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provement. This assumes added significance in view of the fact that in the year 1970-71, though our country had record yields of rice, bajra and wheat, the pulses had shown a marginal decline.

4. (i) A scheme of crop insurance may be introduced in these districts. In almost all cases, the coefficient of variation is more than 20 per cent both in the case of yields and rainfall and crop insurance may give some income stability to the farmer.

(ii) Our analysis has taken only crops into account. In these districts, livestock is an important supplementary enterprise. While jowar and bajra command nearly one-sixth of the total cropped area in these districts, the cattle to which these crops are fed continue to be of poor breed. Improved breeds of milch animals and sheep, suitable for the region, should be introduced on a large scale.

INCOME RAISING POTENTIAL ON RAIN-FED FARMS IN JABALPUR DISTRICT : MADHYA PRADESH

V. P. Shukla

Professor and Head
Department of Agricultural Economics and Farm Management
J. N. Krishi Vishwa Vidyalaya
Jabalpur-4 (Madhya Pradesh)

More than 75 per cent of the cropped area in India is rain-fed and most of the measures to increase production are confined to irrigated areas. In Madhya Pradesh about 95 per cent of the cultivated area is rain-fed. In recent years the planners and the agricultural scientists have shown serious concern over this vast area under rain-fed crops. Possibilities of increasing production and income on these areas are now being explored by introducing new varieties of crops or new management practices.

For all practical purposes, the terms like "dry farming," "dry land farming" or farming under "rain-fed" conditions have been assumed to be the same. The pertinent question like what should be the optimum crop combinations in rain-fed farms of Jabalpur district in the light of available resources inclusive of new technology has been attempted in the present study.

Description of the Area

Jabalpur district of Madhya Pradesh is situated at the upstream of Narbada Valley covering an area of 3,779 square miles. The soils of the district

are medium black and the climate of the district is moderate and permits crop growth in all the seasons. The 1957-67 eleven-year average annual rainfall was 54.22 inches. With good management, the reported rainfall can support double cropping. About 95 per cent of the total cultivated area is rain-fed. The major crops of the district are wheat, paddy and gram. The food crops command 92 per cent of the cultivated area. The power for farm work is predominantly provided by animals.

Purpose and Objectives

The general purpose of this study was to examine a sample of farms in Jabalpur district of Madhya Pradesh for assessing the economics of present resource use under rain-fed conditions with traditional and advanced technology of production, and for finding improvements which might raise the level of farm incomes. The specific objective was to determine the combinations of crops on rain-fed farms with traditional and advanced technology that should achieve maximum net income over a given range of resources. It was assumed that the transfer of resources from one line of production to another can be accomplished from within the known alternatives.

Procedure and Analysis

Primary data were collected by survey method in Jabalpur district of Madhya Pradesh during the months of April through November, 1968. The data were used as the basis for analysis of the existing farm business. For the purpose of finding the optimum income obtainable by the sample farms, programming technique was used.

Farmers living within a ten-mile radius from Jabalpur city and having 10 to 30 acres of unirrigated land (representing most of the cultivated area) were included in the sample population. A random number sampling technique was used to select 90 farms from the list of sample population. Data were obtained from respondents by personal interview using structured questionnaire. Out of the 90 unirrigated sample farms, 21 farms were using fertilizers and other advanced farming practices while 69 farms were not. Consequently, the sample was subdivided into traditional and advanced technology.

Unirrigated farms with traditional practices and negligible purchased inputs with less than 25 per cent land under fertilizer numbering 69, were called category 1 or "unirrigated traditional farms." Unirrigated farms with improved practices and at least 25 per cent of the area receiving fertilizer numbering 21 were called category 2 or "unirrigated advanced farms."

The resources of the farmers in each category were averaged to obtain a model farm for that category. The average input-output coefficients of the farms in each category were used for the programming. The two model farms were programmed to obtain the optimum income with the

existing average resources. The restrictions used in the programming were land and operating capital. Labour was not a limiting resource, so it was not treated as a resource limitation. Two additional restrictions were also introduced in the programme, namely, (a) restriction to supply cereals and pulses for the farm family, and (b) restriction of supplying fodder for the farm animals. Land was classified as *kharif* and *rabi* land. All cash expenses were treated as working capital (charges for hired labour, value of purchased seeds and fertilizers, etc.).

