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9. ABSTRACT

This study examines factors constraining small farmers from intensifying production through adoption of new cereal varieties, increasing fertilizer use, dairying, and changes in cropping combination. The primary data source is a cross-section survey of 120 farmers in Surat District, for 1971-72. The sample is drawn equally from high, middle and low income villages, but is stratified so that the proportion of small farmers is similar to that in India as a whole.

The study concludes that expanding co-operative credit availability would increase fertilizer use, and encourage a shift to higher income crops (new varieties and sugarcane) on irrigated small farms. Greater flexibility of loan repayment would make small farmers more willing to use available credit.

On unirrigated farms, research must play a vital role both to increase yield levels, and to develop varieties or cultivation practices which will minimize yield losses in years of low rainfall.

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The Interaction of Credit and Uncertainty in Determining Resource Allocation and Incomes on Small Farms, Surat District, India

By

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PREFACE

It has for some time been fashionable to be concerned for the small farmer, to espouse programs for him and to criticize the failure of such programs. There has been, however, little effort at rigorous, quantitative analysis of the problems and opportunities of small farmers in accepting new production technologies and labor intensive crop and livestock enterprises. It has become increasingly clear, in part from Michael Schluter's earlier work, that simplistically designed credit programs are not a sufficient condition for the solution to the problems of the small farmer. But, to devise better, more complete programs requires detailed study of small farmers, diagnosis of the specifics of their problems and from that development of appropriate programs.

Michael Schluter, following in the tradition of our research program, provides a detailed, micro study of comparative small farmer behavior with particular reference to new technologies and labor intensive enterprises. In keeping with his earlier findings, Schluter gives special emphasis to small farmer response to risk and uncertainty, and makes imaginative use of a programming model to measure risk and uncertainty effects. This analysis provides the basis for analysis of various policy alternatives for increasing the participation of small farmers in economic growth.

This work is part of a larger effort supported by USAID at Cornell University, dealing with the relation between technological change in agriculture and employment and income distribution. The basic thrust of the research undertaken in this program is positive – based on the assumption that technological change which increases the supply of food grains, the basic wages good and item of expenditure of the poor, is basically desirable for the poor; and the recognition that many economic and institutional aspects of poverty may reduce the extent to which the poor obtain the innate benefits. In diagnosing the policy needs for broadening participation in the increased income from new agricultural technologies it is necessary to consider the direct and indirect effects of increased income – a consideration which has carried our analysis over a broad range of studies of expenditure patterns, labor supply relations, analysis of labor absorption in industry generally and small scale industry specifically, relation between labor absorption in agriculture and various demand and policy variables. And, as in this study, problems of small farmers.

Small farmers are of course not the poorest of the rural poor, but if untreated they may easily drop into the poorest class of landless laborers, while they offer special opportunities for income growth, particularly in the dynamic context of generally rising rural and urban incomes. Michael Schluter's study adds immensely to our knowledge of these processes and provides the basis not only for more detailed further research but also for immediate improvement in policy for reaching the small farmer.

This study is another effort in a continuing, informal interchange and cooperative research effort between researchers of the Indian Institute of Management, Ahmedabad, and Cornell University. I continue to be grateful for the opportunity for research which IIM has provided and particularly for the continuing advice of various members of its faculty. This, as previous studies, reflects their generous contributions.

JOHN W. MELLOR

Ithaca, New York
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TABLE OF CONTENTS

