per acre of crops	35	32	35	34
Value of feed:				
Per farm	708	974	893	1,036

Table 9. Number and Value of Livestock by Technological Categories
172 Farms, Jabalpur District (M.P.), India, 1967-68

Item	Category			
	Traditional		Advanced	
	1	2	3	4
	Unirrigated	Irrigated	Unirrigated	Irrigated
Cows:				
Number per farm	1.9	2.3	2.0	2.0
Value in rupees	428	630	445	464
Value per animal	225	274	222	232
Buffalo:				
Number per farm	.9	2.3	1.1	1.3
Value in rupees	320	1,031	379	434
Value per animal	356	448	345	334
Bullocks:				
Number per farm	3.8	5.2	4.7	4.4
Value in rupees	1,007	1,744	1,278	1,201
Value per animal	265	335	272	273

Cropping Pattern

The most important crop in the district was wheat. The sample had 48 percent crop area under wheat followed by 27 percent under paddy. In

pulses, the grain crop had the largest area with 11 percent followed by masoor crop with 7 percent area. The same trend is observed in technological categories. The largest area is devoted to wheat and is followed by paddy (Table 10). The data indicate that advanced farms are moving toward wheat paddy specialization and hence less diversification of cropping.

Table 10. Cropping Pattern by Categories
172 Farms, Jabalpur District (M.P.), India, 1967-68

Crops	Category			
	Traditional		Advanced	
	1	2	3	4
	Unirrigated	Irrigated	Unirrigated	Irrigated
	Percent			
Wheat (dwarf) irrigated	-	-	-	9
Wheat (local) irrigated	-	11	-	6
Wheat (local) unirrigated	43	35	53	35
Paddy (dwarf) irrigated	-	-	-	2
Paddy (dwarf) unirrigated	-	-	-	1
Paddy (local) irrigated	-	8	-	6
Paddy (local) unirrigated	24	19	26	23
Masoor irrigated	-	1	-	-
Masoor unirrigated	8	8	9	5
Gram irrigated	-	1	-	Negligible
Gram unirrigated	18	8	11	7
Pea irrigated	-	Negligible	-	Negligible
Pea unirrigated	1	2	1	3
Vegetables	-	3	-	1
Jowar	2	Negligible	-	1
Arhar	1	2	-	1
Moong-urid	3	-	-	-
Lesser millets	-	2	-	-
Total	100	100	100	100

Crop Yields

The year of inquiry was a good crop year and the annual rainfall was favorable. The winter rains in particular were more than normal which favors the rabi crops, especially wheat. The winter rains or precisely the cloudy weather is not particularly favorable to some rabi crops like gram and masoor where it promotes certain pests causing heavy damage to these crops. Sometimes this very climate proves injurious to wheat because it promotes the attack of rust. Some farmers who had grown local varieties were affected by the incidence of rust in their wheat crop. The incidence of gram pest was widely reported.

The yield differences between traditional and advanced farms are considerable in wheat and paddy crops in which fertilizer was usually used (Table 11). For instance, the yield of unirrigated wheat was only 270 kg. in traditional irrigated technology (category 2), but was 462 kg. in advanced unirrigated technology (category 3) and 486 kg. in advanced irrigated technology (category 4). However, this relationship does not hold true uniformly for other crops.

Table 11. Yield of Crops by Categories
172 Farms, Jabalpur District (M.P.), India, 1967-68

Crops	Category			
	Traditional		Advanced	
	1	2	3	4
	Unirrigated	Irrigated	Unirrigated	Irrigated
	Kilograms per acre			
Irrigated dwarf wheat	--	--	--	810
Irrigated local wheat	--	415	--	523
Unirrigated local wheat	286	270	462	486
Irrigated dwarf paddy	--	--	--	1,109
Unirrigated dwarf paddy	--	--	--	595
Irrigated local paddy	--	--	--	625
Unirrigated local paddy	319	313	452	378
Irrigated masoor	--	300	--	--
Unirrigated masoor	221	231	216	253
Irrigated gram	--	394	--	300
Unirrigated gram	209	257	273	210
Irrigated pea	--	350	--	225
Unirrigated pea	263	108	293	263
Unirrigated Jowar	264	--	--	145
Unirrigated Arhar	174	219	--	--
Unirrigated moong-urid	107	97	--	--
Unirrigated lesser millets	--	340	--	--
Vegetables	--	728	--	944

Cost and Income

For calculating gross income the actual price obtained by the farmer was used. Since straw is seldom sold, no value was placed on straw. The gross income for this study is a function of yield and price. For computing net income, the cash cost was deducted from gross income. Table 12 shows the average of actual gross income, cash cost and net income obtained in different categories.

Table 12. Gross Income, Cash Cost, and Net Income by Categories
172 Farms, Jabalpur District (M.P.), India, 1967-68

	Category			
	Traditional		Advanced	
	1	2	3	4
	Unirrigated	Irrigated	Unirrigated	Irrigated
	Rupees			
Gross income per farm	5,816	8,508	11,200	13,725
Cash cost per farm	727	1,339	1,465	1,922
Net income per farm	5,089	7,169	9,735	11,803
Gross income per acre	320	345	459	595
Cash cost per acre	40	54	60	83
Net income per acre	280	291	399	512

The difference in net income between the traditional unirrigated (category 1) and irrigated farms (category 2) was small, only Rs. 11 per cultivated acre. This may have been due to the fact that in a good rainfall year like 1967-68, the benefits from irrigation do not show appreciably. On the other hand, the unirrigated advanced farms which had used fertilizers to supplement the soil with plant nutrients had registered net incomes which were higher by Rs. 108 per cultivated acre than the irrigated traditional farms (category 2). The highest per cultivated acre net income was found on irrigated advanced farms. The technological difference on irrigated farms increased the net income by Rs. 221 per cultivated acre over traditional irrigated farms. On unirrigated farms, the technological difference accounts for a gain of Rs. 119 per cultivated acre.

When the per acre net income was calculated on the basis of cropped acres, this clear-cut difference between advanced and traditional farms remains undisturbed but the difference between irrigated and unirrigated farms almost disappeared. This is probably primarily because in this year the winter rains were so bountiful that in most cases the yields were governed primarily by the amount of nutrient in the soil and not by the amount of irrigation. The per cropped acre gross income, cash cost, and net income in different categories is shown in Table 13. It

can be seen that the difference in income per acre on advanced irrigated and unirrigated farms is accounted for largely by higher cropping intensity on the irrigated farms (Table 14).

Table 13. Average Gross Income, Cash Cost, Net Income Per Crop Acre
172 Farms, Jabalpur District (M.P.), India, 1967-68

Category	Gross Income	Cash Cost	Net Income
	Rupees per acre cropped		
1 Traditional unirrigated	240	30	210
2 Traditional irrigated	265	41	224
3 Advanced unirrigated	385	50	335
4 Advanced irrigated	417	58	358

Table 14. Intensity of Cropping by Categories
172 Farms, Jabalpur District (M.P.), India, 1967-68

Category	Cultivated Area	Cropped Area	Intensity of Cropping
	Percent		
1 Traditional unirrigated	18.14	24.14	133
2 Traditional irrigated	24.66	32.10	130
3 Advanced unirrigated	24.35	29.05	115
4 Advanced irrigated	23.05	32.92	142

Net Income Per Man

The highest return to labor was on the advanced unirrigated farms (Table 15). It was Rs. 2,854 per man equivalent which was higher by Rs. 64 than the irrigated advanced farms. It is interesting to note that labor returns were higher in traditional unirrigated farms than the traditional irrigated farms by Rs. 37. This is due largely to the unusually high yields on the unirrigated farms due to good winter rains.

Net Income Per Rupee of Operating Capital

In this study only cash costs were obtained and hence cash expenses actually incurred were treated as operating capital. This resource had a wide range. The traditional unirrigated farms on an average used only Rs. 727 as cash expenses, whereas the advanced irrigated farms used Rs. 1,922. The highest returns for operating capital were found on unirrigated traditional farms and the lowest on irrigated traditional farms (Table 16).

Table 15. Net Income Per Man Equivalent
172 Farms, Jabalpur District (M.P.), India, 1967-68

Category	Man Equivalent	Net Income per Man Equivalent
1 Traditional unirrigated	2.96	1,719
2 Traditional irrigated	4.26	1,682
3 Advanced unirrigated	3.41	2,854
4 Advanced irrigated	4.23	2,790

Table 16. Average Net Income Per Rupee of Cash Expenses
172 Farms, Jabalpur District (M.P.), India, 1967-68

Category	Cash Expenses	Net Income	Net Income per Rupee of Expense
	Rupees		
1 Traditional unirrigated	727	5,089	6.99
2 Traditional irrigated	1,339	7,169	5.35
3 Advanced unirrigated	1,467	9,735	6.64
4 Advanced irrigated	1,922	11,803	6.14

Fertilizer Cost and Return Per Crop Acre

The irrigated farms used fertilizer in greater quantity than the unirrigated farms as shown by fertilizer costs of 11.54 and 17.69 rupees per acre respectively (Table 17). The fertilizer cost per crop acre was higher on irrigated advanced farms. However, the per crop acre net income was not substantially higher. The good rains had increased the yields of unirrigated farms but that alone does not explain why the irrigated farms did not obtain higher yields and higher per crop acre income by greater use of fertilizer. Three reasons may explain this lack of relationship.

1. The irrigated advanced farms have grown the dwarf varieties as a new experience and may have overused fertilizer on these crops without commensurate returns (diminishing returns).

2. The unirrigated farms had used fertilizers moderately but the land may have a backlog of unused fertility from the previous years especially during the drought years when the moisture was so short that the crops could not use the plant food available in the soil.

3. The high intensity of cropping with some crops having relatively very low returns may have diluted the per crop acre net return to bring it on par with the advanced unirrigated farms.

Table 17. Fertilizer Cost and Net Income Per Acre
76 Advanced Farms, Jabalpur District (M.P.), India, 1967-68

Category	Fertilizer Cost per Crop Acre	Net Income per Crop Acre
	Rupees	
3 Advanced unirrigated	11.54	335
4 Advanced irrigated	17.69	358

Cost of Irrigation

The irrigation cost figures calculated include the cost of labor irrespective of whether hired labor was employed or not. In charas irrigation hired labor usually was not employed, but for the purpose of comparing the operating cost of the different systems, labor was charged at the prevailing rates.

In pump irrigation, in most cases, the capacity of the well would allow pumping of less than four hours, or a half-day; as a result, the labor was charged for a half-day. In case of state tube well irrigation, the per irrigation cost was more in kharif than in rabi (because of high fixed cost and the lesser number of irrigations required by paddy than wheat.

In irrigated wheat, the per irrigation cost was found to be cheapest for state tube well irrigation (Table 18). This was because the government charged a fixed amount of Rs. 15 per acre and the farmers could

Table 18. Average Cost of Irrigations in Wheat and Paddy by Mode of Irrigation
82 Farms, Jabalpur District (M.P.), India, 1967-68

Mode	Average Cost per Acre per Irrigation	
	Wheat	Paddy
	Rupees	
Oil pump	8.03	5.68
Electric pump	4.71	3.20
Charas	25.71	21.73
State tube well	3.96	7.50

take as many irrigations as were required by the crop. In view of the fact that there were special efforts made to popularize the dwarf wheat following two consecutive seasons of bad harvest, as many as four irrigations were reported to be given for rabi season. The next lowest average cost per irrigation was found in electric pump irrigation.

In both of the above modes of irrigation, there is an element of subsidy by the state. The irrigation cost of state tube well and electricity charges do not recover the full cost borne by the government.

The next in rank in cost was the oil pump. The costliest when labor was included was the traditional method of irrigation by charas.

During the kharif season the average cost per irrigation of paddy was least for electric pump irrigation and the next lowest for the oil pump. The state tube well per irrigation cost was higher and was ranked third. Its higher cost was due to the fixed charges and the low number of irrigations. The charas irrigation was once again the costliest. There was a noticeable difference in the average cost in rabi and kharif season in all modes of irrigation. Due to fixed government charge per acre, it was higher for paddy in the case of state tube well, but for other modes the average per acre cost was lower in paddy. Two reasons account for this. One, the water requirement was less in kharif and two, the water in the well was not exhausted and pumps could be run for the entire day and thus labor cost was reduced by fuller utilization.

The average investment in oil pump was Rs. 3,444 per farm for the sample. The corresponding figure for the electric pump was Rs. 1,983. Although there was heavy investment for the overhead electric lines, that expenditure was met by the government. The investment situation for the farmer favors the installation of electric pumps.

Since farmers view irrigation cost as a whole in relation to what they obtain in yield, it was appropriate to relate per acre irrigation cost to per acre yield (Table 19). Yields by charas irrigation were consistently lower than irrigation by pumps or state tube wells.

Table 19. Irrigation Cost and Yield Per Acre of Local Wheat and Paddy
82 Irrigated Farms, Jabalpur District (M.P.), India, 1967-68

Crop and Mode of Irrigation	Irrigation Cost Per Acre	Yield Per Acre	
		Traditional Technology	Advanced Technology
	Rupees	kilogram	
Local Wheat			
Electric Pump	12.91	552	549
State tube well	15.00	--	546
Oil pump	17.69	399	592
Charas	41.58	426	507
Local Paddy			
Electric pump	3.58	433	680
State tube well	15.00	--	525
Oil pump	6.02	487	515
Charas	21.73	409	400

CHAPTER III

FARM ORGANIZATION WITH EXISTING RESOURCES

For the purpose of this study, the resources of farms in each of the four farm categories were averaged to obtain the resources for a model farm in that category. For obtaining input-output coefficients, the actual input-output coefficients of farms in each category were averaged. These four model farms were programmed to maximize income under the assumed conditions to see if there was any scope for increasing net income under existing conditions, to compare the differences between categories and to check the reasonableness of the assumptions.

Restrictions Used in Programming

Under the conditions of the sample area, the most limiting farm resources are land, irrigated area, and operating capital. Both permanent hired and casual labor are not found limiting in the sample, so they are not treated as a resource limitation.

Madhya Pradesh has predominantly subsistence farming and the source of power is bullocks. The farmers indicated that they must grow crops to supply the family food needs for fodder for the farm animals. In view of this, additional restrictions were introduced in the program to supply (1) minimum cereals and pulses for the farm family, and (2) the fodder for the farm animals.

Land Restrictions

After the abolition of Zamindari and other types of intermediary settlement, all land is held by the peasants. The farms are owner-operated and there is little scope for increasing area by purchase or lease. There are no crop sharing practices in the sample. Hence, alternatives for increasing the area of land under operation are not included in the model.

The land classification for data enumeration is for light and heavy soils. Since very few farmers have light soils and the area is negligible, it is not provided in the model. The soils are medium black and fairly homogeneous. Since land can be cropped in three seasons; namely kharif, rabi, and summer, land is classified as follows: (1) Unirrigated kharif, (2) Irrigated kharif, (3) Unirrigated rabi, (4) Irrigated rabi, (5) Irrigated summer.