The prices used in the programming were those that had been actually received by the farmers during the period of investigation. The net income has been defined as the gross income less the actual cash expenses incurred in raising an acre of crop.

Results and Discussion

The results of the programmed analysis have been discussed under the heads of (a) resources and activities used, (b) allocation of resources, (c) crop plan, (d) marginal value products of limiting resourcs, (e) production pattern, and (f) potential gains.

(a) Resources and Activities Used

The resources and activities used for each category of sample farms are summarized in Tables I and II, respectively.

TABLE I—RESOURCES USED FOR CATEGORY 1 AND 2 FARMS, JABALPUR: 1967-68

Resource restrictions	Category 1 (69)	Category 2 (21)
1. Total cultivated land (acres)		
(a) *Kharif*	18·14	24·35
(b) *Rabi*	18·14	24·35
2. Operating capital(cash expenditure) (Rs.)	727·05	1,464·6
3. Restriction for supply of		
Cereal (kg.)	1,081	1,187·5
Pulses (kg.)	373	362·5
Straw (kg.)	4,850	5,360

TABLE II—ACTIVITIES CONSIDERED FOR CATEGORY 1 AND 2 FARMS, JABALPUR : 1967-68

Activities		Category 1				Category 2			
		Yield (kg.)	Gross income (Rs.)	Cash cost (Rs.)	Net income (Rs.)	Yield (kg.)	Gross income (Rs.)	Cash cost (Rs.)	Net income (Rs.)
X_1	Wheat	285·9	286·6	31·2	255·4	462·4	462·4	48·8	413·6
X_2	Paddy	318·8	210·4	54·7	155·7	451·6	298·0	67·8	230·2
X_3	*Masoor*	220·6	227·3	16·5	210·8	215·0	222·3	18·8	203·5
X_4	Gram	208·6	158·6	17·5	141·1	272·6	207·1	21·6	185·5
X_5	Pea	263·8	285·2	16·8	268·4	292·8	315·9	13·6	302·3
X_6	Jowar	264·2	132·0	14·9	117·1	264·2	132·0	14·9	117·1
X_7	*Arhar*	174·4	190·4	16·0	174·4	218·0	238·6	16·9	221·8
X_8	*Urad-moong*	107·4	107·4	10·6	96·8	107·4	107·4	10·6	96·8
X_9	Minor millets	200·0	80·0	10·0	70·0	—	—	—	—

(b) Programmed Allocation

The programmed allocation under category 1 and 2 has been shown in Table III. It is obvious from this table that the optimum income from the existing resources through programming was Rs. 5,603 and Rs. 11,001 for category 1 and 2 respectively. All the *rabi* land was used up in both the categories but a part of the *kharif* land was left unused. The cash expenses were completely used up in category 2 while in category 1 the cash expenditure was not limiting.

TABLE III—CROP PLAN ACTUAL AND PROGRAMMED UNDER CATEGORY
1 AND 2 FARMS, JABALPUR : 1967-68

(acres)

Crops			Category 1		Category 2	
			Actual	Programmed	Actual	Programmed
Wheat	..	..	10·17	6·64	15·45	23·13
Paddy	..	..	5·67	5·48	7·38	4·59
Masoor	..	..	1·96	—	2·57	—
Gram	..	..	4·16	—	3·29	—
Pea	..	..	0·26	11·49	0·33	1·21
Jowar	..	..	0·38	—	—	—
Arhar	..	..	0·18	—	—	—
Urad	..	..	0·82	—	—	0·07
Income (Rs.)	..	..	5,089	5,603	9,735	11,001
Increase in income by programming (per cent)				10		13

(c) Crop Plan Actual and Programmed

The actual land programmed crop plans for the given resources is shown in Table III. It is evident from this table that the programmed crop plan has selected only three crops out of eight crops in category 1 and only four out of five in category 2. The largest area in category 1 was devoted to pea followed by wheat and paddy. Pea as a vegetable crop has a better market at Jabalpur city and fetches a good price. In category 2 wheat shared the largest programmed area followed by paddy, pea and *urad*. Dwarf varieties of wheat and paddy grown by this category gave higher yield and profit per unit of land. The programmed area under pea also increased from 0.33 acre to 1.21 acre in category 2.