Chapter		Page
I	INTRODUCTION	1
II	CREDIT, UNCERTAINTY AND AGRICULTURAL INCOMES: A THEORETICAL FRAMEWORK	2
	Small Farmers' Resource Constraints	2
	The Small Farmer's Utility Function	4
	Deriving the Efficient Set of Farm Plans	5
	The Interaction of Credit and Uncertainty	5
	Conclusions	6
III	THE IMPACT OF INTENSIFICATION ON THE SUPPLY OF FAMILY LABOR AND DEMAND FOR HIRED LABOR ON SMALL AND LARGE FARMS	6
	The Theoretical Model	6
	Inter-crop Difference in Labor Used per Acre	8
	Family Labor Supply on Unirrigated Farms	9
	Family Labor Supply on Irrigated Farms	11
	Demand for Hired Labor on Farms Using Family Labor Only for Supervision	14
	Conclusions	14
IV	THE ROLE OF COOPERATIVE CREDIT IN SMALL FARMER ADOPTION OF THE NEW CEREAL VARIETIES	15
	Cooperative Credit in the Small Farmer's Supply of Capital	15
	The Importance of Cooperative Credit at Different Stages of the Diffusion Process	18
	Factors Influencing Small Farmers' Decision to Adopt	20
	Conclusions	23
V	THE EFFECT OF CAPITAL CONSTRAINTS AND UNCERTAINTY ON THE DEMAND FOR CHEMICAL FERTILIZERS	23
	Evidence that Shortage of Working Capital Constrains the Demand for Fertilizer on Irrigated Farms	24
	Evidence that Uncertainty Constrains the Demand for Fertilizer	25
	Implications for Policy	26
VI	INCREASING MILK PRODUCTION ON SMALL FARMS	27
	The Profitability of Dairying	27
	Increasing Buffalo Productivity	28
	Increasing the Number and Quality of Buffaloes on Small Farms	29
	Conclusions	33
VII	CHOICE OF CROPPING PATTERN ON UNIRRIGATED AND IRRIGATED FARMS	33
	Part A. Unirrigated Farms	33
	The Estimated EV Frontier and Farmer's Observed Behavior	36
	Effects of Changing Resource Availability	39
	Cotton versus Groundnut: A Regression Model	40
	Part B. Irrigated Farms	40
	The EV Frontier for the Representative Farm	41
	Sugarcane versus a Rice-Wheat Combination	42
	Policies to Reduce Uncertainty	43
	Conclusions: Helping Farmers Bear Uncertainty	45
VIII	CONCLUSIONS AND IMPLICATIONS FOR POLICY	46
	Increasing Incomes Through Intensification	46
	Policy Measures to Raise Incomes of Small Farmers	47
APPENDIX A:	Appendix Tables	49
APPENDIX B:	Marketing Handicaps of the Small Farmer	69
APPENDIX C:	Crop Calendar for Surat District	72
APPENDIX D:	Items Included in Expenditure per acre and List of References for Tables 8, 9, 12	73
SELECTED BIBLIOGRAPHY		74

CHAPTER I
Introduction

The problems of small farmers are receiving increasing attention in a policy context in India for two reasons.[1] They contribute a significant proportion of agricultural production and marketed surplus, so that a substantial increase in their productivity would affect national income significantly. Secondly, they form a large part of the rural poor, so an increase in their productivity would have a major impact on levels of social welfare, and limit the number of those requiring direct welfare assistance. The fear that the new varieties have increased income disparities in rural areas has increased awareness that small farmers face special problems in production.

The objective of this study is to identify factors constraining intensification on small farms. Having examined adoption of new varieties, levels of labor and fertilizer use, dairying, and changes in cropping pattern as ways to intensify, we consider policies to overcome the effective constraints, identified as credit and uncertainty.

The definition of a small farmer should rest on some income criterion, since low income is the primary reason for concern for this subset of farmers. A definition related to size of operational holding approximates to income, and has the additional advantage of indicating the potential income of the farm family;[2] it is also easily measurable. Hence, farmers with a net cultivated acreage of two to five acres have been defined by the Small Farmer Development Agency (S.F.D.A.) as being small farmers. However, an acreage definition taking the irrigation factor into account would have been more closely correlated with income, and with the income-generating potential of the land. Our data from canal-irrigated Surat district indicate that net returns over variable costs per acre are six times greater on irrigated relative to unirrigated land or five times greater if sugarcane acreage is excluded.[3] This disparity is reduced a little if associated dairying income is added, but some weighting of irrigated relative to unirrigated land would result in a closer correlation between the measure of farm size and income.

In this study, a small farmer is defined as one with net cultivated acreage of less than five acres, because this is the size limit being used in policy formation for small and marginal farmers in India.[4] However, we differentiated at all points in the analysis between irrigated and unirrigated small farms, and at many points, farm size is treated as a continuous variable in assessing its impact on farmers' behavior.

Using net cultivated acreage of less than five acres as a working definition of a small farm, from All-India data 33 of the 84 million male workers belonged to families owning small farms in 1960-61, and these families constituted 42 percent of rural households in 1960-61, with 23 percent of the operated acreage.[5] These farms generated about 25 percent of the marketed surplus prior to the introduction of the new varieties.[6]

