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INDIAN SOCIETY OF AGRICULTURAL ECONOMICS, BOMBAY resources to modify the environment with improved infrastructure to realise the potential of the existing varieties.

A cost-benefit analysis would have given more insights to this problem, but owing to our data constraint, it could not be attempted here. However, it is not rational for a country like India with differing dimensions and characteristics of agricultural growth in different regions to depend entirely on anyone of these two alternatives of investment and research. As Dantwala[20] has argued, in the long run the best policy-mix could be a combination of technology and public investment in agricultural infrastructure depending on the specificity of the country's temporal and spatial situation.

A STRATEGY FOR AGRICULTURAL GROWTH IN THE DRYLAND FARMING AREAS OF HARYANA

I. J. Singh and K. N. Rai*

The usual definition of growth of a particular sector is a sustained increase in its total and per capita product, most often accompanied by a sustained and significant rise in population. In order to have a sustained increase in a particular sector, stability in its production is the primary requirement. Therfore, between the twin problems of increased and stabilised agricultural production in the dryland tracts, stable agricultural production comes first in the planning priorities. As such, the present paper attempts to suggest suitable agricultural growth strategy via farm income stabilisation in dryland areas of Haryana.

METHODOLOGY

The data for this study were obtained both from farmers and secondary sources. Hissar, Sirsa, Bhiwani and Mohindergarh districts which form the major part of dryland tract of Haryana State were selected. The dryland tract selected for this study was divided into two zones based on averge yearly rainfall. The Hissar zone had 328 mm. annual rainfall. The Narnaul zone had more than 328 mm. annual rainfall. Field data on input and output for crops and dairy enterprises on farms were obtained from 240 randomly selected farmers (78 small, 42 medium and 30 large from Hissar zone; and 52 small, 23 medium and 15 large from Narnaul zone). Secondary data on yield and prices of food and non-food crops for ten years (1965-66 to 1975-76) were obtained from the Statistical Abstract of Haryana. Secondary data on dairy enterprise were collected from the office of the Chief Superintendent, Government Livestock Farm, Hissar. The input-output coefficients for the recommended crops

20. M. L. Dantwala, "Future of Institutional Reform and Technological Change in Indian Agricultural Development", *Economic and Political Weekly*, Vol. XIII, Nos. 31, 32 and 33, August 1978, pp. 1299-1306.

* Professor and Head, and Assistant Scientist, respectively, Department of Agricultural Economics, Haryana Agricultural University, Hissar.

and livestock practices were derived from the farms of the progressive farmers of the respective zones.

THE MODEL

The optimal farm plans for income stabilisation at varying level of income risk involved were developed as follows:

The standard linear programming model was used to develop optimum farm plans for each holding size in the two selected dryland zones. Risk evaluation model developed[1] to evaluate the income risk of the optimum plans was used to evaluate the income risk of the optimum plans. In the risk evaluation model, the expected product generated by a combination of activities can be expressed as:

$$E\ (Z) = \sum_{j=1}^{n} X_j^{*}\ ,\ j=1 \qquad \ldots\ldots \quad (1)$$

$$X_j^{*} = x_j\ c_j$$

where x_j = level of activity and c_j = gross margin of activity;

$$\text{Therefore, } E\ (Z) = \sum_{j=1}^{n} x_j\ c_j \qquad \ldots\ldots \quad (2)$$

and expected variance is

$$V\ (Z) = \sum_{j=1}^{n} v(x)_j = 1 \text{ - - - - } n \qquad \ldots\ldots \quad (3)$$

However, since the x_j(s) are not independent, the variance of a combination of activities would be equal to the sum of variances of individual activities and the covariance between activities. That is,

$$V\ (Z) = \sum_{j=1}^{n} x_j^2\ v_j + 2 \sum_{\substack{i,\ j=1 \\ j \neq i}}^{n} x_i\ x_j\ k_{ij} \qquad \ldots\ldots \quad (4)$$

where v_j = variance of activity j,

k_{ij} = covariance between activities i and j.