Irrigation Restrictions

The major source of irrigation in the sample is surface wells. Only seven farms receive water from state tube wells. The irrigated area is measured by the physical location of a certain plot on the farm which has the well. Since wells have a limited supply of water, the

total possible irrigations per acre is estimated for each season. Thus, in respect to irrigation, there are two restrictions; first, the acres of the plot which has the well or is in the command area of state tube well, and second, the number of irrigations that are possible in each season.

Cash Expense Restrictions (Operating Capital)

Generally, operating capital is a limiting factor in Indian agriculture and is said to be inhibiting many inexpensive improvements. In this study, the cash expenses were used as an indication of the amount of operating capital.

The selected sample did not show cash to be very limiting. None of the farmers in the sample were anxious to take a loan from the cooperative. The farms sampled averaged around twenty acres and were relatively well off. For the purpose of this part of the study, a restriction on funds available for cash expenses was set equal to that actually spent for crop production during the year of inquiry, 1967-68. Subsequently, different levels of cash expenses were tried. The coefficient for cash expenses included all expenses made by the farmer, namely (1) Hired labor charges, (2) Value of seed purchased, (3) Value of fertilizer or manure purchased, (4) Other cash expense.

Prices Used in Programming

The prices used in the programming were those that had been actually received by the farmers and were higher than the levy prices announced by the government. A farmer who had not sold his crops at the time of the inquiry was asked to quote the price that he would receive if he were to sell his produce on that day.

Net Income Definition

The net income has been defined as the gross income less the actual cash expenses incurred in raising an acre of crop. The cost of cultivation does not include the value of any inputs not purchased. The gross income per acre is the total yield (sold and home consumed) multiplied by the price received. The net income is relatively higher than what it would have been if noncash inputs were also included in the cost.

Resources and Activities For Model Farms

The resources of the model farms in each technological category and the crop activities considered for programming are shown in Tables 20 and 21.

Table 20. Resources Available and Essential Supplies, by Technological Categories
172 Farms, Jabalpur District (M.P.), India, 1967-68

Resources and Supplies	Category			
	Traditional		Advanced	
	1	2	3	4
	Unirrigated	Irrigated	Unirrigated	Irrigated
Resources				
Land unirrigated (acres)	18.14	19.81	24.35	17.03
Land irrigated (acres)	--	4.85	--	6.02
Total Acres of Crop	23.62	31.57	29.02	32.92
Irrigations Kharif(No.)	--	12.66	--	21.00
Irrigations Rabi (")	--	8.59	--	15.67
Irrigations Summer(")	--	0.66	--	0.60
Cash Expenses (Rs.)	727.05	1,339.10	1,464.60	1,922.10
Supplies				
Cereals (Kg.)	1,081.00	1,236.29	1,187.5	1,129.46
Pulses (Kg.)	372.60	387.03	362.50	292.81
Straw (Kg.)	48.50	53.70	55.40	5,028.00

Table 21. Net Income from Activities Considered, for Each Technology,
172 Farms, Jabalpur District (M.P.), India, 1967-68

Activities	Category			
	Traditional		Advanced	
	1	2	3	4
	Unirrigated	Irrigated	Unirrigated	Irrigated
	Net Income (Rs.)			
Wheat(dwarf) irrigated	--	--	--	693
Wheat(local) irrigated	--	369	--	463
Wheat(local) unirrigated	255	240	414	437
Paddy(dwarf) irrigated	--	--	--	630
Paddy(dwarf) unirrigated	--	--	--	323
Paddy(local) irrigated	--	247	--	348
Paddy(local) unirrigated	156	152	230	194
Masoor irrigated	--	288	--	288
Masoor unirrigated	211	221	203	245
Gram irrigated	--	278	--	203
Gram unirrigated	141	177	186	146
Pea irrigated	--	322	--	204
Pea unirrigated	266	103	302	261
Vegetable irrigated	--	334	--	464
Jowar unirrigated	117	120	117	60
Arhar unirrigated	174	222	222	55
Urid Moong unirrigated	97	--	97	--
Lesser millets unirrigated	--	158	--	--

Programming Results With Existing Resources and Response Coefficients

The validity of a linear programming solution for profit maximization depends on realistic coefficients and activities. These should be in conformity to real life. For the present study only those activities have been included which were actually grown by the farmers of the sample in 1967-68. For coefficients, also, the average of the sample for each category has been used. The validity of the optimality of the programmed solution will depend upon how realistic are the assumptions which have been made. For instance, the farmers when they planned their cropping scheme, did so on the basis of expectation and, hence, had to face risk and uncertainty about price, weather, and yield. This is not the case for the programmed solution of this study. As such, while evaluating the gains made by the optimization procedure, allowance should be made for this limitation.

Category 4

The program obtained by the above procedure is shown for the category 4 farms in Table 22.

Table 22. Crop Plan: Actual 1967-68 and Programmed for Irrigated Advanced Technology 55 Category 4 Farms, Jabalpur District (M.P.), India

Crop	Programmed	Actual 1967-68
	Acres	
Wheat(dwarf) irrigated	—	3.03
Wheat(local) irrigated	6.02	2.04
Wheat(local) unirrigated	15.91	11.55
Paddy(dwarf) irrigated	6.02	.54
Paddy(dwarf) unirrigated	1.98	.35
Paddy(local) irrigated	—	1.93
Paddy(local) unirrigated	—	7.66
Masoor irrigated	—	
Masoor unirrigated	—	1.63
Grain irrigated	—	.14
Grain unirrigated	—	2.3
Pea irrigated	—	.02
Pea unirrigated	1.11	.83
Vegetables irrigated	—	.25
Jowar unirrigated	—	.40
Arhar unirrigated	—	.25

The total net income by programming comes to Rs. 14473 as against Rs. 11803 from the actual average for this category in the sample. This is an increase of Rs. 2670 or 22 percent. The actual crop plan was diversified with nine crops whereas the programmed plan leads to specialization and takes only three crops. The program was drawn with the constraint that it should not exceed the actual average cropped acres of 32.92 acres. The program, however, used only 31.05 acres of land; thereby the intensity of cropping was reduced but the net income increased. The degree of specialization would have gone still further if the restriction of growing pulse was not imposed, as is apparent by the minimum acreage devoted to produce the necessary pulse. In the use of irrigated area the actual plan used only 7.95 acres of irrigated land whereas the programmed plan used up all the irrigated land in both seasons totalling 12.04 acres.

Most of the gain in income was brought by dwarf paddy. The local varieties of paddy had low returns and were dropped. The existing crop plan had less than an acre of dwarf paddy, because it had just been introduced and very few farmers could obtain the seed. Presumably as seed becomes more readily available, the acreage of dwarf paddy will increase rapidly. The rest of the gain in income was due to expansion of wheat area which had given better returns relative to other crops due to unusually good rains, and because wheat was fertilized in this group of farms. The area from all other crops was withdrawn except the minimum necessary to meet the self-sufficiency requirement of pulses.

Category 2

The programmed crop plan for traditional irrigated farms selects as many as five crops as against only three in the case of advanced irrigated farms, which shows that under traditional system the degree of specialization is less (Table 23). However, the crops grown under the program are less than the actual nine crops in 1967-68 on this sample of farms.

The total net income from the programmed crop plan comes to Rs. 8092 as against the actual of Rs. 7169 or a gain of Rs. 923 which is 12 percent higher than the actual. The programmed crop plan slightly reduces the vegetable acres but finds the crop competitive as against the advanced farms in which case the vegetable crop is completely eliminated. In every other selected crop the acreage has been increased. The crops of masoor, gram, arhar and jowar are eliminated.

Category 3

Four crops are grown as against five in the actual set of farms in the category for unirrigated advanced technology farms in 1967-68 (Table 24).

Table 23. Crop Plan: Actual 1967-68 and Programmed Under Irrigated Traditional Technology 27 Category 2 Farms, Jabalpur District (M.P.), India

Crop	Programmed	Actual
Wheat local irrigated	3.74	3.37
Wheat local unirrigated	19.81	11.17
Paddy local irrigated	4.32	2.5
Paddy local unirrigated		5.89
Masoor irrigated		.26
Masoor unirrigated		2.52
Gram irrigated		.33
Gram unirrigated		2.54
Pea irrigated	1.11	.08
Pea unirrigated		.74
Vegetables irrigated	.74	.92
Jowar unirrigated		.09
Arhar unirrigated		.54
Lesser millets unirrigated	1.84	.62

Table 24. Crop Plan: Actual 1967-68 and Programmed Under Unirrigated Advanced Technology 21 Category 3 Farms, Jabalpur District (M.P.), India

Crop	Programmed	Actual
	Acres	
Wheat local unirrigated	23.13	15.45
Paddy local unirrigated	4.59	7.38
Masoor unirrigated		2.57
Gram unirrigated		3.29
Pea unirrigated	1.21	.33
Jowar unirrigated		
Arhar unirrigated		
Urid-Moong unirrigated	.07	

The total net income from the program comes to Rs. 11001 whereas the actual average income in this category was Rs. 9735 or a gain of Rs. 1266 which is 13 percent above the actual. The gain was mainly because the programmed plan diverts land to wheat and completely eliminates masoor and gram crops. The requirement of pulses was met by increasing the pea crop from .33 acres to 1.21 acres plus .07 acres of urid-moong crop.

Category 1

The programmed crop plan for unirrigated traditional technology farms includes only three crops as against eight actually grown on the sample of these farms in 1967-68 (Table 25).

Table 25. Crop Plan: Actual 1967-68 and Programmed Under Unirrigated Traditional Technology
69 Category 1 Farms, Jabalpur District (M.P.), India

Crop	Programmed	Actual
	Acres	
Wheat local unirrigated	6.64	10.17
Paddy local unirrigated	5.48	5.67
Masoor unirrigated		1.96
Gram unirrigated		4.16
Pea unirrigated	11.49	.26
Jowar unirrigated		.38
Arhar unirrigated		.18
Urid-moong unirrigated		.82

The largest area was devoted to one of the unimportant pulse crops, namely pea, which was due to the fact that this year there were unusually good rains in the winter season which were beneficial to this crop. The actual area under this crop averaged only .26 acres per farm, whereas the programmed crop plan allots 11.49 acres. In terms of cost of growing this crop it had about the same cost as other pulse crops; however, the price of the crop was Rs. 1.05 per kilogram, and hence gave a net income better than the wheat crop which is usually the most profitable crop. Net income was increased in the programmed solution by only 10 percent.

Changes in Crop Pattern

On examination of the crop plans suggested by the programs in all the categories, it is evident that the programming procedure has selected fewer crops than were actually grown in that category of farms in 1967-68 (Table 26). For all four technological categories, the programmed crop plan completely eliminates the three pulse crops, i.e., masoor, gram and arhar.

In respect to wheat the four categories allocate 57.78 acres in the actual crop plan which had 3.03 acres of dwarf wheat. The programmed crop plan does not find dwarf wheat competitive and allocates 9.76 irrigated acres to local wheat as against 6.41 in the actual plan. The unirrigated and total area under wheat is increased.

Table 26. Crop Pattern: Actual 1967-68 and Programmed
172 Farms, Jabalpur District (M.P.), India

Crops	Actual Acres	Actual Percent	Programmed Acres	Programmed Percent
Wheat(dwarf) irrigated	3.03			
Wheat(local) irrigated	6.41		9.76	
Wheat(local) unirrigated	48.34		65.44	
Total Wheat	57.78	49.0	75.25	66.0
Paddy(dwarf) irrigated	.54		6.02	
Paddy(dwarf) unirrigated	.35		1.98	
Paddy(local) irrigated	4.43		4.32	
Paddy(local) unirrigated	26.60		10.07	
Total Paddy	31.92	27.0	22.34	19.5
Masoor irrigated	.26			
Masoor unirrigated	8.68			
Total Masoor	8.94	7.5		
Gram irrigated	.47			
Gram unirrigated	12.29			
Total Gram	12.76	11.0		
Pea irrigated	.10		1.11	
Pea unirrigated	1.73		13.91	
Total Pea	1.83	1.5	15.02	13.0
Total Vegetables	1.17)			
Total Jowar	.87)			
Total Arhar	.97)	4.0		
Total Urid-Moong	.82)		.07	
Total Lesser Millets	.62)		1.84	1.5

In respect to paddy the actual plan had only .89 acres under dwarf varieties, but the program devotes the entire irrigated acres in category 4 to dwarf paddy and increases unirrigated paddy to 1.98 acres. The programmed plan reduces unirrigated and total paddy area.

Thus in aggregate the existing cropping had 76 percent area for wheat and paddy. The program increased it to 85.5 percent indicating a shift of 9.5 percent of the area from other crops to wheat and paddy. Particularly the shift to wheat may be dictated by the extremely favorable weather of 1967/68. The farmers generally included a variety of pulse crops to meet the uncertainty of weather and variability of prices.

Since these risks and uncertainties were not accounted for in programming the solution, the above shift was indicated. A greater shift to new paddy varieties was not possible in actual practice because of the unavailability of seeds in 1966-67.

Net Income Increase

The total net income increase by programmed allocation of resources in the four categories of farms ranges from 10 to 22 percent (Table 27).

Table 27. Net Income: Actual 1967-68 and Programmed 172 Farms, Jabalpur District (M.P.), India

Category	Actual Income	Programmed Income	Net Gain	Percent Change
		Rupees		
1 Traditional unirrigated	5089	5603	514	10
2 Traditional irrigated	7169	8092	923	12
3 Advanced unirrigated	9735	11001	1266	13
4 Advanced irrigated	11803	14473	2670	22

The most important variation in circumstance between actual farm decision-making conditions and that of the program is with respect to knowledge of weather. The program coefficients reflect the weather which actually occurred whereas farmers must have felt considerable uncertainty with respect to weather. With these assumptions, the maximum income increase shown by programming was observed on the advanced irrigation farm. The minimum increase in income was seen on the unirrigated traditional farm with an increase of about 10 percent, followed by traditional irrigated and advanced unirrigated farms with increases of 12 and 13 percent respectively. The increase of income by 10 to 13 percent as obtained by linear programming procedure is hardly of economic significance in light of the weather and other sources of uncertainty.

On category 4 farms the rise in income was large. A 22 percent change in programmed income from the actual suggests that there is undoubtedly some disturbing factor in their allocation of resources. A comparison of the crop plans of actual and programmed shows the difference. On the actual farm 3.03 acres of land had been allocated to dwarf wheat, whereas the programmed allocation did not bring this crop in the solution. Growing of dwarf wheat and dwarf paddy were new to these farms and hence cost of cultivation was high because the dwarf variety seed had to be purchased at a price, whereas for other crops the seed was locally produced. Since growing of these two crops is a new experience, the farmers have not yet attained a high degree of efficiency.