Surat district in South Gujarat was selected for a detailed survey of 120 farmers; this survey is the main source of data for the analysis. The primary criterion in selecting the district was availability of time-series data for crop yields and prices, which are required for an objective measure of uncertainty. Bardoli taluka, the sub-district selected, is part of a heavy rainfall tract only 30 miles from the coast, with extensive canal irrigation facilities. Appendix Table 1, showing selected economic and social indicators for the sub-district relative to the district, the state, and India as a whole, shows that small farmers form a slightly lower proportion of cultivating households in the sub-district relative to the national average, and a relatively high proportion of gross-cropped acreage is irrigated. There is a relatively high population density, and high proportion of scheduled tribal people.[7] A crop calendar for the district is shown in Appendix C.[8]

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[1]See, for example, Government of India, "Special Projects for Small Farmers, Marginal Farmers and Agricultural Laborers (A Note from the Ministry of Agriculture, New Delhi)," paper presented at Seminar on Rural Development for Weaker Sections, organized by the Indian Society of Agricultural Economics and Centre for Management in Agriculture, Indian Institute of Management, Ahmedabad, October 1972.

[2]Value of land is highly correlated with value of total assets in All-India data. See V. M. Jakhade, "Small Farmers and Co-operative Credit." *Seminar on Problems of Small Farmers* (Bombay: Indian Society of Agricultural Economics, June 1968), p. 82.

[3]The cost of irrigation per acre is much lower from a canal than from a pump, so the ratio of 1:6 would be reduced in a well-irrigated tract.

[4]B. Venkatappiah, "Small Farmers Development Agency – Outline of a Programme of Action," Address at 29th Annual Conference of the Indian Society of Agricultural Economics, Waltair, December 1969.

[5]Census of India, 1961, Vol. 1, Part II (A), Table BI, and Part III (11), Table BXII.

[6]D. Narain, *Distribution of the Marketed Surplus of Agricultural Produce by Size-Level of Holding in India, 1950-51*, Occasional Paper No. 2 (Delhi: Institute of Economic Growth, 1951). It seems unlikely that there was any great change between 1950-51 and the introduction of the new varieties in 1965.

[7]In the eastern part of the district, from which the low-income cluster of villages was selected, tribal people own and cultivate land. In the irrigated tracts, they only work as landless agricultural labor. All farmers selected from the low-income villages were tribal people.

[8]For a list of crops grown, by variety, and their characteristics in terms of yields, prices and duration, see Michael G. G. Schluter, "The Interaction of Credit and Uncertainty in Determining Resource Allocation and Incomes on Small Farms, Surat District, India," (Unpublished Ph.D. Thesis, Cornell University, 1973).

Five villages in the sub-district were selected to reflect differences in income; two were selected from the irrigated high-income zone, two from the partially-irrigated medium-income zone, and one from the unirrigated, low-income, tribal zone. From each cluster of villages, 40 farmers were randomly selected, using a stratified random sample. In each cluster, eight farmers had a net cultivated acreage 0 to 1.9 acres, 17 had 2.0 to 4.9 acres, eight had 5.0 to 9.9 acres and seven had over 10 acres. A high proportion were selected from the two to five acre group because these limits define farmers eligible for assistance from the S.F.D.A. in the district.[9] The questionnaire was canvassed five times in the irrigated zone and three times in the unirrigated zone between December 1971 and October 1972.

In Chapter II, we outline the conceptual framework within which credit and certainty emerge as the central and related problems of the small farmer, drawing on analysis of the relationship between the level of income and the variance of income developed by Markovitz,[10] and adapted for farmers' decisions in a linear-programming framework by Hazell.[11]

Factors influencing inter-farm differences in the labor input per farm and per crop are analyzed in Chapter III. A recursive system of equations is used to examine the demand and supply of family labor on small farms. The analysis indicates likely changes in the supply of family labor and demand for hired labor which may occur if small or large farms intensify production.

In Chapter IV, we examine the role of credit and uncertainty in small farmer adoption of the new cereal varieties. Survey data from Mehsana district in North Gujarat are used for comparative analysis with the Surat data, and macro-economic data for Gujarat State are used to examine the role of credit for widespread diffusion of the new varieties. A large number of micro studies undertaken by the Agro-Economic Research Centres all over India are used to estimate the profitability of the new varieties in a broader context.

In Chapter V, increasing levels of fertilizer application are examined as a means of raising incomes of small farmers. Specifically, we analyze the role of credit *availability* and uncertainty in determining year of first use of chemical fertilizers, and rates of application in 1971-72.

In Chapter VI, we consider constraints to expanding milk production on small farms. We analyze factors affecting milk yields per day per buffalo in milk, and factors determining the number of buffaloes owned by a farmer and their quality, as reflected in the value of the herd. We also consider the possibility of substituting buffaloes for bullocks on small farms, by providing alternative sources of bullock labor, and by mechanizing some operations.