Finally, the total income risk involved in an optimum plan was taken as a constraint and the income risks involved in growing production activities were considered as resource requirements in the linear programming model. The linear programming model used for calculations is:

$$\text{Maximize } (Z) = \sum_{\substack{i,\ j=1 \\ j \neq i}}^{n} a_{ij}\ c_j\ x_j \qquad \ldots\ldots \quad (5)$$

Such that

$$\sum_{i=1}^{n} a_{ij}\ x_j \leqslant b_i \qquad \ldots\ldots \quad (6)$$

$$x_j \geqslant 0 \qquad \ldots\ldots \quad (7)$$

and

$$\sum_{j=1}^{n} x_j^2\ v_i + 2 \sum_{\substack{i,\ j=1 \\ j \neq i}}^{n} x_i\ x_j\ k_{ij} \qquad \ldots\ldots \quad (8)$$

1. M. C. Murphy, "Risk Evaluation in Farm Planning: A Statistical Approach", *Journal of Agricultural Economics*, Vol. XXII, No. 1, January 1971, pp. 61-71.

where λ is a given level of total income risk of a plan. Five values of λ were taken for each holding size-group in each zone, and the optimum plans at each given value of λ were worked out. The first value of λ represents the total income risk at the optimum farm plan. The second, third, fourth and fifth values of λ represent 10, 20, 30 and 40 per cent less total income risk than the total income risk at the optimum farm plan.

The Activities

Ten crop activities, *viz.*, sorghum, pearl-millet, green gram, cluster bean, pearl-millet mixed with cluster bean and green gram, cotton, wheat, chickpea, barley and oilseeds were included in the model. One dairy activity was also included. Besides, capital borrowing and minimum fodder quantity were also considered in the model.

The Constraints

Land is included as one of the constraints in the model. Considering irrigation restriction and crop seasons, four land constaints, *viz.*, irrigated and unirrigated *kharif* as well as *rabi* land were identified and included in the model. Labour hiring activity was not considered due to already surplus human and bullock labour on the selected farms. Capital (credit) was considered as one of the over-riding barriers for growth of dryland farms. Hence, it was included as one of the binding constraints in the model. Restriction on minimum acreage under pearl-millet to meet the family consumption requirement was also included in the model. Similarly, minimum fodder acreage was included as a constraint to meet the feed requirements of the farm animals.

Coefficients

In the absence of time-series data on cost of production, the risk coefficients (variance and covariance) used in the programming model were derived from the gross returns estimated for the ten-year period, *viz.*, 1965-66 to 1975-76. Input-output coefficients used in the programming model were developed on the basis of inputs used and output produced for different enterprises on the progressive farms of the respective zones. The input-output coefficients for these progressive farms were taken as a proxy for the dryland technology to be viable and feasible under existing resource situation.

RESULTS AND DISCUSSIONS

1. Rainfall Characteristics and Percentage Occurrence of Droughts in Kharif Season

Table I reveals higher variability of rainfall in Hissar and Narnaul zone from year to year having 39 per cent and 42 per cent coefficient of variation (CV) respectively. This variability, if viewed in the context of negligible irrigation facilities, shows the magnitude of the fluctuation in rainfed agriculture in Haryana. The potential evaporation and rainfall observation of Narnaul which received less than one per cent higher rainfall than its potential evapora-

TABLE I—RAINFALL CHARACTERISTICS OF THE SELECTED LOCATIONS IN THE STUDY AREA

Station	Seasonal rainfall (mm.)	S.D.	CV (per cent)	Seasonal potential evaporation (mm.)	Number of rainy days per year	Data for period studied
Hissar	328	128	39	516	25	1915-70
Narnaul	456	192	42	452	35	1950-70

tion shows a deficit soil moisture status for growing a single good crop in a year. The position of Hissar was even worse, receiving only 60 per cent rainfall to its potential evaporation.

The percentage occurrence of drought during different months of *kharif* season worked out in Table II indicates 59 per cent possibility of late drought in Hissar zone as compared to 51 per cent possibility of late drought in Narnaul zone. The possibility of early drought (June-July) is more for Narnaul zone being about 44 per cent as against approximately 38 per cent for Hissar zone. The possibilities of mid-season drought are 27 per cent and 31 per cent for Narnaul and Hissar zones respectively. These findings show less possibility of mid-season drought in Narnaul zone as compared to early and late droughts, whereas in Hissar zone the possibility of mid-season and early droughts was almost equal.