Although there were many farmers who obtained high yields, there were some who had only modest increases. The growing of these crops requires a higher degree of management and skill. In subsequent years when the farmer will have his own seed and has gained experience the cash cost will decrease and the yields would be higher to make the crop more competitive. One acre of dwarf wheat required 40 kilograms of seed, but all the farmers did not buy it. Some had it from previous years and others had to buy. Roughly half the farmers had to buy dwarf wheat. In other words, the cash cost of Rs. 115.8 was inclusive of this Rs. 20 this year but will not be so next year. Thus, for the purpose of programming the net income per acre would increase by Rs. 20. Since the shadow price of dwarf wheat was only Rs. 18.22 above its present price, its inclusion in the optimal solution is certain if adjustment is made for this component of cost. In addition cash cost restriction may not be felt. Thus the farmers really have not violated the optimal allocation and they may have taken this fact into account while growing this crop. Thus allocating acres of dwarf wheat according to its present price considering that the present high cost was only for the initial years, cannot be considered nonoptimal.

Apart from noninclusion of dwarf wheat, the inclusion of 6.02 acres of irrigated dwarf paddy as against 0.54 in the actual plan greatly increased the income of the programmed solution. Since dwarf paddy was a new introduction, there was not sufficient seed available for all farmers to enable them to grow this crop at the desired level and hence this restriction should have been imposed on the program to determine a realistic program. Accordingly a new programmed solution was derived with the restriction that dwarf paddy cannot be grown more than what was actually grown in the existing plan. The revised programmed net income not only comes closer to the existing income but also the crop pattern includes the dwarf wheat which was left out in the previous programmed plan. Table 28 compares the two programmed plans with the existing plan.

Table 28 shows that when the programmed plan was not allowed to grow more dwarf paddy than the actual, the programmed income was only 14 percent higher than the existing income. This increase of 14 percent in income was also due to withdrawal of acreage from pulse crops to wheat and increase in irrigated paddy which had shown better performance due to less than normal distribution of rain this year. In a normal year the difference in yield of local paddy between irrigated and unirrigated is not much.

Thus most of the apparent nonoptimality of the advanced irrigated farm is explained by the presence of pulse crops and lack of adequate irrigated paddy. The dwarf paddy crops show high marginal value product. An acre of dwarf irrigated paddy could raise the net income by Rs. 233. This shows substantially in advanced technology the unavailability of modern inputs can greatly retard the income raising potential.

Taking the sample as a whole the average net income could be increased by 12 percent and most of this increase would be confined to the

Table 28. Crop Plan: Actual 1967-68 and Programmed Without and With Dwarf Paddy Restriction 55 Category 4 Farms, Jabalpur District (M.P.), India

Crop	Actual plan	Programmed without restriction on dwarf paddy	Programmed with restriction on dwarf paddy
Wheat(dwarf) irrigated	3.03		2.3
Wheat(local) irrigated	2.04	6.02	
Wheat(local) unirrigated	11.55	15.91	17.03
Paddy(dwarf) irrigated	.54	6.02	.54
Paddy(dwarf) unirrigated	.35	1.98	.35
Paddy(local) irrigated	1.93		5.48
Paddy(local) unirrigated	7.66		3.48
Masoor irrigated			
Masoor unirrigated	1.63		
Gram irrigated	.14		
Gram unirrigated	2.3		.97
Pea irrigated	.02		
Pea unirrigated	.83	1.11	
Vegetables irrigated	.25		
Jowar unirrigated	.40		
Arhar unirrigated	.25		
Net Income (Rs.)	11,803	14,473	13,552
% Increase in Income		22	14

advanced irrigated farms which are in a state of disequilibrium due to the recent introduction of dwarf varieties of wheat and paddy. If it is assumed that in a couple of years the farmers have adjusted to the new crops, then their allocation would become such as to allow income increases of 10 to 12 percent by a programmed solution which is drawn under perfect knowledge and certainty. Thus, the logical conclusion is that the farms in the sample on an average are allocating their resources close to the optimum and the extent of gain by a sophisticated programmed allocation is insignificant under the pattern of existing resources.

Table 29 shows the comparative marginal values of limited resources on these four categories of farms under the basic assumptions set forth above.

The cash expenses in category 1 are not a limitation as shown by zero marginal value product (Table 29). Similarly on category 2 farms the limitation of cash is very slight. Both of these categories are traditional and have adjusted to the requirements of cash through a long period of experience. On category 3 farms every additional rupee brings

Table 29. Marginal Value Product of Resources
172 Farms, Jabalpur District (M.P.), India, 1967-68

Item	Categories: Traditional 1 Unirrigated	Traditional 2 Irrigated	Advanced 3 Unirrigated	Advanced 4 Irrigated
	Rupees			
Cash Expenses	0	0.38	2.01	4.65
Irrigated rabi land	—	97.93	—	172.71
Irrigated kharif land	—	69.69	—	157.91
Irrigated summer land	—	0	—	0
Unirrigated rabi land	99.70	74.68	221.33	210.15
Unirrigated kharif land	0	0	0	0
Total crop acre	165.87	153.05	93.75	0
Rabi irrigations	—	50.72	—	0
Summer irrigations	—	23.23	—	0

back a net income of Rs. 2.01 and here cash expansion is clearly indicated. These farms have moved from traditional technology and are in the process of adjustment.

A good response to fertilizer in a favorable rainy year required more cash expenses than what had been actually used. Similarly on category 4 farms the cash expenses seem to have been very limited and the possibility of great income increases by expanding cash expenses were indicated by marginal value product of Rs. 4.65 for every additional rupee. In this category the potential of advanced technology comes into full play. The dwarf varieties require much higher cash expenses than what had actually been spent on these farms. Since the present cash expenses were short of this requirement, a very high marginal value product of Rs. 4.65 was obtained. In both categories of advanced technology the need for expanding cash expenses is clearly indicated for the development of full potential for income increases.

The second important limitation is the restriction of total crop acres. On category 1 the marginal value product of total crop acres was highest with Rs. 165.87. These farms had a higher intensity of cropping than the category 3 unirrigated farms, as this was the only way that the category 1 farms could increase their net income. The irrigated traditional (category 2) farms also had a fairly high marginal product for total crop acres as shown by Rs. 153. In spite of this, these farms had a lower intensity of cropping than the unirrigated traditional farms which may indicate their concern to conserve fertility by keeping low intensity of cropping. The total crop acres had marginal value product of Rs. 93.75 on category 3 farms suggesting expansion of cropping intensity as the logical course for these farms. The cropping

intensity on category 4 farms was already 142 percent. The marginal value product of total land acres is zero.

A very important resource is rabi and kharif land, but is not considered for expansion because of the difficulty of increasing the size of holdings because of heavy pressures of population. However, category 3 shows the highest marginal value product for unirrigated rabi land, showing that these farms make better use of unirrigated land than even the category 4 farms which represented the highest technological category. This is mainly due to the fact that on category 4 farms major attention is on irrigated land.

CHAPTER IV

EFFECT ON FARM ORGANIZATION AND INCOME OF RESOURCE EXPANSION

Seven Alternative Resource Restraints

In order to find the most feasible program for increasing income seven situations will be examined, as follows: (1) no change in resources from the bench-mark situation presented in Chapter III; (2) a 10 percent increase each in cropping, cash expenses and irrigated area; (3) a 25 percent increase in cropping and irrigated land plus cash expense increase of 10 percent; (4) 10 percent increase in cropping and irrigated land plus 25 percent increase in cash expenses; (5) a 25 percent increase in cropping and irrigated area plus 25 percent increase in cash expenses; (6) a 25 percent increase in cropping irrigated land and 50 percent increase in cash expenses; (7) a 50 percent increase in irrigated area and cropping plus 50 percent increase in cash expenses.

In all seven situations increase in irrigated area by a certain percentage is accompanied by increase in the number of irrigations by the same percentage. The above situations can be viewed either as an average for the sample over a period of time for the purpose of planning or may be viewed as individual applications for a particular farm or group of farms at a point of time. For unirrigated farm situations 6 and 7 may not apply. The above situations allow the total holdings to remain the same, but permits the cropped area to increase either by more irrigated area or more cropping or both.

Programmed Income (category 4)

The programmed incomes for various situations described above are shown in Table 30 for the advanced irrigated farms in category 4. As shown in Table 30 there was not much difference between situations 2 and 3, which have cash expenses 10 percent above the present use as common, but in situation 3 the cropping and irrigated area is 15 percent more than situation 2. The income gain difference between the two is only one percent.

In situations 4 and 5 the cash expenses were equal at 25 percent above the present use and the difference again lies in cropping and irrigated land. In situation 4 cropping and irrigated area was 10 percent above the present use while in situation 5 it was 25 percent above the present use. Once again the difference in net income gain was only two percent.

Table 30. Net Income: Actual and Programmed With Resource Expansion on Advanced Irrigated Farms 55 Category 4 Farms, Jabalpur District (M.P.), India, 1967-68

Situations	Actual Income	Programmed Income	Gain
	Rupees		Percent
1 No change in resources	11,803	14,473	22
2 10% more cropping, 10 % more cash, 10% more irrigated area		15,439	30
3 25% more cropping, 10% more cash, 25% more irrigated area		15,547	31
4 10% more cropping, 25% more cash, 10% more irrigated area		16,747	41
5 25% more cropping, 25% more cash, 25% more irrigated area		16,888	43
6 25% more cropping, 50% more cash, 25% more irrigated area		18,880	60
7 50% more cropping, 50% more cash, 50% more irrigated area		19,305	63

Between situations 6 and 7 which have common expenses of 50 percent above present use and call for 25 percent more cropping and irrigated area, the gain in income difference between the two was only three percent.

There is immense scope on these farms to make big income increases not only by optimal allocation of the existing resources but also by expanding the present resources as shown in the above table. In comparing situations 2 and 3 or 4 and 5 it was found that when cash expense was common the difference in net income was not significant, which indicates that the real contributing factor to raising net income was the cash expense. This is supported by the marginal value product of cash expense which remains above Rs. 4 for all situations except 6 where cash expense was expanded by 50 percent as is shown in Table 31 of marginal value products of limited resources under different situations. In situation 6 the crop intensity is raised only by 25 percent whereas cash is raised by 50 percent and hence the M.V.P. of cash expenses drops considerably.

Programmed Income (category 3)

As indicated earlier the present allocation of resources by the average farm though not optimal is quite near optimal, because the programmed income is only 13 percent above the actual income. Since the financial position of the advanced unirrigated farmers is good, the

Table 31. Marginal Value Products With Resource Expansion on Advanced Irrigated Farms 55 Category 4 Farms, Jabalpur District (M.P.), India, 1967-68

Situations	Cash Expense	Land: Kharif Irrigated	Land: Rabi Unirrigated	Land: Rabi Irrigated
	Marginal Value Product in Rupees			
1 No change in resources	4.65	157	210	172
2 10% more cropping and 10% cash 10% more irrigated area	4.65	157	210	172
3 25% more cropping and 10% cash 25% more irrigated area	4.65	157	210	172
4 10% more cropping and 25% cash 10% more irrigated area	4.30	168	203	170
5 25% more cropping and 25% cash 25% more irrigated area	4.65	157	210	172
6 25% more cropping and 50% cash 25% more irrigated area	1.49	259	144	—
7 50% more cropping and 50% cash 50% more irrigated area	4.65	157	210	172

possibility of increase in cash expenses together with increase in intensity of cropping may offer substantial gains in net income. Table 32 shows the changes of net income under various situations described before.

As indicated in Table 32, the big potential for increase in income lies in increasing the intensity of cropping whereas cash expense increase does not seem to be sufficiently remunerative. For example, situations 2 and 3 which differ in cash expenses by 15 percent have a difference of net income of only 1 percent. On the other hand, situations 2 and 4 differ only in cropping intensity of 15 percent with a net income difference of about 5 percent, which also does not seem to be very attractive. Situations 2 and 5 differ by 15 percent both in crop intensity and cash expenses with a corresponding net income increase of 9 percent from the programmed income of situation 2 and a total gain of 27 percent from the present actual income. Thus it would be logical to expect that the feasible expansion would be either situation 2 which increases net income by 18 percent or if the intensity of cropping can be raised by 25 percent, then it would be prudent to go directly to situation 5 which increases the present income by 27 percent.

Table 32. Net Income: Actual and Programmed With Resource Expansion on Advanced Unirrigated Farms 21 Category 3 Farms, Jabalpur District (M.P.), India, 1967-68

Situation	Actual Income	Programmed Income	Percent Change
		Rupees	
1 No change in resources	9,735	11,001	13
2 10% more cropping and 10% cash		11,568	18
3 25% more cropping and 10% cash		11,675	19
4 10% more cropping and 25% cash		11,914	23
5 25% more cropping and 25% cash		12,419	27
6 25% more cropping and 50% cash		12,676	30
7 50% more cropping and 50% cash		13,806	41

On unirrigated farms it may not be possible to raise the intensity of cropping by more than 25 percent and hence the only situation which can be reached is situation 6 which gives about 3 percent more net income than situation 5. In other words, the income increasing possibilities on category 3 farms are very limited, primarily because these farms are operating at near optimal allocation of resources.

The above inference is supported by the marginal productivities of land and cash expenses. In most of the situations stated above the marginal productivity of either rabi land or total land remains above Rs. 200. In situations 3 and 6 cash expenses are shown in slack and their marginal value product is zero. Even in situation 5 where intensity of cropping has been raised by 25 percent the rabi land had a marginal value product of Rs. 93.75. The restriction of total crop acres is most acutely felt when cash expenses are in slack activity such as in situations 3 and 6 when its marginal value product was Rs. 230.21.

Thus the real potential change in income for this category lies in its change in cropping intensity. The other possibility lies in further technological change such as use of higher rates of fertilizer per crop acre or introduction of dwarf varieties of wheat and paddy, which is the logical direction for this category of farm. This possibility has not been considered because none of the farmers have grown dwarf wheat or paddy. Thus for the present, this category can raise its income by 13 percent by optimal allocation and another 14 percent by raising its intensity of cropping and cash expenses by 25 percent. In case some farmers feel that they are willing to take more risk and are prepared to raise the intensity of present cropping by 50 percent, situation 7 indicates that net income could be increased by 41 percent if cash expenses are also raised by 50 percent.

Programmed Income (category 1)

The programmed allocation in category 1 farms resulted in a net income increase of only 10 percent which shows that this category of farms is nearest to optimal allocation. The possibility of increasing the net income in the present technology are extremely limited. As it is, its intensity of cropping is high, and the cash expenses in the program have been shown in slack.

However when its resources both cash expenses and crop acres are increased by 10 percent the programmed income indicated 17 percent more income than the present actual. The cash expenses once again appear in slack indicating zero marginal value product. That is the best that can be expected in category 1 farms.

Any further expansion of crop acres may not be feasible. In case the farmers are willing to take that much risk and are prepared to raise the intensity of cropping by 25 percent, then with only 10 percent additional cash the present income can be raised by 23 percent or if the cash expenses are also raised by 25 percent, then the net income could rise by 28 percent. However with 25 percent more cropping and 50 percent more cash expenses the net income increased by 29 percent, a rise of only one percent at the cost of 25 percent increase in cash expenses. Hence the most likely change that could be brought about is situation 2 in which net income is raised by 17 percent from the actual with only 10 percent more cash and cropping. In Table 33 the gain in income for different situations is reported.