Factors governing choice of cropping pattern are analyzed in Chapter VII. For unirrigated farms, we use parametric linear programming to estimate the relationship between income and uncertainty for alternative cropping combinations (the EV frontier), based on six years time-series data of crop yields and prices. We then examine how close each farmer operates to his estimated EV frontier. This analysis gives an indication of the extent to which farmers include the minimizing of uncertainty as part of their objective function, and provides insights into appropriate policies to raise incomes on unirrigated farms. For irrigated farms, we show the capital requirements, uncertainties and expected incomes of alternative cropping combinations; factors influencing acreage under sugarcane relative to a rice-wheat combination are then analyzed, as illustrative of the problems of capital shortages and uncertainty for small farmers, in the context of modernizing agriculture.

In the conclusions, we summarize the constraints for alternative methods to intensify production on small farms, and indicate the relevance of alternative policies to raise incomes of small farmers in view of these constraints.

CHAPTER II

Credit, Uncertainty and Agricultural Incomes: A Theoretical Framework

Small Farmers' Resource Constraints

In the short run, the inputs working capital, land and labor determine agricultural output and incomes. We first examine availbility of these resources to the small farmer, and then consider the small farmer's objective function to see how this may influence the allocation of available resources.

Labor

Small farmers have a relative abundance of family labor available, as shown by the high family workers to land ratio on small farms in the 1961 Census (see Appendix Table 2). Use of available family labor is an important determinant of a small farmer's income, which may be divided conceptually between returns to land and returns to family labor. In Chapter III, we analyze the effect of intensification on the supply of family labor for both on-farm and off-farm employment. However, if we assume

[9] Project Officer, "A Note on Small Farmer Development Agency, Surat," (Surat: Small Farmer Development Agency, 1971).

[10] H. M. Markovitz, *Portfolio Selection: Efficient Diversification of Investments* (New York: Wiley and Sons, 1959).

[11] P. B. R. Hazell, "Rational Decision-Making and Parametric Linear Programming for Combining Farm Enterprises Under Uncertainty" (Unpublished Ph.D. thesis, Cornell University, 1970).

a perfectly competitive labor market for hired labor, any "labor shortage" on small farm reflects only a shortage of working capital with which to hire labor.

Land

The most obvious solution for a small farmer is to buy or lease-in additional land. In a perfectly competitive land market, two factors should lead to a transfer of land towards the small farmer:

1. If we assume a diminishing marginal utility of money, the utility (of a given income) per acre is greater on a small farm.
2. If we assume diseconomies of scale, owing to difficulties of supervising a large, hired labor force, as suggested by the results of the farm management studies in the 1950's, productivity is greater on small farms.

However, imperfections in both land and capital markets prevent small farmers buying or leasing-in land. Sen argues that "a variety of regulations, traditional and modern, make renting out land a more hazardous occupation than lending capital; there are regulations about tenancy and customary rights of cultivators."[12] Mabro has suggested that the immobility of land results in imperfection of the market: "Family farms are not always able to rent either adjacent strips or pieces of land in the immediate neighborhood, and there is an economic limit to the number of separate plots an individual farmer can operate at a time."[13] He also points out that in an imperfect capital market, as we argue below, in which a small farmer or tenant finds it relatively difficult to obtain capital, optimal adjustments could be inhibited.

We conclude that land may be regarded as a fixed factor by small farmers in the short run, in the absence of a major institutional change such as land reform. In the Surat sample, the few farmers leasing-in land had more than five acres, and the only farmers leasing-out land had less than five acres.

Capital

In traditional agriculture the high interest rate may be accounted for by uncertainty;[14] it is not necessary to postulate moneylenders with monopoly power. In a perfectly competitive capital market under conditions of certainty, Knight has summarized the eclectic theory of interest as follows:[15]

> *Other things being equal, the investment of resources should be carried to a point of equilibrium at which the amount of value income and the amount of value which must be sacrificed to create it become equal to every person in the system.*

The greater the uncertainty, for any given marginal productivity of investment function, the smaller the supply of savings, since uncertainty reduces the amount individuals are willing to save for any expected rate of return. Thus, for demand and supply to remain in equilibrium, the price of capital has to rise.

A second consequence of uncertainty is that small farmers have to pay a relatively high price for capital. If the price at which an individual is willing to lend depends on certainty of repayment, a small farmer with low assets is a greater credit risk, and therefore is charged a relatively high price. In the sample low-income villages, most small farmers paid 25 percent interest to moneylenders, whereas large farmers paid 12½ percent[16] (see Appendix Table 25).