TABLE II—PERCENTAGE OCCURRENCE OF KHARIF SEASON DROUGHTS

	June	July	August	September	October	November	Data for period studied
Hissar	47	30	31	59	63	91	1915-70
Narnaul	58	30	27	51	—	—	1950-70

2. *Gross Income Variability of the Crops Grown*

In Hissar zone the gross income variabilities in the case of pearl-millet and barely were 45.75 and 49.40 per cent respectively. In the case of wheat and cotton, both yield and price variabilities were low with the result that gross income variabilities were also low (Table III). On the other hand, the yield variabilities of green gram and sorghum were low but the price variability was relatively high, resulting in moderately high gross income variability. In Narnaul zone, gross income variability varied from a lowest of 27.79 percent for wheat to a highest of 64.71 per cent for pearl-millet. Green gram stands second from the botton. Similar to the Hissar zone, gross income variability of the crops in Narnaul zone also corresponds closely to the yield and price variabilities of the respective crops.

TABLE III—YIELD, PRICE AND INCOME VARIABILITY OF MAJOR CROPS: 1965-66 to 1975-76

	Hissar zone			Narnaul zone		
	Yield	Price	Income	Yield	Price	Income
1. Sorghum	16·55	40·89	50·98	23·97	40·89	49·27
2. Pearl-millet ..	23·03	45·31	45·75	45·42	45·31	64·71
3. Green gram ..	21·10	49·84	48·08	10·71	49·84	32·69
4. Cotton	23·75	32·72	38·92	—	32·72	—
5. Wheat	0·29	27·57	22·74	10·32	27·57	27·79
6. Chickpea	35·25	40·37	26·28	56·39	40·37	41·30
7. Barley	27·09	35·48	49·40	24·30	35·48	56·18
8. Oilseeds	25·51	32·46	18·61	35·93	32·46	65·57

3. *Strategy for Stabilising Farm Incomes*

Table IV shows the combination of crop and livestock enterprises which give maximum income with minimum income variance for the small, medium and large farm size-groups of Hissar and Narnaul zones respectively. On small farms, the preferred way to obtain Rs. 8,038.02 gross farm income is to grow 1.00,0.18, 1.32, 1.40 and 1.00 hectare of hybrid pearl-millet, sorghum, American cotton, Mexican wheat and improved variety of chickpea respectively in addition to maintaining one buffalo. This combination shows a standard error of Rs. 2,408. On medium farms, the preferred way to produce Rs. 16,821.56 gross farm income is to grow 1.20, 1.50, 1.22, 1.30, 1.00, 2.00,0.90 hectare of sorghum, hybrid pearl-millet, American cotton, improved variety

TABLE IV—STANDARD ERRORS FOR VARIOUS INCOME LEVELS

(*Rs. per farm per year*)

Hissar zone		Narnaul zone	
Income	Standard error	Income	Standard error
Small holdings			
8,038·02	2,408·00	8,256·34	2,015·48
7,604·29	2,296·48	7,759·34	1,915·48
7,270·56	2,179·69	6,438·32	1,809·96
6,936·83	2,056·28	6,102·32	1,699·82
6,487·02	1,924·55	5,510·32	1,451·21
Medium holdings			
16,821·56	5,382·00	16,853·95	4,125·60
15,579·20	5,341·74	16,013·55	3,920·12
15,069·98	5,178·76	14,733·55	3,703·19
14,626·29	4,984·75	13,789·55	3,472·75
14,151·41	4,851·22	13,383·23	2,958·49
Large holdings			
24,962·74	6,972·99	26,105·05	7,719·00
24,510·79	6,847·05	25,185·90	7,360·88
23,860·12	6,601·42	24,065·90	6,983·83
23,220·20	6,436·36	23,041·90	6,585·22
22,576·33	6,248·15	20,849·90	5,705·07

of green gram, cluster bean, Mexican wheat and improved variety of mustard respectively, in addition to keeping three bufflaloes with standard error of Rs. 5,382. Similarly, on large farms the preferred way to obtain gross farm income of Rs. 24,962.74 with a minimum standard error of Rs. 6,972.99 and a lower income limit of Rs. 11,295.68 is to raise 0.60, 3.00, 3.70, 2.00, 3.00, 2.60 and 2.83 hectares of sorghum, hybrid pearl-millet, improved variety of green gram, American cotton, Mexican wheat, improved variety of chickpea and barley respectively. Besides the above mentioned crops, the large farmer has to raise three buffaloes (Table IV). The remaining four plans for the small, medium and large farm sizes for Hissar zone with reduced income standard errors can be seen from Table IV.