Table 33. Net Income: Actual and Programmed With Resource Expansion on Unirrigated Traditional Farms 69 Category 1 Farms, Jabalpur District (M.P.), India, 1967-68

Situations	Actual Income	Programmed Income	Percent Change
		Rupees	
1 No change in resources	5,089	5,603	10
2 10% more cropping and 10% cash		5,994	17
3 25% more cropping and 10% cash		5,994	17
4 10% more cropping and 25% cash		6,266	23
5 25% more cropping and 25% cash		6,516	28
6 25% more cropping and 50% cash		6,582	29
7 50% more cropping and 50% cash		7,299	43

Programmed Income (category 2)

The gain in net income by programmed allocation was found to be 12 percent in the case of traditional irrigated farms. The above increase in income does not show much promise in programmed allocation within the existing resources. Looking to the present intensity of cropping, this category of farms shows that there is sufficient room for enlarging the cropped acres. Cash expenses can also be easily increased. Thus it would be appropriate to examine the programmed allocations and the resultant gain in net income under various situations described earlier. In Table 34 the changes in net income in the above situation are reported.

Table 34.Net Income: Actual and Programmed With Resource Expansion on Traditional Irrigated Farms 27 Category 2 Farms, Jabalpur District, (M.P.), India, 1967-68

Situations	Actual Income	Programmed Income	Percent
	Rupees		
1 No change in resources	7,169	8,092	12
2 10% more cropping and 10% cash 10% more irrigated area		8,717	21
3 25% more cropping and 10% cash 25% more irrigated area		9,577	33
4 10% more cropping and 25% cash 10% more irrigated area		8,949	24
5 25% more cropping and 25% cash 25% more irrigated area		9,655	34
6 25% more cropping and 50% cash 25% more irrigated area		9,784	36
7 50% more cropping and 50% cash 50% more irrigated area		11,217	56

It can be seen from Table 34 that situation 3 which requires only 10 percent rise in cash expenses and 25 percent rise in cropping and irrigated acres raises the net income of the category by 33 percent more than the present income. Even situation 2 which requires only 10 percent more cash, cropping and irrigated acres raises income substantially by 21 percent, As indicated earlier these farms are at a relatively low intensity of farming and hence a 10 percent or even 25 percent more cropping and irrigated acres is within the possible range of expansion, with corresponding substantial increase in net income.

For this category of farms situations 4 and 5 are not relevant in that they call for higher level of resource allocation without commensurate returns. For example, situation 5 requires 15 percent more

cash expenses but causes net income to rise by only 1 percent more than situation 3. Similarly, situation 4 requires 15 percent more cash than situation 2 but the net income rises only 2 percent more than situation 2.

In case the cropping and irrigated area can be increased to 50 percent more, then it would be worthwhile to go to situation 7 which raises net income by 56 percent more than the present net income. Since such a large increase of cropping may not be possible, situation 3 may represent the logical goal for expansion which increases net income by 33 percent.

The Most Feasible Resource Expansion

Having examined the effect of expansion of resources under various situations on production and income, the most feasible situation of expansion was determined for each category of farms. A comparison of the potential of income increase in different categories according to the most feasible situation of expansion along with the net gain due to resource expansion is reported in Table 35.

Table 35. Gain in Income From the Most Feasible Situation to Expand 172 Farms, Jabalpur District (M.P.), India, 1967-68

Category and Situation	Gain in Income by Programming: With Expanded Resources	Gain in Income by Programming: With Same Resources	Net Gain by Resource Expansion
	Percent		
1 Traditional unirrigated 10% more cropping 10% more cash expenses	17	10	7
2 Traditional irrigated 25% more cropping and irrigated area 25% more cash expenses	33	12	21
3 10% more cropping 10% more cash expenses	23	13	10
4 25% more cropping and irrigated area 25% more cash expenses	60	14	46

In Table 35 it is shown that a substantial net gain on resource expansion occurs only on irrigated farms. On irrigated farms also, the largest net gain was found on advanced farms which was more than double the gain on traditional farms and is more than six times that of traditional unirrigated farms. On unirrigated farms the net gain on resource expansion was 7 and 10 percent only. This gain was calculated on the basis of an extremely favorable rabi season in 1967-68.

Programmed Cropping Pattern for the Sample

The cropping pattern of the sample is represented by the sum of the average acres grown by each category, so it can be compared with the sum of the programs derived for each category. This will indicate the change in cropping pattern which may be brought about by programming for the sample as a whole. Table 36 compares the programmed cropping pattern with the same resources, with 10 percent more resources, and with the actual cropping pattern.

The program with the same resources used less crop acres than the actual (Table 36). The same was true for the program with 10 percent more resources which could use 128.34 acres (116.68 plus 10 percent) but had used only 185.98 acres. The crops that were found noncompetitive; namely, dwarf wheat, masoor, gram, jowar, and arhar were not grown in the programs. These crops were grown on 26.57 acres in the actual crop plan, i.e. 22 percent of the area was under crops which were noncompetitive. In the competitive crops, wheat had 56.78 acres in the actual crop plan which was increased to 75.25 acres in the programmed crop plan with the same resources. When the resources were enlarged by 10 percent, wheat acreage was not expanded but was slightly reduced to 73.17 acres.

The acreage of paddy in the actual plan was 31.92 acres, which was reduced to 22.39 acres in the programmed crop plan with the same resources and was raised to 29.18 acres under program with 10 percent more resources. The reduction of acres under paddy is mostly confined to unirrigated local paddy. The dwarf paddy acres have been expanded under irrigated and unirrigated conditions in both the programs. The local irrigated paddy has been between four to five acres in actual and programmed. In other words, 16.53 acres of unirrigated paddy was under nonoptimal use together with 26.57 acres under noncompetitive crops. Thus, the total area under nonoptimal use comes to a little over 37 percent of the cropped acres.

The cropping pattern in actual and programmed in terms of percentage area under each crop is shown in Table 37.

Production With Expansion of Resources

In addition to changes in cropping pattern, it would be appropriate to see the effects of programming on the nature of production of various commodities and compare it with the existing production. In this respect,

Table 36. Cropping Pattern: Actual and Programmed 172 Farms, Jabalpur District (M.P.), India, 1967-68

Crops	Actual	Programmed: Same Resources	Programmed: 10 Percent More Resources
		Acres	
Wheat dwarf irrigated	3.03		
Wheat local irrigated	5.41	9.76	10.73
Wheat local unirrigated	48.34	65.49	62.44
Total Wheat	56.78	75.25	73.17
Paddy dwarf irrigated	.54	6.02	6.62
Paddy dwarf unirrigated	.35	1.98	3.75
Paddy local irrigated	4.43	4.32	4.56
Paddy local unirrigated	26.60	10.07	14.25
Total Paddy	31.92	22.39	29.18
Masoor irrigated	.26	--	--
Masoor unirrigated	8.68	--	--
Gram irrigated	.47	--	--
Gram unirrigated	12.29	--	--
Pea irrigated	.10	1.11	1.23
Pea unirrigated	1.73	13.91	15.77
	23.53	15.02	17.00
Vegetable irrigated	1.17	.74	1.01
Jowar unirrigated	.87	--	--
Arhar unirrigated	.97	--	--
Urid-Moong unirrigated	.82	.07	1.15
Lesser millets unirrigated	.62	1.84	4.47
Total	116.68	115.31	125.98

the sum of the average farms of each category produced 23,596 kilograms of wheat, 13,029 kilograms of paddy, 6,013 kilograms of pulses, 395 kilograms of millets, and 904 kilograms of vegetables during the year of inquiry. The change in production is shown in the following tables for each category.

As indicated in Table 37, the percentage increase in production by programming is relatively small even after increase of resources by 10 percent except in the case of advanced irrigated category, where it ranges from 22 to 24 percent.

Table 37.

Production: Actual and Optimum
172 Farms, Jabalpur District (M.P.), India, 1967-68

Crops	Tradition Unirrigated			Tradition Irrigated			Advanced Unirrigated			Advanced Irrigated		
	Actual Existing Resources	Existing Res.	10% more	Actual Existing Resources	Existing Res.	10% more	Actual Existing Resources	Existing Res.	10% more	Actual Existing Resources	Existing Res.	10% more
	Kilograms											
Wheat (dwarf) irrigated	—	—	—	—	—	—	—	—	—	2453	—	—
Wheat (local) irrigated	—	—	—	1396	1550	1703	—	—	—	1067	3150	3464
Wheat (local) unirrigated	2907	1898	1223	3015	5348	5216	7144	10741	10880	5614	7733	7442
Total Wheat	2907	1898	1223	4411	6898	6919	7144	10741	10880	9143	10883	10906
Paddy (dwarf) irrigated	—	—	—	—	—	—	—	—	—	598	6676	7341
Paddy (dwarf) unirrigated	—	—	—	—	—	—	—	—	—	208	1178	2231
Paddy (local) irrigated	—	—	—	1177	2035	2148	—	—	—	1226	—	—
Paddy (local) unirrigated	1807	1747	2499	1843	—	—	3332	2072	2894	2898	—	—
Total Paddy	1807	1747	2499	3020	2035	2148	3332	2072	2894	4930	7854	9572
Masoor irrigated	—	—	—	78	—	—	—	—	—	—	—	—
Masoor unirrigated	432	—	—	589	—	—	552	—	—	413	—	—
Gram irrigated	—	—	—	130	—	—	—	—	—	42	—	—
Gram unirrigated	867	—	—	782	—	—	896	—	—	482	—	—
Pea irrigated	—	—	—	28	388	430	—	—	—	05	—	—
Pea unirrigated	68	3031	3653	79	—	—	96	354	237	222	291	291
Arhar unirrigated	31	—	—	117	—	—	—	—	—	16	—	—
Urid-Moong unirrigated	88	—	—	—	—	—	—	08	123	—	—	—
Total Pulses	1476	3031	3653	1803	388	430	1544	362	450	1180	291	291
Vegetable irrigated	—	—	—	668	537	733	—	—	—	236	—	—
Jowar unirrigated	100	—	—	23	—	—	—	—	—	58	—	—
Less millets	04	—	—	210	625	1519	—	—	—	—	—	—
GRAND TOTAL	6294	6676	7375	10135	10483	11720	12020	13175	14224	15538	19028	20769
Percent increase	—	6%	17%	—	3%	16%	—	10%	18%	—	22%	34%

Effect of Variable Weather on Farm Organization

The above estimates of income increases with programming for resource expansion are based on the data of a very good rabi rainfall year. The cropping pattern suggested by the program shows a distinct swing of acreage to wheat with a corresponding reduction in pulses and paddy. The existing cropping pattern in general and that of traditional farms in particular shows substantial acreage under pulse crops which generally give good yields in bad rainfall years. It would, therefore, be appropriate to view the results of this programming for resource expansion with caution and examine the possible effect of different weather on cropping patterns and incomes.

Since the monsoons are known for their vagaries rather than normality and no two years are alike, three different weather situations were defined below for the purpose of examining the likely effects of differences in weather on the programs studied.

W. I: The net incomes per acre of irrigated wheat lower than 1967-68 by 10 percent and that of unirrigated wheat lower by 25 percent. The net income per acre of irrigated paddy higher by 25 percent and that of unirrigated paddy higher by 50 percent. All other crops remain unaffected. This would be likely if distribution of rainfall was normal.

W. II: The net incomes in wheat reduced as defined above but the irrigated paddy incomes higher by 10 percent and that of unirrigated paddy higher by 25 percent. All other crops remain unaffected. This would be likely if distribution of rainfall was favorable in kharif and normal in rabi.

W.III: The net incomes in wheat reduced as defined above but no change in paddy and all other crops remain unaffected. This would be likely if rainfall was normal for rabi and some moisture stress in kharif as was the case in 1967-68.

Under the above defined assumptions of weather new coefficients were assumed and a program was drawn for each category of farms.

Cropping Pattern and Income (category 4)

Tables 38 and 39 show the new programs for advanced irrigated farms (category 4) based on the different assumed weather conditions.

The optimal programs for advanced irrigated farms had little variation in the 4 different weather situations, both in respect to crop patterns and incomes (Table 38). In Weather I the programmed income was closest to actual income with a difference of only 12 percent. It

Table 38. Cropping Pattern: Actual and Programmed With Different Weather on Advanced Irrigated Farms 55 Category 4 Farms, Jabalpur District (M.P.), India, 1967-68

Crop	Actual Crop Plan 1967-68	Programmed Crop Plan 1967-68	W. I	W.II	W. III
		Acres			
Wheat dwarf irrigated	3.03	2.30	3.91	2.38	1.81
Wheat local irrigated	2.04	2.74		3.07	4.20
Wheat local unirrigated	11.55	17.03	13.61	15.91	15.91
Paddy dwarf irrigated	.54	.54	.54	.54	.54
Paddy dwarf unirrigated	.35	.35	.35	.35	.35
Paddy local irrigated	1.93	5.48	5.48	5.48	5.48
Paddy local unirrigated	7.66	3.48	5.60	4.06	3.37
Masoor irrigated					
Masoor unirrigated	1.63				
Gram irrigated	.14	.97			
Gram unirrigated	2.3				
Pea irrigated	.02				
Pea unirrigated	.83		3.41	1.11	1.11
Vegetable irrigated	.25	.01			.12
Jowar unirrigated	.40				
Arhar unirrigated	.25				

Table 39. Income: Actual and Programmed With Different Weather on Advanced Irrigated Farms 55 Category 4 Farms, Jabalpur District (M.P.), India, 1967-68

Income	Actual	Programmed	Change
	Rupees		Percent
Net Income: 1967-68	11,803	13,552	+ 14
Net Income: Weather I	11,805	12,411	+ 12
Net Income: Weather II	10,432	11,801	+ 13
Net Income: Weather III	9,780	11,375	+ 16

appears that the farmers may have planned the cropping with the expectation of this weather. This is supported by the optimal cropping pattern also inasmuch as it allocates greater acres to pulse crops with this weather situation, while in all other weather a minimum of acres needed to meet the pulse requirement was allocated.

The cropping pattern on these farms shows very little sensitivity to variations in weather and the profitability of crops shows a distinct dominance for cereals as against pulse crops. The fact that a number of pulse crops are grown by these farms may be because of diversification to insure against unexpected bad weather since these crops yield equally well under various weather situations. For instance, the weather of the 1967-68 programming led to only 14 percent increase in net income. Out of this 14 percent increase about half of the increase was attained by reorganization of cereal crops mostly by diverting unirrigated paddy to irrigated and the other half of the increase was by diverting pulse crops to wheat. In other words, the element of error in allocation was only 7 percent and the other 7 percent may be the cost of insurance for keeping more acreage under pulse crops than was provided in the optimized allocation. Thus the allocation of resources on these farms was not only optimal but can withstand great variations of weather.