(d) Marginal Value Products of Limiting Resources

The resources found to be limiting were *rabi* land, total crop acreage,[1] cash expenses and pulses restrictions in category 2 while in category 1 the

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1. Average total acreage found in the sample was used as a restriction.

limiting resources were *rabi* land, total crop acreage and straw, as shown in Table IV. The total crop acres had a marginal value product of Rs. 165.87

TABLE IV—MARGINAL VALUE PRODUCTS OF LIMITED RESOURCES UNDER
CATEGORY 1 AND 2 FARMS, JABALPUR : 1967-68

Resource or supplies			Category 1			Category 2		
			Range (acres)		MVP (Rs.)	Range (acres)		MVP (Rs.)
			From	To		From	To	
Rabi land	..	..	16·97	23·62	99·70	16·28	24·52	221·33
Total crop acreage	..	..	18·14	24·30	165·87	28·97	31·26	93·75
Straw (kg.)	..	..	2192	5611	0·02	—	—	—
Cash expenses (Rs.)	..	..	—	—	—	1,312·62	1,467·85	2·01
Pulses (kg.)	..	..	—	—	—	76·60	393·94	0·17

in category 1 and of Rs. 93.75 in category 2. Due to dwarf varieties of wheat *rabi* land seems to be most limiting in category 2 because one acre of additional *rabi* land will enhance income by Rs. 221.33.

(e) *Actual and Programmed Production*

Programming with existing resources as shown in Table V, the aggregate production increased only by six per cent in category 1. The six per cent increase in aggregate production in category 1 was entirely due to rise in production of pea by 106 per cent more than the existing level. A decrease in the production of wheat by 35 per cent and of paddy by 3 per cent was brought about

TABLE V—ACTUAL AND PROGRAMMED PRODUCTION UNDER
CATEGORY 1 AND 2 FARMS, JABALPUR : 1967-68

Crops	Category 1			Category 2		
	Actual (kg.)	Programmed		Actual (kg.)	Programmed	
		Same resources			Same resources	
		(kg.)	Percentage change		(kg.)	Percentage change
Wheat	2907	1898	—35	7144	10741	+50
Paddy	1807	1747	—3	3332	2072	—38
Masoor	432	—	—	552	—	—
Gram	867	—	—	896	—	—
Pea	68	3031	+106	96	354	—
Arhar	31	—	—	—	—	—
Urad-moong	88	—	—	—	7·5	—77
Jowar	100	—	—	—	—	—
Minor millets	4	—	—	—	—	—
Grand total (production)	6294	6675	+ 6	12020	13174·5	+10
Net income (Rs.)	5,089	5,603	+10	9,735	11,001	+13

to accomplish a 106 per cent increase in pulses. The shallow rooted crops like wheat and paddy have poor yields due to lack of nutrients and soil moisture in the upper strata of soil. The pulse crops (pea) are deep rooted and can extract plant food as well as soil moisture from greater depth and, hence, are able to give better performance. In category 2 the programme showed

a ten per cent increase in aggregate production which was brought about by increasing wheat production by 50 per cent. The corresponding decrease in paddy production was 38 per cent.

(f) Potential Gains

In order to assess the potential gain of advanced technology and resource expansion separately the necessary computations were made and the results are given Table VI.

(i) *Technological*: Assuming that the traditional farmers can be educated to attain the advanced technology in due course of time, the co-efficients of category 2 were used to programme the resources of category 1 to show income change through advanced technology and the results are presented in Table VI.

TABLE VI—POTENTIAL INCREASE IN INCOME WITH EXISTING RESOURCES AND TECHNOLOGICAL CHANGE ON CATEGORY 1 FARMS, JABALPUR

Actual income (Rs.)	Programmed income		Percentage gain in income		Percentage net gain with technological change
	T_1 (Rs.)	T_2 (Rs.)	T_1	T_2	
5,089	5,603	7,234	10	42	32

Note: T_1 = With traditional technology. T_2 = With advanced technology.

In the above table an attempt has been made to isolate and measure the contribution of advanced technology as is being practised by the category 2 farmers. It is found that the net gains by technology alone are to the tune of 32 per cent.

(ii) *Resource expansion*: The marginal value products of resources have indicated that the crop acreage and cash inputs were fairly high in category 2. As the climate of Jabalpur district allows double cropping, both the resources were expanded by 50 per cent to examine the potential rise in income. Necessary iterations to achieve these results were made and the results are summarized in Table VII.