In Narnaul zone, on small farms, the best possible way to produce an income of Rs. 8,256.34 is to raise 0.09, 0.39, 0.17, 2.15, 0.48, 1.60 and 0.40 hectares of sorghum, hybrid pearl-millet, improved variety of green gram, mixed crop, Mexican wheat, improved variety of chickpea and improved variety of mustard respectively along with maintaining a buffalo. This is expected to yield a minimum standard error of income to the tune of Rs. 2,015.48. A farmer of medium farm size is required to grow 0.40, 0.80, 4.15, 1.20, 3.30 and 0.60 hectares of sorghum, hybrid pearl-millet, mixed crop, Mexican wheat, improved variety of chickpea and improved variety of mustard respectively with two buffaloes which will give him the expected income of Rs. 16,853.95. This enterprise combination will result in a standard error of Rs. 4,125.60. Similarly on large farms, to get a gross farm income of Rs. 26, 105.05, the farmer has to grow 0.80, 1.00, 1.30, 6.90, 2.10, 4.00 and 2.00 hectares of sorghum, improved variety of cluster bean, hybrid pearl-millet, mixed crop, Mexican wheat, improved variety of chickpea and improved variety of mustard respectively. This enterprise combination shows a standard error of income of Rs. 7,719. The remaining four farm plans at successive lower incomes for small, medium and large farm sizes are given in Table IV.

These five plans with different resource requirements and levels of risk involved give a good range of choice to the farmers according to their resource constraints for the continuously increasing stable farm incomes. As such, the above finding supports the concept of graded technology. That is, dry-land farmers having low resource base, low technical know-how and low risk bearing capacity may not be able to adopt the full package of recommended dry farming technology. The findings in Table IV facilitate the adoption of dry farming technology in phases depending upon the farmers' resource position and risk bearing capacity. This phased adoption of recommended dry farming technology will reduce the financial requirement of the farmers and thereby reduce the risks involved in investment and increase the risk bearing capacity through additional income generation. This will also motivate the farmers to adopt recommended dry farming technology.

Policy Implications

On the basis of the findings cited above, the following policy implications emerge:

(1) The cropping pattern for Hissar zone should have relatively more area under short duration crops followed by medium duration crops whereas in the case of Narnaul zone, the cropping pattern should have relatively more area under long duration crops followed by medium and short duration crops.

(2) Because of high risk involved in dryland farming, it is necessary to develop a combination of farm plans for each holding size based on varying levels of expected net farm income and risk involved. It will provide a good range of choice for the farmers to choose from on the basis of their resource structure, financial position and risk bearing capacity.

(3) In the short run, planning efforts need to be made to improve the existing cropping pattern of the farmers through variety substitution and acreage reallocation based on the farmers' own resources, family needs and income variability of different crops. Introduction of new enterprises may be taken in phases.

(4) In the dry farming areas, livestock of non-descript breed raised mainly on crop residues and by-products is an important supplementary enterprise.

THE SCOPE FOR A NEW SURGE OF AGRICULTURAL DEVELOPMENT IN THE DRYLAND OR DROUGHT-PRONE AREAS OF INDIA

Alfred S. J. Jacob*

It is worth recalling that the Planning Commission's Memorandum on the Fourth Five-Year Plan defined the backward regions as those regions which are also chronically drought affected with mainly rainfed crops. These areas were forgotten in the desperate effort to increase total agricultural production through the Intensive Agricultural Development Programme and the High-Yielding Varieties Programme. It is in these regions that there is an urgent necessity to develop suitable agricultural practices and techniques to raise agricultural production and productivity, so as not to have festering pockets of poverty in the country. The case for development becomes all the more stronger when we observe that even if all of the irrigation possibilities are fully realised in these regions, still half of the cultivated area will continue to face the problems of drought which has largely been responsible for the failure in achieving our objective for self-sufficiency in foodgrains. The crying need for a more realistic approach towards farming in these rainfed dryland areas is felt even more, with the increasing realisation that the occurrence of drought is, more or less, inevitable.

Though a number of hybrids have been developed of short duration and with high-yielding power, they are primarily taken up under the *kharif* season and for the *rabi* season the local varieties are more popular. This is because

* Teacher (Economics), Ahmednagar College, Ahmednagar (Maharashtra). The author has been associated with many agricultural development projects implemented by the Centre for Studies in Rural Development, Ahmednagar College.