Cropping Pattern and Income (category 2)

The existing and programmed cropping patterns and incomes in different weather situations for traditional irrigated farms (category 2) are reported in Tables 40 and 41.

Table 40. Cropping Pattern: Actual and Programmed With Different Weather on Traditional Irrigated Farms 27 Category 2 Farms, Jabalpur District (M.P.), India, 1967-68

Crop	Actual Crop Plan 1967-68	Programmed Crop Plan			
		1967-68	W. I	W. II	W. III
		Acres			
Wheat irrigated	3.37	3.74	3.74	3.74	3.74
Wheat unirrigated	11.17	19.81			
Paddy irrigated	2.5	4.32	4.85	3.47	3.12
Paddy unirrigated	5.89		10.00	1.84	
Masoor irrigated	.26				
Masoor unirrigated	2.52		1.84	1.84	1.84
Gram irrigated	.33				
Gram unirrigated	2.54				
Pea irrigated	.08	1.11	1.11	1.11	1.11
Pea unirrigated	.74				
Vegetables	.92	.74	.22	1.59	1.94
Jowar	.09				
Arhar	.54		9.8	17.97	17.97
Lesser millets	.62	1.84			1.84

Table 41. Income: Actual and Programmed With Different Weather on Traditional Irrigated Farms 27 Category 2 Farms, Jabalpur District (M.P.), India, 1967-68

Income	Actual	Programmed	Change
	Rupees		Percent
Net Income: 1967-68	7,169	8,092	+ 12
Net Income: Weather I	7,112	8,126	+ 13
Net Income: Weather II	6,768	7,911	+ 16
Net Income: Weather III	6,415	7,796	+ 20

In Table 40 it is seen that in Weather I the programming could have increased incomes by Rs. 34 only over 1967-68. However, it would have required a considerable change in cropping pattern. For instance, unirrigated wheat was completely dropped to bring an expansion of unirrigated paddy and arhar crops. The pulse crop acreage was raised to about 12 acres as compared to 1.11 acres in the program of 1967-68 or 7 acres in the existing plan. In the other two weather situations, the pulse crops assume a major importance as both wheat and paddy crops do not fare well.

It appears the farmers have correctly anticipated the weather of 1967-68 to be favorable to wheat, but as a caution have grown sufficient pulses to insure against the error in expectation. Since the weather proved to be extremely favorable to wheat, the existing allocation of 11 acres in unirrigated wheat fell short of the program which allocates the entire unirrigated area of 19.81 acres to wheat. The existing allocation is such that even if Weather I prevailed, the difference in either the existing or optimal income would not have made a big difference.

Perhaps these farms have allocated acres as an optimist for good weather, because they were closest to 1967-68 weather, inasmuch as they are only short of 12 percent from program. If the adverse weather of Weather II and Weather III had occurred, these farms would have been shorter by 16 percent and 20 percent respectively from programmed incomes. In other words, it shows the traditional irrigated farms' dependence on good weather as against the advanced irrigated farms which would have been more optimal in Weathers I and II.

Cropping Pattern and Income (category 1)

The existing and programmed cropping patterns and incomes in different weather for traditional unirrigated farms (category 1) are shown in Tables 42 and 43.

Table 42. Cropping Pattern: Actual and Programmed With Different Weather on Traditional Unirrigated Farms 69 Category 1 Farms, Jabalpur District (M.P.), India, 1967-68

Crop	Actual Crop Plan 1967-68	Programmed Crop Plan 1967-68	W. I	W. II	W. III
	Acres				
Wheat	10.17	6.64	5.47	6.64	6.64
Paddy	5.67	5.48	6.64	5.48	5.48
Masoor	1.96				
Gram	4.16				
Pea	.26	11.48	11.49	11.49	11.49
Jowar	.38				
Arhar	.18				
Urid-Moong	.82				
Lesser millers					

Table 43. Income: Actual and Programmed With Different Weather on Traditional Unirrigated Farms 69 Category 1 Farms, Jabalpur District (M.P.), India, 1967-68

Income	Actual	Programmed	Change
	Rupees		Percent
Net Income: 1967-68	5,089	5,603	+ 10
Net Income: Weather I	4,898	5,694	+ 16
Net Income: Weatner II	4,669	5,447	+ 16
Net Income: Weather III	4,439	5,231	+ 18

It is clearly shown in Table 42 that the programs in all kinds of weather are more or less the same. Eleven acres in pulse were maintained with marginal adjustments in wheat and paddy. The traditional unirrigated farms like the traditional irrigated farms were closest in optimization in a very good weather year only. As the weather became adverse, the nonoptimality increased and reached 18 percent in weather condition III. This shows that traditional farms are very vulnerable to bad weather. The unirrigated farms usually allocate large acreage to pulse crops and this was also suggested by the programs.

Cropping Pattern and Income (category 3)

The existing and programmed cropping patterns and incomes in different weather for advanced unirrigated farms (category 3) are shown in Tables 44 and 45.

Table 44. Cropping Pattern: Actual and Programmed With Different Weather on Advanced Unirrigated Farms 21 Category 3 Farms, Jabalpur District (M.P.), India, 1967-68

Crops	Actual Crop Plan 1967-68	Programmed Crop Plan 1967-68	W. I	W. II	W. III
	Acres				
Wheat	15.45	23.13		23.00	23.00
Paddy	7.38	4.59	18.84	4.67	4.67
Masoor	2.57				
Gram	3.29				
Pea	.33	1.21	10.17	1.34	1.34
Jowar	—				
Arhar	—				
Urid-Moong	—	.07			

Table 45. Income: Actual and Programmed With Different Weather on Advanced Unirrigated Farms 21 Category 3 Farms, Jabalpur District (M.P.), India, 1967-68

Income	Actual	Programmed	Change
	Rupees		Percent
Net Income: 1967-68	9,735	11,001	+ 13
Net Income: Weather I	8,978	9,578	+ 6
Net Income: Weather II	8,542	8,883	+ 4
Net Income: Weather III	8,106	8,613	+ 6

The advanced unirrigated farms as shown in Table 44 were closest to optimal in Weather II in which the programmed income would have been only 4 percent above their existing income. It appears that advanced farms tend to follow a cropping program with a view to being closer to bad weather rather than good weather. This may be due to the fact that the cash expenses on advanced farms are high and hence they may be trying to hedge against losses in bad weather.

Thus on the whole the traditional farms in the weather of 1967-68 were found to be closer to programmed incomes than the advanced farms. However the advanced farms had probably allocated resources in such a manner that if the weather turned out to be adverse, their losses would have been minimum. From the point of view of variable weather, the best allocation was made by the irrigated advanced farms which gain or lose at most by only 2 percent in any of the 4 weather situations. The un-irrigated advanced farms are on the other extreme where if the weather becomes adverse, they stand to gain only as compared to traditional farms which stand to lose only for any other weather than that of 1967-68.

CHAPTER V

IMPACT OF IRRIGATION AND TECHNOLOGICAL CHANGES

In India it is difficult to increase the area of land holdings in farms. Operating capital has some possibilities for expansion in the near future. The most promising possibilities for increasing production and incomes seem to be in the areas of irrigation and changes in technology.

The potentials for improving Indian agriculture through moderate expansion of resources were examined in Chapter IV. In this chapter the likely impact of changes in irrigation and technology will be investigated in detail.

Returns to Irrigation and Technology

The returns of the 172 sample farms in 1967-68 provide information on the existing situation as related to irrigation and technology. The linear programming for the four categories of farms, based on the sample farms, gives an indication of the possibilities with various changes in resource use. The comparative detailed study should provide guidelines for use in determining future changes in agricultural policy and in the organization of individual farms.

Irrigation Potentialities

The marginal value product, as determined by linear programming, of rabi land on irrigated traditional farms was Rs. 97.93 and on irrigated advanced farms it was Rs. 172.71. This would indicate that traditional farmers could afford to spend up to Rs. 97.93 for an acre of rabi irrigation water. In like manner, the advanced farmers could spend up to Rs. 172.71. This indicates that the marginal returns from irrigation on the advanced farms are 76 percent higher than on the traditional farms.

In considering the marginal value product for irrigation it would be an error to treat kharif and rabi irrigated land separately. When a farmer adds an irrigated rabi acre an irrigated kharif acre is automatically added, hence the marginal value products should be considered jointly. Thus an irrigated acre of traditional irrigated (category 2) land has a combined marginal value product of Rs. 167.62 and on advanced irrigated (category 4) the combined marginal value product of irrigated land is Rs. 330.62 and expansion of every acre under irrigation can be expected to increase net income by the above amount. In view of this joint consideration returns on the advanced irrigated (category 4) farms with an additional capacity of one acre of irrigation would be 97 percent higher than on the traditional irrigated (category 2) farms.

Since the returns to irrigation in traditional agriculture are only about half that of agriculture with advanced technology, investment in expansion of irrigated area may be slow and may not be possible if the annual cost of the expansion is higher than Rs. 167.62 per acre. However, in the case of advanced technology, more rapid expansion of irrigation capacity can be anticipated.

The above estimates were based on the marginal value product of irrigated land and applies to additional expansion only. If, however, a larger expansion of irrigated area were considered, it would be appropriate to estimate the returns on the basis of average value product of irrigated land over unirrigated land. Such an estimate would be relevant to the farms in the unirrigated categories also. A comparison of the average net returns per acre from irrigated and unirrigated areas on the basis of programming within the constraints of existing cash expenses are shown in Table 46.

Table 46. Net Returns Per Acre of Irrigated And Unirrigated Land 82 Irrigated Farms, Jabalpur District (M.P.), India, 1967-68

	Irrigated		Category Income Difference	Percent Difference in Income
	Category 2 Traditional	Category 4 Advanced		
	Rupees			
Average net income per irrigated acre	629	1,130	501	80
Average net income per unirrigated acre	249	452	203	82
Difference in net income due to irrigation	380	678	—	—
Percent difference in income due to irrigation	152%	150%	—	—

On the basis of average returns both categories of farms (2 and 4) had per acre incomes with irrigation about 150 percent higher than unirrigated acres. Thus within respective technologies the relative returns to irrigation were about equal even though the actual returns in advanced category 4 farms were much greater (Rs. 678 per acre versus 380). When returns are compared between technologies, the advanced category 4 farms gave 80 percent higher net returns per irrigated acre than the traditional category 2 farms (Table 46).

It is of interest to observe the difference in net return per acre for unirrigated traditional and irrigated advanced. The irrigated advanced category 4 net income per acre was Rs. 1,130 while the unirrigated

traditional category 2 was only Rs. 249 or the one was 354 percent more than the other. This shows the extent of scope for raising income if both the advanced technology and irrigation are introduced.

The average value of a well and pump reported by the sample farms was Rs. 3,554. Considering the depreciation and the rise of prices, an investment in the neighborhood of Rs. 6,000 may be required now for a well and electric pump (Rs. 4,500 for well and Rs. 1,500 for electric pump). The cost of oil pump is much higher and estimated to be about Rs. 4,500. The investment required for oil pump farmers may be about Rs. 9,000 including well. The average irrigated area on category 2 farms was 4.85 acres and hence returns were calculated on the basis of 4.85 acres of irrigated land. Given the above investment and using a 20 year life span for a well and 10 year life span for a pump, the estimated annual cost of irrigation per farm for two different modes of irrigation are shown in Table 47.

As indicated in Table 47 the annual cost of an oil pump is almost double that of an electric pump. The returns to irrigation differed greatly depending upon the mode of irrigation. The returns to irrigation also will be affected by the technology. The returns to irrigation in traditional and advanced technologies by the two modes of irrigation are reported in Table 48.

The rate of return on investment to provide irrigation with traditional technology was low compared to advanced technology. A 9 percent return from irrigation with an oil pump is not attractive enough to cause rapid expansion of irrigation. If electricity were made available to the farm, it would be more attractive with a 22 percent rate of return.

Table 47. Estimated Annual Cost of Irrigation by Electric Pump and Oil Pump Jabalpur District (M.P.), India

	Electric Pump	Oil Pump
	Rupees	
Depreciation on a well costing Rs. 4,500 with a 20 year life span	225	225
Depreciation on pump with 10 year life span (Cost of electric pump, Rs. 1,500; oil pump, Rs. 4,500)	150	450
Annual cost of servicing and running	100	300
Total annual cost	475	975

Table 48. Rates of Return From Irrigation Investment With Traditional and Advanced Technologies 82 Farms, Jabalpur District (M.P.), India, 1967-68

	Traditional Technology		Advanced Technology	
	Oil Pump	Electric Pump	Oil Pump	Electric Pump
	Rupees			
Additional net income from 4.85 acres of irrigation	1,843	1,843	3,288	3,288
Cost of irrigation	975	475	975	475
Net gai due to irrigation	868	1,368	2,313	2,813
Investment required	9,000	6,000	9,000	6,000
	Percent			
Rate of net return	9	22	25	47

The returns to irrigation are higher with advanced technology. The oil pump gives a 25 percent return and an electric pump shows a 47 percent return. The application of advanced technology appears to be closely related to the creation of irrigation facilities. It would seem that they are dependent on each other — and hence the question of technological change may be examined under irrigated and unirrigated conditions on these farms.

Shift from Traditional to Advanced Methods

Changes in Income

Computations were made to determine what the gain in net income might be if category 1 and 2 farms were to operate with the advanced technology of category 3 and 4 farms. These results are reported in Table 49.

The largest calculated potential gain in income was for category 2 farms, with a gain of 60 percent (Table 49). This gain was due to two factors, namely programming with existing resources and a change in technology. The programming gain was only 12 percent, thus the net gain from a change of technology was 48 percent. This assessment of gain by programming and technological change has an implicit assumption that the farmers have the necessary management skill to handle the interaction of change in resources and technology.

Table 49. Net Income: Actual 1967-68 and Programmed Under Traditional and Advanced Technologies 172 Farms, Jabalpur District (M.P.), India

Item	Category: Traditional 1 Unirrigated	Traditional 2 Irrigated	Advanced 3 Unirrigated	Advanced 4 Irrigated
	Rupees			
Actual Income 1967-68	5,089	7,169	9,735	11,803
Programmed Income:				
Traditional Technology	5,603	8,092	—	—
Advanced Technology	7,234	11,478	11,001	14,473
Gain in Income		Percent		
Traditional Technology	10	12	—	—
Advanced Technology	42	60	13	22
Gain by Technological Change	32	48	—	—

Technology offers substantial scope for traditional unirrigated farms in years of good rainfall. However, the element of risk due to adverse weather is more. For instance, the advanced unirrigated farms could have obtained an income of Rs. 11,001 during this favorable year, but if the rabi weather would have been adverse, i.e. Weather III, the programmed income would have gone down to Rs. 8,613 or a drop of about Rs. 2,400. It appears that these farms are aware of this risk and hence have followed a cropping pattern which is near programmed income in adverse weather. In other words, in order to remain in advanced technology, these farms have to plan for adverse weather and refrain from full returns of advanced technology. It is mainly because of this risk element that farmers are reluctant to adopt advanced technology on unirrigated farms.