TABLE VII—POTENTIAL INCREASE IN INCOME DUE TO EXPANSION OF RESOURCES ON CATEGORY 1 AND 2 FARMS, JABALPUR

Resource position	Category 1			Category 2		
	Actual income (Rs.)	Programmed income (Rs.)	Percentage change	Actual income (Rs.)	Programmed income (Rs.)	Percentage change
Existing resources	5,089	5,603	10	9,735	11,001	13
50 per cent more cropping and cash	—	7,299	43	—	13,806	41
Net gains (per cent)			33			28

The table reveals that the contribution of additional resources to the potential gains through programming was 33 per cent and 28 per cent in Category 1 and 2, respectively.

Conclusions

In the study both the categories of farms were close to optimal resource allocation in Jabalpur district. Similar findings were reported by several workers.[2] The potential rise in income largely depends upon the level of technology and extent of resource expansion on the farms. However, if the gains of technology and resource expansion are assumed to be additive, the income rise potential exceeds 60 per cent. In fact there would be an interaction possibly to an advantage. But these conclusions are based only on one-year data and need further study.

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2. (a) Raj Krishna, "Rapporteur's Report and Summary of Group Discussion on Economics of the Cropping Pattern," *Indian Journal of Agricultural Economics*, Vol. XVIII, No. 1, January-March, 1963, p. 181, and (b) John W. Mellor: The Economics of Agricultural Development, Cornell University Press, Ithaca, New York, U.S.A., 1966, p. 135.

COSTS AND RETURNS OF CONVERTING DRY LANDS
INTO IRRIGATED AREAS

A. SACHIDANANDAM

Research Officer
Programme Evaluation Organisation
Planning Commission, New Delhi

SUMMARY

Conversion of dry land into wet land is made possible by irrigation under canals, tanks, tube-wells and wells. This paper confines itself to canal irrigation only. At macro level the problem consists of tangible costs like expenditure incurred on the construction of dam, digging canals and distributaries, maintenance staff for extension work and research, and provision of loans for developing ayacut. The primary direct benefits consist of increased area under irrigation and increased revenue to the State exchequer. It has primary indirect benefits also in the form of higher land values, greater capital formation covering increased investment on farm and other assets; better wages paid to human and bullock labour; and greater consumption of agricultural inputs. At the micro level the costs and yields of cultivating irrigated and unirrigated holdings reflect the expenditure involved in converting dry land into irrigated area. Facts available about flow irrigation through canals, however, point to the difficulties faced by the authorities in terms of organization, extension and research for developing ayacut. The story of all irrigation projects is essentially a human problem where the local cultivator has to change from his traditional dry cultivation to the cultivation of crops under irrigated conditions. The problem is extremely difficult and delicate for him to adjust to conditions of providing light irrigation judiciously to dry crops. If the Department of Agriculture does not provide a suitable pest-resistant variety that responds admirably to light irrigation, the struggle of the cultivator increases. Experience in Hirakud and elsewhere had shown that the ryot who adopted irrigation of dry crops had run into losses which he could compensate only by raising perennial or wet crops. Thus except for area on which irrigated dry crops had to be raised, the ayacut under wet and perennial crops developed substantially since, despite their higher costs of cultivation, wet crops, sugarcane and cash crops provided very high profits to the ryot.

DIVERSIFICATION OF CROPPING TO REDUCE INSTABILITY
IN DRY FARMING AREAS OF MAHARASHTRA

M. K. SHINGAREY

Department of Agricultural Economics
Punjabrao Krishi Vidyapeeth, Akola

SUMMARY

About 92 per cent of the cropped area in the State is dependent on rainfall. Instability in weather conditions from year to year gives rise to instability in crop output, which in turn affects the prices and finally the income of farmers. Crop diversification as a measure of security against unfavourable weather conditions is an age-old agronomic practice. Diversification apart from reducing instability of crop output permits better utilization of resources, maintenance of soil fertility and aids in controlling weeds. The idea underlying crop diversification is 'if one crop suffers other will be better.'

Diversification model described below has been employed to determine the pattern of resource allocation between two different crops. The efficacy of diversification depends on the associations between two crops. Hence correlation coefficients of yields, prices and gross income for the principal crops grown in the State have been determined. Diversification model employed to determine the coefficient of variation (CV) is :