Changes in Production

In years of good rainfall the unirrigated traditional farms (category 1) can register an increase of 24 percent (Table 50) in aggregate production if they come to the level of technology attained by the advanced unirrigated farms of the sample.

Under traditional technology, programming brought about gains in income by doubling the production of a pulse crop (peas), whereas when the technology was changed, two pulse crops and wheat production were

Table 50. Production Potential of Programs in Traditional and Advanced Technologies Compared With Actual on 69 Traditional Unirrigated Farms in Jabalpur District (M.P.) India With Existing Resources

Crops	Actual Production	Programmed Production Existing Resource: Traditional Technology	Programmed Production Existing Resource: Advanced Technology
		kg.	
Wheat local unirrigated	2907	1898	5326
Paddy local unirrigated	1807	1747	
Masoor unirrigated	432		
Grain unirrigated	867		
Peas unirrigated	68	3031	1885
Jowar unirrigated	31		
Urid-Moong Unirrigated	88		586
Total pulses	1476	3031	2421
Jowar unirrigated	100		
Lesser millets	4		
Total millets	104		
Grand Total	6294	6676	7797
% change in production	—	6%	24%

increased. The paddy crop became uncompetitive and was dropped from the program, while in traditional technology it was reduced only by 3 percent in production, but the wheat production was reduced by 35 percent.

Under the existing resources a technological change on irrigated traditional farms (category 2) can bring about a 41 percent increase in aggregate production as shown in Table 51.

The extent of gain in aggregate production by programming under traditional technology was only 3 percent which calls for heavy reduction in pulses and paddy production. The increase in production is confined to only wheat and lesser millets which were not considered important crops. However, tedhnological change brings about a general expansion except that vegetables and lesser millets were dropped. More than 50 percent increase in wheat, paddy and pulses were brought about.

Shift From Unirrigated to Irrigated Technology

Irrigation requires considerable fixed investment in digging a well and installation of a water lift. The average investment in wells with pump by the irrigated farms was Rs. 3,554 and the average expenditure for water lift was Rs. 2,712. Thus the total of Rs. 6,266 was reported. However, for future projection a greater investment would be required for two modes of irrigation and is reported in Table 49.

Table 51. Production Potential of Programs in Traditional and Advanced Technologies Compared With Actual on 27 Traditional Irrigated Farms in Jabalpur District (M.P.) India Within Existing and Expanded Resources

Crops	Actual Production	Optimal Production Existing Resources: Traditional Technology	Optimal Production Existing Resources: Advanced Technology
		kg.	
Wheat dwarf irrigated			
Wheat local irrigated	1396	1550	1957
Wheat local unirrigated	3015	5348	4816
Wheat total	4411	6898	6773
Paddy dwarf irrigated			4569
Paddy dwarf unirrigated			
Paddy local irrigated	1177	2035	
Paddy local unirrigated	1843		
Total paddy	3020	2035	4569
Masoor irrigated	78		
Masoor unirrigated	589		
Gram irrigated	130		333
Gram unirrigated	782		
Peas irrigated	28	388	
Peas unirrigated	79		2601
Tuar unirrigated	117		
Urid-Moong			
Total pulses	1803	388	2934
Vegetables irrigated	668	537	
Jowar unirrigated	23		
Lesser millets	210	625	
Total millets	233	625	
Grand Total	10135	10483	11720
% Change in Production		+ 3%	+ 41%

How much area will be irrigated will depend on the individual situation. There were two categories of irrigated farms with average irrigated area of 4.85 and 6.02 acres. For a safe and conservative estimate the lower figure can be assumed to hold true on an average for the above investment. Hence 4.85 acres of land can be irrigated by making the above investment. It was assumed that the farmers would be willing to increase their cash expenses by 25 percent on becoming irrigated farmers. Although the farms in the size group are in a position to increase their cash expenses by larger percentages, a conservative increase of 25 percent will hold good for the average. In respect to total crop acres an intensity of 142 percent of total cultivated area will be assumed because this intensity was attained by category 4 farms.

A similar investment would enable the category 3 farms to transform themselves to category 4 technology with 4.85 acres of irrigated land, 25 percent more of cash expenses and 142 percent of cropping. Accordingly, with this new resource structure the category 1 and 3 farms were programmed with the technological matrix of category 4 farms and the programs obtained are presented in the following pages to see the possible changes in income, crop pattern, and production which were open to these categories (Table 52).

Changes in Income

Table 52. Income: Actual and Programmed in Technological Change to Advanced Irrigated Technology (Category 4) 90 Category 1 and 3 Farms, Jabalpur District (M.P.), India, 1967-68

Category	Actual Income	Programmed Income	Percent Gain From Actual
		Rupees	
1 Traditional unirrigated	5,089	7,810	51
3 Advanced unirrigated	11,001	14,115	45

By creating irrigated area of 4.85 acres, using advanced technology and organizing according to the optimal program the category 1 farm could increase income by 51 percent. However only 9 percentage points of this was due to irrigation alone, which is not impressive. However, the low percentage rise attributed to irrigation is due to the year 1967-68 being a good rainfall year and also because the 25 percent rise in cash expenses may not be sufficient to meet the cost of irrigation and advanced technology as was suggested by the marginal value product of cash expenses which was found to be Rs. 6.24. The present level of cash expenses in this category was Rs. 725 and was raised to Rs. 906 which was falling very short of requirement as indicated by high marginal value product.

In the case of category 3 farms the present level of cash expenses was high, an addition of 25 percent was considerable and hence a rise of income from actual was by 45 percent. Since category 3 farms were already in advanced category and programming had increased income by 13 percent, the remainder of 33 percent rise in income was due to irrigation.

Although cash expenses were found limited and had a marginal value of 4.65 the limitation was not as acute as was the case in category 1. The acute shortage of cash expenses in category 1 was also evident from the fact that irrigated land and total crop land were being shown in the

slack activity, in spite of the fact that there was an option to take dwarf paddy both as irrigated and unirrigated crop. In fact, the program took only 1.13 acres of irrigated dwarf paddy in irrigated kharif land and left the rest as unsued as shown in Table 53.

Table 53. Programmed Resource Use of Unirrigated Traditional Farms Under Advanced Irrigated Technology (Category 4) 69 Category 1 Farms, Jabalpur District (M.P.), India, 1967-68

Resources	Used	Unused	Total	M.V.P.
			Acres	
Land kharif unirrigated	0	13.29	13.29	0
Land kharif irrigated	1.13	3.71	4.85	0
Land rabi unirrigated	13.29	0	13.29	151
Land rabi irrigated	4.85	0	4.85	18.62
Land summer irrigated	0	4.85	4.85	0
Total crop acres	19.27	6.47	25.75	0
			Rupees	
Cash Expenses	906.31	0	906.31	6.24

Income Gain in Shift to Advanced Irrigated Technology

The income increase possibilities of unirrigated farms if converted to irrigated advanced technology are shown in Table 54. In order to allow these farms to operate under irrigated conditions their existing cash expenses were increased 25 percent. Since irrigated traditional farms already had irrigation their cash expenses were not increased. Thus the extent of gain by each lower category and technology on transformation to the highest technology in irrigated advanced technology has been determined under the cash restraints specified above and are shown in Table 54 with the marginal value products of cash expen

Table 54. Income Gain by Programming in Shift to Advanced Irrigated Technology (Category 4) 117 Farms, Jabalpur District (M.P.), India, 1967-68

Category	Gains from Existing Income	M.V.P. of Cash Expense
	Percent	Rupees
1 Unirrigated traditional	51	6.24
2 Irrigated traditional	60	6.24
3 Unirrigated advanced	45	4.65

In Table 54 by changing the lower technology farms to advanced irrigated technology (category 4) farms, incomes can be increased substantially. Although cash expenses were increased by 25 percent for the unirrigated farms, the marginal value product of cash expenses remains high. This suggests that greater incomes can be obtained by raising the level of cash expenses.

Cash Needs of Technological Change

In the study all the categories were close to optimal resource allocation in Jabalpur District. A similar finding was found by Raj Krishma in the case of Punjab (India). He observed,[1] "Many recent studies seem to support the hypothesis that even in traditional agriculture, peasants make highly rational or near optimal use of limited resources (including knowledge) they have, considering all the effective constraints. To the extent that resource allocation by peasants is rational, policy makers can concentrate on resource expansion." Another inquiry by T.P.S. Choudhari, et al[2] found in the case of Delhi farmers that their allocation was also near optimum. Mellor states[3] "The logic for believing that farms are relatively efficiently organized in low income countries is strong and is based on the relatively static nature of conditions. With static level of technology, physical conditions and factor costs, farmers gradually evolve efficient organizations."

However while studying the cropping pattern of Gujarat State, Desai[4] found that on the principle of comparative advantage, the crops could be shifted from one area to another and the resultant cropping pattern could increase the gross income by 39.25 percent. Similarly, Kapur and Kahlon[5] found in Ludhiana District (Punjab) that with optimization and technological change incomes could be raised by 77 percent. But this was possible because it was assumed that as much cash as was needed could be borrowed for higher technology and better cropping patterns. Desai

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1. Raj Krishma, Indian Journal of Agricultural Economics, Jan.-Mar., Vol. XVIII, no. 1, p. 181.

2. T. P. S. Choudhari, et al., "Optimum combination of competitive crops in the intensive cultivation scheme area Delhi," Indian Journal of Agricultural Economics, Jan.-Mar., 1963, Vol. XVIII, no. 1, pp. 143-153.

3. John W. Mellor, The Economics of Agricultural Development. Cornell University Press, 1966, p. 135.

4. D. K. Desai, "Economics of Cropping Pattern in Gujarat State," Indian Journal of Agricultural Economics, Jan.-Mar. 1963, Vol. XVIII, no. 1, p. 111.

5. T. R. Kapur and A. S. Kahlon, "Optimum Cropping Pattern for upper Dhaia Region of I.A.D.F. District Ludhiana (Punjab), Indian Journal of Agricultural Economics, Jan.-Mar. 1963, Vol. XVIII, no. 1, pp. 49-51

had worked with state production figures and, hence, cash expense was not considered. In many other studies, it has been found that changing cropping patterns lead to greater incomes or production. It appears that in all such macro projections of changing cropping patterns, the assumption of resource expansion is implicit. In other words, although there is optimal allocation at the micro level, yet on the basis of technological change or comparative advantages, the macro cropping pattern may offer greater incomes, provided the relevant constraints at the micro level are removed.

It would, therefore, be appropriate to examine what income raising potential exists for Jabalpur District farmers if their cash expense restrictions were relaxed and they were able to invest for construction of wells, etc., to become irrigated farms. In Jabalpur, the average rainfall is nearly fifty-five inches per year giving surface wells capacity for four to five acres of irrigation. However, only 4.55 acres of irrigated land has been assumed for these farms as this figure was the average for category 2 farms. In cash expenses, different levels were tried.

Cash expenditure was raised successively by twenty-five percent till cash was shown in slack. Crop intensity was kept at 142 percent, the same as that reached for category 4 technology. The increase in income and the marginal value products of cash expenses are shown in Table 55.

Table 55. Income Gains on Resource Expansion (25% Cash)
In Technological Change to Advanced Irrigated Technology
172 Farms, Jabalpur District (M.P.), India, 1967-68

Category	Increase Cash Expense 25 Percent	Net Income	Percent Change From Existing Income	M.V.P. of Cash Expense
1	906	7,810	53%	6.24
2	1,674	13,406	87%	5.6
3	1,831	14,115	45%	4.65
4	2,402	15,712	42%	0

As shown in Table 55, a twenty-five percent increase in cash expenses in category 4 farms increased the income by 42 percent and the marginal value product of cash expenses becomes zero. The program did not require this much cash expense and Rs. 87.88 remained unused. In the program operated with the existing cash expenses, dwarf wheat was not found competitive, but in this program dwarf wheat came at the level of 3.91 acres and no irrigated local wheat was taken. In fact remaining irrigated rabi land was shown in slack. Formerly, the emphasis was on rabi land which now switched to kharif land. This only shows how

important it is to meet the full cash expense requirement of the technological change and how great the changes in cropping pattern can become. It appears that although the category 4 farms have changed technology, they were the full extent of cash expense requirement for full advantage was not realized. This may simply reflect a gradual shift to meet the new potentials in order to reduce risk.

For category 4 farms, the program required cash expenses of Rs. 2,314.61. For other categories, a mere twenty-five percent increase in their present cash expenses was not enough as is shown by their high marginal value products. The cash expenses for other categories were increased until they were shown in slack activity (Table 56).

Table 56. Total Cash Needs and Programmed Income in Technological Change to Advanced Irrigated Technology 172 Farms, Jabalpur District (M.P.), India, 1967-68

	Categories			
	Traditional		Advanced	
	1 Unirrigated	2 Irrigated	3 Unirrigated	4 Irrigated
Existing Cash Expenses (Rs.)	727	1,339	1,464	1,922
Cash Expenses Required (Rs.)	1,768	2,036	2,254	2,314
Rupee increase in cash expense	1,041	697	790	392
Percent increase in cash expense	143	52	54	20
Existing Net Income (Rs.)	5,089	7,169	9,735	11,803
Optimal Net Income (Rs.)	11,903	14,518	15,469	15,712
Percent Increase in Income	134	103	59	33

With no cash restraint, the maximum percentage gain in net income of 134 percent above their existing incomes, is possible for traditional unirrigated farms. Of the unirrigated farm of the sample, 77 percent are traditional farms and, hence, about three-fourths of the unirrigated farms have the potential of raising their existing incomes by 134 percent, provided their technologies were changed and irrigation to 4.85 acres is provided. The remainder of the unirrigated farms are already in advanced technology and need only the above fixed investment in wells and pumps. Their cash needs will rise by fifty-four percent with a corresponding income increase of fifty-nine percent.

The quickest opportunity to make a large income rise is available to category 2 farms which have only to increase their cash expenses by 52 percent and the advanced technology offers them the possibility to increase their income by 103 percent. The category 4 farms were already in advanced technology but have also shown substantial income gain which may be due to the fact that the dwarf varieties of crops have been introduced lately and the seed was in short supply. These farms were also operating with lower cash expenses than are required for maximum income and, hence, when their cash expenses are raised by 20 percent, their rise in income is 33 percent above the existing level.

Changes in Cropping Pattern and Production

Apart from income changes, the change-over to advanced technology brings about a specialization of production for this district by concentrating on cereal production (Tables 57 and 58). The programs include the minimum of pulse production dictated by the restriction of self-sufficiency. The growing of paddy assumes a place of importance. The growing of vegetables is reserved for the summer season when other alternatives are lacking.

It is seen from Table 58 that the programs under existing resources increases acreage under wheat and reduces it from paddy, pulses, and other crops. However, when advanced technology is applied to all category farms with adequate cash expenses, specialization in cereal production results and 95 percent of the area is devoted to cereal production. The four percent of the area in pulses had to be maintained for the restriction of pulse self-sufficiency. The vegetable area of less than one percent remained competitive for summer crops of vegetables. As a result of technological change, backed with necessary change in fixed resources and annual cash expenses, the total production registered an increase of 34,678 kilograms. The gain in production was confined to only wheat and paddy; the production of all other crops was reduced or abandoned. In Table 59 the changes in production in percentage terms are shown.

It is seen from Table 59 that technological change and irrigation had the potential for increasing the total production on these farms by 79 percent as against only 12 percent by programming under existing technologies and resources. Thus, technological change and irrigation coupled with adequate finances holds the key of agricultural development.

Technological Change and Small Farms

The present sample of farms ranged between ten to fifty-five acres in size. The state has fifty-five percent cultivated area in farms in this size range. But twenty-six percent of the area consists of small farmers of under ten acres. They include seventy-eight percent of the farming population (Table 60).

Table 57. Cropping Pattern and Production: Actual and Programmed
172 Farms, Jabalpur District (M.P.), India, 1967-68

Crops	Actual Under Existing Resources & Existing Technologies	Programmed Under: Existing Resources & Existing Technologies	Programmed Under: Expanded Resources & Advanced Irrigated Technology
		Acres	
Wheat (dwarf) irrigated	3.03		10.33
Wheat (local) irrigated	6.41	9.76	—
Wheat (local) unirrigated	48.34	65.44	64.23
Total Wheat	57.78	75.25	74.56
Paddy (dwarf) irrigated	.54	6.02	20.57
Paddy (dwarf) unirrigated	.35	1.98	23.38
Paddy (local) irrigated	4.43	4.32	—
Paddy (local) unirrigated	26.60	10.07	—
Total Paddy	31.92	22.34	43.95
Masoor irrigated	.26		
Masoor unirrigated	8.68		
Total Masoor	8.94		
Gram irrigated	.47		
Gram unirrigated	12.29		
Total Gram	12.76		
Pea irrigated	.10	1.11	
Pea unirrigated	1.73	13.91	5.36
Total Pea	1.83	15.02	5.36
Total Vegetable irrigated	1.17		.86
Total Jowar unirrigated	.87		
Total Arhar unirrigated	.97		
Total Urid-moong unirrigated	.82	.07	
Total Lesser millets	.62	1.84	
	117.68	114.52	124.73
Total cereal produced (kg.)	36,685	43,428	76,348
Total pulses produced (kg.)	6,003	4,071	1,413
Other production	1,299	1,862	904
	43,987	49,361	78,665

Table 58. Percentage Area of Two Programs Compared With Existing Crop Plan 172 Farms, Jabalpur District (M.P.), India, 1967-68

Crops	Actual Under Existing Resources and Existing Technologies	Programmed Under Existing Resources and Existing Technologies	Programmed Under Expanded Resources & Advanced Irrigated Technology
	Percent of area		
Wheat	49	65	60
Paddy	27	19	35
Pulses	20	13	4
Others	4	3	1

Table 59. Percentage Change in Production by Programming Irrigated Advanced Technology and Resource Expansion 172 Farms, Jabalpur District (M.P.), India, 1967-68

Crops	Actual Production 1967-68	Percent Change in Program With Existing Resources and Technologies	Percent Change in Program With Resource Expansion and Advanced Irrigated Technology
	kilograms	Percent	
Cereals	36,685	+ 18	+ 108
Pulses	6,003	- 32	- 76
Others	1,299	+ 43	- 30
Total Production	43,987	+ 12	+ 79

Table 60. Size and Distribution of Small Farms in Madhya Pradesh, India, According to 1954-55 Census

Size in Acres	Number in Millions	% of Total Farms in State	Area in Million Acres	% of Total Cultivated Area	Average Size in Acres
0 - 5	2.65	59	5.07	11	1.91
5.01 - 10	.94	19	6.72	15	7.15

It is apparent from Table 60 that 59 percent of the farming population had an average of 1.91 acres of land. Another 19 percent of the farms had an average of 7.15 acres of land. The first group of farmers is almost like a landless labor group and works most of the time on larger farms as permanent or temporary hired labor. The second group is likely to be independent but makes a bare living.

On the basis of per cultivated acre net incomes obtained by the sampled farms in this study, incomes and cash expenses for the three sizes of small farms and the four technological categories (Table 61) have been estimated. The two acre farms even in category 4 obtain an estimated net income of only Rs. 1,127 which is below the income which could be obtained if the operator and his wife had worked as daily wage earners rather than operating their farm business, provided of course that they could get jobs off the farm.

Table 61. Estimated Present Farm Net Incomes and Cash Expenses in Different Categories for Small Farms Jabalpur District (M.P.), India

Category	2 Acre Farm		5 Acre Farm		10 Acre Farm	
	Net Income	Cash Expense	Net Income	Cash Expense	Net Income	Cash Expense
	Rupees					
1	641	80	1,603	200	3,206	400
2	590	109	1,725	272	3,450	543
3	919	120	2,299	300	4,599	601
4	1,127	167	2,818	417	5,636	834

It was found that the allocation of resources was near optimum for category 1, 2, and 3 farms and, hence, there may be very limited scope for improving income through reorganization of these farms. Accordingly, the necessary additional fixed investment must be made on unirrigated farms to convert them to irrigated farms and the technology on all small farms should be brought to the level of category 4 farms.

To study the potentials for small farms, increased irrigation and three alternative levels of cash restrictions are assumed (Table 62).

When these farms were programmed with the technological matrix of advanced irrigated technology (category 4), the following incomes were obtained (Table 63).

Table 62. Hypothetical Resources of Small Farms
Jabalpur District (M.P.), India

Resources	Farms 2 Acres	5 Acres	10 Acres
Irrigated land acres	2	5	5
Unirrigated land acres	—	—	5
Total Acres of Crops	4.5	11	17
Cash expense (1) Rupees	250	625	1,251
Cash expense (2) Rupees	334	834	1,668
Cash expense (3) Rupees	417	1,042	2,085

Table 63. Hypothetical Programmed Income of Small Farms
When Operated by Technology of Category 4 Farms
Jabalpur District (M.P.), India

Cash Expense Level	Net Income 2 Acre Farm	5 Acre Farm	10 Acre Farm
		Rupees	
1	1,702	4,216	8,264
2	2,212	5,242	8,425
3	2,570	5,242	8,425

It is shown in Table 63 that two acre farms make an income of Rs. 2,570 when they are allowed Rs. 417 as cash expenses. The program includes dwarf irrigated wheat at 1.66 acres and dwarf irrigated paddy at two acres. When full cash requirements of Rs. 492 are met, the program takes two acres each of dwarf paddy and wheat and .22 acres of summer vegetable. The net income rises to Rs. 2,775. Assuming that the family of this farm consists of six members, then the per capita income would be Rs. 463, which is more than the per capita income of India.

The five acre farm found Rs. 834 as cash expenses to be just enough to make an income of Rs. 5,242. In fact, the cash requirement is only Rs. 834. Surprisingly, the five acre farm does not find dwarf irrigated wheat competitive and instead takes 4.29 acres of local irrigated wheat. This is because dwarf wheat requires twice the amount of irrigation than local wheat. If dwarf wheat is taken or forced in the solution, net income is reduced by Rs. 232 per acre.

The ten acre farm required only Rs. 1,380 as cash expenses and made an income of Rs. 8,425. The program takes 2.14 acres of irrigated dwarf wheat, five acres of irrigated dwarf paddy, and 4.63 acres unirrigated dwarf paddy. In addition, .22 acres of vegetables are taken in summer. In Table 64 the optimal cropping pattern of these farms is shown.

Table 64. Programmed Cropping Pattern of Hypothetical Small Farms Operated Under Advanced Technology With Full Cash Expense Requirement

Crops	Farm Size 2 Acre	5 Acre	10 Acre
		Acres	
Wheat dwarf irrigated	2		2.14
Wheat local irrigated		4.29	
Wheat local unirrigated			5.00
Paddy dwarf irrigated	2	5.00	5.00
Paddy dwarf unirrigated			4.63
Vegetables	.22	.22	.22

Returns to Irrigation on Small Farms

Estimates have been made of the returns to irrigation to these farms in the advanced technology when the full cash requirement is met. An unirrigated 2 acre farm in traditional technology has a net income of Rs. 641 only, whereas the net income of similar 5 acre farms is Rs. 1,603. However when the technology is changed to advanced irrigated the net incomes become Rs. 2,775 and Rs. 5,242 respectively. Thus Rs. 2,134 and Rs. 3,639 are the likely net gains in income to 2 acre and 5 acre farms respectively due to advanced technology and irrigation. The annual cost of irrigation already determined (Table 47) is used for these farms. In addition the additional increase in cash expenses for advanced technology is also added to arrive at the added capital cost of irrigation and technology. In Table 65 the cost and returns to irrigation in advanced technology for 2 and 5 acre farms are shown.

It is shown in Table 65 that returns to irrigation remain high in advanced technology even on small farms. In fact, the returns are slightly higher than already determined for the sampled farms, because those were determined at less than full cash expense limits. On a 2 acre farm the returns to irrigation are at 12 percent level for the oil pump irrigation. This can be increased if the farm sells water or if the farmers were given cheaper credit for production needs. Thus, even for small farms investment in irrigation is highly profitable under conditions of advanced technology.

Table 65. Estimated Returns to Irrigation on Small Farms in Advanced Technology

	2 Acre Farm		5 Acre Farm	
	Oil Pump	Electric Pump	Oil Pump	Electric Pump
	Rupees			
Additional net income due to irrigation	2,134	2,134	3,639	3,639
Annual cost of irrigation	975	475	975	475
Interest on additional cash expense (Rs. 412 at the maximum rate of 24%)	99	99	-	-
Interest on additional cash expense (Rs. 634 at the maximum rate of 24%)	-	-	152	152
Net returns to oil pump irrigation, i.e. on Rs. 9,000 investment	1,060	-	2,513	-
Net returns to electric pump irrigation, i.e. Rs. 6,000 investment	-	1,560	-	3,012
Percent return	12%	26%	27%	50%

CHAPTER VI

SUMMARY OF MAJOR FINDINGS AND CONCLUSIONS

The level of agricultural productivity in Madhya Pradesh is low and the state of agricultural technology has been relatively static although the state has made considerable effort to increase farm resources. In the Third Five Year Plan, 25 percent of the Plan resources were invested in agricultural programs yet no promising increase in yield level of crops was visible. Similarly, 39 percent of the Plan resources were devoted to power and irrigation, yet the irrigated area remains at the unimpressive figure of less than 6 percent of the total cropped area. The use of chemical fertilizers per hectare in 1967-68 was about 2 kilograms as against 11 for all of India, 23 for Kerala and 36 for Madras. The yields of wheat and paddy, the two predominant crops, are only about half of those obtained in other advanced states like Madras and Punjab. The intensity of cropping is very low, only 111 percent and the percentage area devoted to commercial crops is 15 percent as compared to 21 for India. Thus, the state is in the grip of a vicious circle where backward agriculture is both the cause and effect of low income. This study of 172 farms in Jabalpur District was undertaken to examine the causes of the present low income in agriculture and to seek promising possibilities for improving conditions.

The sample was purposefully chosen around three different sampling units to represent three influences; namely, the effect of nearness to a large city, the effect of an agricultural university and its extension work, and the effect of the absence of both. The sample farms were randomly drawn from the medium-size group of 10 to 55 acres, and consisted of 90 unirrigated farms and 82 irrigated farms. The sample was further subdivided into traditional and advanced techniques of farming. Thus, there were four categories of farms -- traditional unirrigated, traditional irrigated, advanced unirrigated, and advanced irrigated. Various factors were analyzed for the purpose of diagnosing the means of increasing farm income. Returns to fixed resources were optimized by employing linear programming technique. Changes such as cropping pattern, irrigated area, cash expenses, and technological change, were examined in relation to their feasibility.

Analysis of variance was employed to study the variability of gross income per acre for various groups such as educational levels, castes, age of operators, leadership levels, and modes of irrigation. Education, caste and mode of irrigation were significantly related to the per acre gross income. The rest of the factors did not show any significant effect. Farmers having the highest education had the highest income and the ranking was in order of educational level. Similarly, the lowest caste group obtained the lowest income. However, in caste groups, the ranking of income was not according to the caste status. The highest

income was obtained by the third caste. It appears there is an interaction of education and castes, the educational level of the third caste is higher than the rest. The third caste had 42 percent farms operated by persons with higher educational level, while the fourth caste [illegible] had only 17 percent in higher education. The first and second caste group each had 31 percent in higher education.

The mode of irrigation also shows significant differences in per acre gross income. The highest income was obtained by farms with electric pumps and the lowest by charas irrigation. The second and third ranking income was obtained by state tube wells and oil pumps. In order to probe the performance of mode of irrigation further the yields of crops were analyzed by mode of irrigation. Since the year of the study was very favorable to rabi crops due to timely rains, no significant effect was observed in the yields of wheat. However, the paddy yields were significantly affected by modes of irrigation and once again the electric pump farms had the highest yield and the lowest were obtained by charas irrigation. The ranking remained the same. The consistently poor performance of oil pumps in yield and gross income is explained by their low percentage of farms in advanced technology. The level of technology is measured by the extent of the use of fertilizers and improved seeds. Only 57 percent of the farms with oil pumps were in advanced technology as against 87 percent with electric pumps and 100 percent in state tube well irrigation. The oil pump farms have less irrigated area and lowest intensity of farming also. However, when a comparison is made only in advanced technology farms, then oil pump farms obtain the second best yields as shown by the yield of dwarf wheat.

Using linear programming techniques an assessment was made of the income increasing possibilities for an average farm in the four technological categories by an optimum allocation of the resources actually used by the farms in the sample. [illegible]r the sample as a whole only 12 percent increase in income was poss[illegible]e. This is not a significant increase, suggesting that the existing allocation of resources was close to optimum. Some sub-optimal organization or advanced irrigated farms may be due to the recent introduction of new crop varieties. Income may increase further as farmers adjust to these new varieties which require greater degrees of skill in crop husbandry management such as early harvest, greater use of water and fertilizers.

In programming income on advanced irrigated farms a restriction on the acreage of dwarf paddy was placed because the seed of dwarf paddy was extremely limited. When no restriction for dwarf paddy was imposed, the programmed income was 22 percent higher than existing income as against only 14 percent of programmed with the above restriction. This indicates that incomes have been reduced by 8 percent due to nonavailability of the seed of dwarf paddy. It shows how important a single input becomes in advanced technology. As such, the requisite production or supply of modern inputs for realization of full income raising potentials of advanced technology are extremely essential. This has an obvious policy implication for the state, not only in the sphere of seed but all other modern inputs, which have to be supplied to millions of farmers in remote areas.

It appears that traditional farms used adequate cash for their needs. On unirrigated traditional farms (category 1), the marginal value product of cash expense was zero, and on irrigated traditional farms, it was Rs. 0.38. Since both of these categories are traditional, these have adjusted to the requirement of cash through the long periods of experience.

On advanced farms, the marginal value product of operating capital (cash expense) was high. The advanced unirrigated farms indicated that income would rise by Rs. 2.01 for every additional rupee. These farms have moved from traditional technology and are in the process of change. It appears that a good response to fertilizer in a favorable rainy year required more cash expenses than was actually used. This also was the case with advanced irrigated farms where cash expenses were limiting income. A great income raising possibility is indicated by marginal value product of cash which is Rs. 4.65 for an additional rupee. In this category, the true potential of advanced technology is seen. The dwarf varieties require much higher level of cash expenses than what has actually been used on these farms. These farms are clearly in need of further adjustment to the potentials and requirements of their technologies.

In respect to irrigated land, one acre of additional irrigated land increased incomes by Rs. 167 on traditional farms and by Rs. 330 on advanced farms. In other words, an expansion of operating capital (cash expenses), cropping intensity, and irrigated area were the three possibilities for raising income. Accordingly, these three resources were increased by 10 percent and all the category farms were reprogrammed to see the extent of gain in income. The sample as a whole gained in income by 8 percent more than what it would have gained by existing resources. This indicated that there may be further scope for income increase by expansion of resources. Accordingly, different levels of cash expenses, crop intensities, and irrigated areas were examined to find the most likely level within practical limits of expansion for different categories in their respective technologies. That analysis showed that a substantial net gain on resource expansion occurs only on irrigated farms. Also, the largest net income gain on irrigated farms is found in advanced technology which is more than double compared to traditional technology and is more than six-fold compared to traditional unirrigated farms. The net gain with resource expansion on unirrigated farms was 7 and 10 percent only. This being the case, a clear policy implication emerges that unless irrigation is expanded substantial increase in farm incomes is not possible. The net income gain by resource expansion (crop intensity 25 percent, irrigated area 25 percent, and cash expenses 50 percent) for advanced irrigated farms comes to 46 percent as against 21 percent on traditional irrigated farms.

Since the survey year had extremely good rainfall, the effect of bad weather on programmed allocation was examined. In the case of unirrigated farms, it was found that the traditional farms' allocation was nearest to that programmed (10 percent away) for good weather like 1967-68, but if the rabi weather were to turn adverse by 25 percent, these farms would have been 18 percent away from programmed optimum.

The allocation of advanced unirrigated farms would have been closer to programmed optimum under adverse rabi weather which shows that these farms may have planned to meet the situation of unforeseen weather risk. Since these farms had already taken the risk of using fertilizer under unirrigated condition, planning for good weather would have been a second risk.

The maximum scope for increasing income (i.e., net 22 and 46 percent) and production was available on irrigated farms. The expansion of irrigation is also suggested by the marginal value product of irrigation. An acre of irrigated land in traditional technology shows Rs. 167 as its marginal value product. In advanced technology the marginal value product rises to Rs. 330. However, returns to irrigation were estimated on the basis of average product, so that they could be used for unirrigated farms for considering creation of irrigation facilities. Returns to irrigation greatly differ according to the mode of irrigation and technology. In traditional technology returns to irrigation are low. Oil pump irrigation in traditional technology gives only 9 percent return on investment of Rs. 9,000 on a well and pump, whereas in advanced technology the same investment gives a return of 25 percent. In this respect, the electric pump irrigation pays very well. The returns to electric pump irrigation in traditional technology were 22 percent, and in advanced technology they were 47 percent or more than two-fold the returns on traditional.

The adoption of advanced technology and mode of irrigation have a direct relation to irrigation expansion. The returns from traditional technology are low and, hence, the irrigation expansion is slow but may expand rapidly with advanced technology and farm electrification. Since electric pump irrigation is very profitable, a rapid expansion of irrigation through farm electrification would be natural. This would eventually lead to rapid adoption of advanced technology which would expand returns to irrigation. The sampled farms lend weight to this argument inasmuch as 87 percent of the electric pump farmers have adopted advanced technology as against 57 percent of oil pump farmers, and 44 percent of charas irrigation farmers.

The sample had two categories of farms which were traditional and the potential for increasing their incomes and that of the sample by a technological change was investigated. Under the existing resources, if the traditional unirrigated farms adopt the advanced technology, the net gain in income over and above the programmed income would be by 32 percent, and for irrigated traditional farms, it would be 47 percent, and the entire sample gain would be 18 percent. Thus, the possibilities for increasing income through a technological change for the traditional farms is large, even under unirrigated conditions. Since the above change would not call for any increase in existing resources, it offers an immediate opportunity for raising incomes. However, since the gains of 32 percent in technological change on unirrigated farms were based on data for a very good rainfall year and may be overestimated it would take several years' data to correctly assess the true extent of gain in a technological change on unirrigated farms. The farmers consider using

fertilizer without irrigation to be very risky and, hence, there is slow adoption of advanced technology on these farms, but on traditional irrigated farms, no such risk is involved.

Since technological change is considered to be risky without irrigation and few farmers appear willing to take that risk, an attempt was made to find the potential income that might be generated if the necessary investment in wells and pumps were made on the unirrigated farms. These farms were programmed with the technological matrix of advanced irrigated farms assuming that these farms have created irrigation facilities for 4.85 acres.

Given the necessary fixed investment in irrigation and the required cash expenses, adoption of advanced technology can bring about outstanding changes in present income. An increase of 134 percent income is indicated for the traditional unirrigated farms in category 1. The irrigated traditional farms could double their income. Apart from tremendous increases in incomes, the advanced technology introduces a superior cropping pattern leading towards a solution to the chronic food shortages. Dynamic agriculture offers an increase in production of cereals by 108 percent. The pulse production would be kept at a minimum as dictated by the requirements of home consumption. The cropping pattern suggested by the program with full requirement of cash, does not include local irrigated wheat and local paddy crops. The entire irrigated area is devoted to dwarf wheat. Similarly, in kharif all paddy area is under dwarf paddy. The total production would increase by 79 percent and specialization in cereal production is clearly indicated with 95 percent area under cereals.

These results have direct application for the medium-size farms which account for 55 percent of the agricultural area of the state. But 26 percent of the area is in farms in the size group of less than 10 acres and these farms account for about 78 percent of the farming population. The potential for raising incomes of these small farms was also estimated. This was done in the context of advanced technology assuming that a two-acre farm would have full two acres and a five acre farm would have all area under irrigation. The ten acre farms would have half the acreage under irrigation. These farms were programmed with the necessary cash expenses required for the advanced technology. According to the programming, a two acre farm could make a net income of Rs. 2,775, a five acre farm could make a net income of Rs. 5,242, and a ten acre farm could make Rs. 8,425 as net income. Thus, the use of modern technology in agriculture would make it possible for a two acre farm with a family of six members to make a per capita income higher than the present national per capita income of the nation.

Finally, the estimated returns to irrigation on these farms were calculated for the advanced technology. On a five acre farm, the returns to irrigation investment on wells and oil pumps were found to be 27 percent, whereas for electric pumps, the returns were 50 percent. On a two acre farm, returns to oil pump irrigation were 12 percent, and on electric pump irrigation, these returns were 26 percent. Furthermore

returns can be raised by selling surplus water which these farms will have after irrigating two acres. High returns to irrigation by electric pump, which are primarily due to low running costs and one-third less depreciation cost than oil pumps, can enable the small farms to invest in irrigation and reap the benefits of advanced technology.

In conclusion, it can be said that the advance in technology, symbolized by the dwarf wheat and paddy varieties, tremendously increases the potential returns to advanced agriculture. The increase in crop yields was more than two-fold but a corresponding expansion of resources in cash expenses, modern inputs and irrigation is required. Given the necessary expansion of resources, a dynamic agriculture would greatly increase farm incomes, and in turn a growing rural demand for consumer goods such as fertilizer, pesticides, small machines, tools, pumps, irrigation and plant protection equipment and the processing industry. In other words, strength in the farm economy would generate a real demand for rapid industrialization. In addition, a dynamic agriculture would create a surplus in food and other agricultural products with subsequent lowering of agricultural prices which would provide an opportunity for industrialization to flourish in an environment of lower agricultural prices. The enlarged agricultural incomes can then flow to profitable investments in industrial sectors.

The farmers have attempted to maximize income under the constraints of uncertain weather with remarkably good judgment. Except for fuller use of the irrigated area during the rainy season, there appears to be little room for improving the allocation of the existing resources. Less than full utilization of the irrigated area is primarily because in Jabalpur District the present yields of paddy varieties are low and the differential returns do not excite the farmers to grow irrigated paddy. Perhaps the extra labor and cost involved with low differential gains are not worth loss of leisure.

The implications of modernization are many. It will require a comprehensive approach and simultaneous development of complementary influences to bring about a rapid rise in farm incomes. The findings of this study point out certain policy issues, indicate what resources need to be expanded, and policies to be pursued to facilitate rapid modernization of agriculture.

The findings of this study have two broad limitations. First, the programming technique employed for assessing income increasing potential. The extent of income increase shown by a program may be overstated because a program is drawn under conditions of certain prices and yields, whereas the actual farming has to face the conditions of risk and uncertainty.

The second limit[illegible] certains to data. The year 1967/68 was an extremely good year for [illegible] crops which are dominant in Jabalpur District. For this reason, the findings of this study in respect to advanced unirrigated farms which use fertilizer may be overstated and

should be used with caution. It may take several years' data for ing the response of fertilizer use under unirrigated conditions.

Conclusions

Irrigation

The state has an irrigation potential of nearly ten million hectares of which only one-tenth is under irrigation at present. Since the success of dynamic agriculture depends overwhelmingly on irrigated area, the state may have to make hard decisions to curtail investment in other areas, to create as much area under irrigation as possible. Irrigation can be provided in several ways. Nearly 43 percent of the state's irrigated area received water by canals from large projects in 1966/67. However, large projects require heavy investment which this poor state has been unable to procure for a rapid increase in percentage area under irrigation. In addition, the fate of the Narmada Valley project hangs in the balance. Even if it is settled favorably and the necessary funds are found, it might take another ten years before irrigation becomes available. For want of irrigated land, the adoption of fertilizer has been slow for over twenty-five years and the state has lagged behind most of the other states in modernizing agriculture. A delay of another ten years would keep the state's income low and the gap will become wider and wider. There needs to be an intense search for ways and means of quickly increasing the irrigated area in the state.

Thirty-three percent of the irrigated area is irrigated by surface wells. On an average, the cost of a new well is Rs. 4,000 to 5,000. In a good rainfall area of over 30 inches of rain, a well can command an area of four to five acres. Thus, in a year it may irrigate about ten acres of crops. The sample of farms studied in Jabalpur District showed the average of 4.85 acres as the area irrigated per well. During the last four years over 20,000 irrigation wells have been added annually largely with government loans. Enlarged credit and farm electrification should encourage rapid expansion of well irrigation. The returns to electric pump irrigation were highest in both technologies. The sample data showed that a high percentage of farms with electric pumps have advanced technology; thus, indirectly, electrification leads to modernization of agriculture. In addition, farm electrification will increase the number of tube wells which substantially increase the irrigated area.

Close to three-fourths of the state received moderate to high rainfall and several big and medium rivers flow out in all directions. These rivers maintain a strong flow up to the end of January. Thus, pumping water on both sides of the river even without a dam will irrigate several thousand acres of land at a nominal cost.

One more possibility exists for expanding irrigation. Water of several small and big rivers can be blocked at suitable bridges and culverts by inexpensive blockades and then it can be pumped for irriga-

tion. In both of these possibilities, irrigation potential can be created at a small cost especially if the water lift is an electric pump.

Role of Agricultural University

Research

The pessimism of the food-population race suddenly disappeared largely due to the research breakthrough of dwarf varieties. It may not always be possible to transplant new technologies from other parts of the world. This research finding has provided a breathing time. The accelerated growth of a dynamic agriculture will depend on a continuous stream of new technologies adapted to local conditions. A research institution with high standards is needed to do this. Such an institution needs a staff of trained persons with a thorough knowledge of local conditions, who can constantly react and provide insights for different aspects of local problems. Developing agriculture is a complex process and requires scientists to make decisions based on their past successes and failures in those environments.

For instance, returns to irrigation are low in traditional agriculture but the returns increase tremendously with a technological change. This shows high interaction of water, seed, and fertilizer with good management. The basis for technological change was provided by the recent research in biological sciences which must continue. This in turn has greatly expanded the need for accelerating research in social sciences for providing insights and policies to foster and sustain dynamism in agriculture.

Agricultural Education

The new agricultural technologies will demand a variety of technical men for various complex needs. So far, most of the technical persons have been employed by the state for its various departments. These demands have been routine and required men with general training. This has more or less determined the curriculum of the agricultural university. However, this would not be the case in a dynamic agriculture. A greater degree of specialization will have to be introduced to cater to special needs. The demand by the private industry sector for technical manpower will expand. The banks will require trained persons if they begin financing agriculture. The fertilizer, insecticide, pesticide, the engineering industries, and commerce may soon be looking for adequately trained manpower. The agricultural university must prepare in advance so these needs can be met.

Extension Education

The acceptance of new technology or a particular innovation depends on the degree of profitability and its successful experience. Since the

profitability is presumably tested before the innovation is released, the acceptance then depends on the profitability on farmers' fields. With an extremely profitable technology, even a partially successful experience may fall within the profitability limits of acceptance and the technology may be adopted quickly as was the case with dwarf varieties.

Farmers are said to be tradition-bound, but they have proved to be extremely intelligent in refusing to accept a technology of doubtful gains. Thus, the role of extension education is not only that of awakening the mind, but surely in the process of providing full technical information, which is educational. There is a great need for a good job of selling the genuine and distinctly superior technology developed by the research workers. An effective educational program can do much to shorten the time lag between the discovery of a new practice and its adoption by all farmers.

The implications of the findings that farm incomes can rise by 70 percent are clear. With resource expansion of the type suggested above along with continued research, manpower training and an effective significant increase in income can be obtained through technological change.

The requirements of a dynamic agriculture are diverse. The attitudes of the agencies which will foster it should change. The government policies should be flexible demonstrating a readiness to release the necessary resources. The university should strive to provide a flow of new innovations and train the technical manpower needed to service the various needs. The Extension Service must work closely with farmers to help them analyze their problems, request new research, and keep the new findings moving into areas where they can be used. The agri-business should be aggressive enough to keep pace with the demands placed on it by a dynamic agriculture. Given the necessary conditions, the output and income will rise rapidly, the prices of agricultural produce will decline, and additional policy measures will be required, but these will be the opposite of scarcity conditions. Zoning will have to be abolished and a free trade policy instituted, otherwise prices will crash.

A portion of the increased incomes of the farms will need to be siphoned off for capital formation. This will require careful thought. A direct tax will not be politically feasible nor will it be possible to collect cheaply. A better way might be a sales tax for which the state already has an efficient organization. Lower agricultural prices and an indirect tax might be the best way of promoting the economic development and the industrialization of this giant sleeping state.