With modernizing of agriculture, a huge shift in the production function raises the marginal productivity of capital and thus the demand for investible funds. However, aggregate supply is inelastic, especially for the small farmer. Large farmers may meet part of the increased demand out of savings; often this exacerbates problems of small farmers, because previously these funds had been made available from large farmers acting as moneylenders in the village. This may account in part for the rapidity with which moneylenders' share in the total credit supply fell in the 1960's.[17] Small farmers borrow heavily in the kharif season and are heavily in debt,[18] so any increase in their incomes is unlikely to lead to increased savings in the short run. The added supply from cooperatives only partially meets the demand, because supply is inadequate to the individual under the crop loan system,[19] and the low interest rate charged by the cooperatives further increases demand. Hence, demand for cooperative credit is often greater than supply in areas with technological change.

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[12] A. K. Sen, "Peasants and Dualism With or Without Surplus Labor," *Journal of Political Economy*, Vol. 74, No. 4 (October 1966), p. 425.

[13] Robert Mabro, "Employment and Wages in Dual Agriculture," *Oxford Economic Papers*, Vol. 23, No. 1 (November 1971), p. 402.

[14] We follow Knight's distinction that when an objective statement can be made about the probability of an event occurring, the situation is one of risk, and when no objective statement may be made, the situation is one of uncertainty. See F. H. Knight, *Risk, Uncertainty and Profit*, 1921 (Reprints of Economic Classics, Augustus M. Kelley, Bookseller, 1964), Ch. 7, p. 197.

[15] *Ibid.*, p. 164.

[16] In the middle-income villages, moneylenders had been completely displaced by cooperatives, and in the high-income villages, farmers relied almost entirely on their own funds.

[17] See H. C. Jain, "Growth and Recent Trends in Institutional Credit in India," *Indian Journal of Agricultural Economics*, Vol. 26, No. 4 (October-December 1971), p. 555.

[18] Jakhade, *op. cit.*

[19] Gokul O. Parikh and U. S. Sharma, "Some Reflections on Co-operative Short-Term Credit," paper presented at the Second Gujarat Economic Conference, Vallabh Vidyanagar, India, 1970.

The Small Farmer's Utility Function

In economic theory, with the assumption of perfect knowledge, i.e. certainty, the individual producer behaves "rationally" if he maximizes net returns.[20] In situations of uncertainty, the individual producer is assumed to be averse to risk or uncertainty, so that his objective function is defined by the dual criteria of maximizing net returns and minimizing the variance of net returns, or some other measure of uncertainty. Empirically, the addition of uncertainty to the farmer's objective function is necessary to account for the diversification of farm enterprises, which often does not occur in deterministic linear programming solutions.[21] The two criteria of maximizing net returns and minimizing the variance of net returns are particularly appropriate for subsistence agriculture, where a farmer's response to uncertainty may determine his ability to survive.

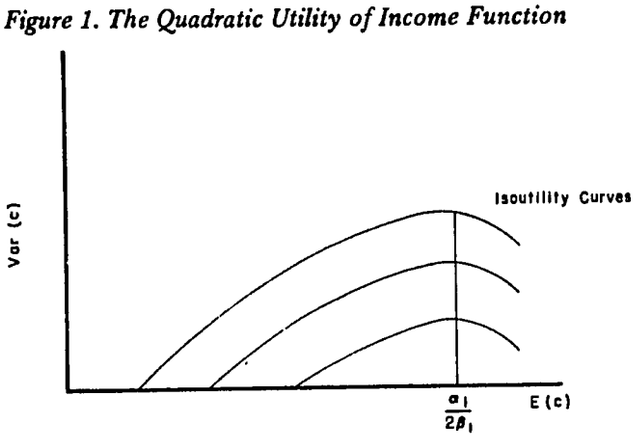
Following these criteria, and assuming a quadratic relation, the individual's utility function is of the following form (where c = the sum of net returns from farm enterprises).

$$u(c) = \alpha_1 c + \beta_1 c^2 \qquad \text{(i)}$$

This results in a set of utility curves of the form shown in Figure 1.

The utility function is important because it limits the number of strategies that need to be considered by the decision maker. The infinite set of possible farm plans becomes limited to those which are "efficient" under these criteria – those maximizing E(c) for a given var (c) or minimizing var (c) for a given E(c). This has been called the EV frontier by Markovitz[22] and is shown in Figure 2; he shows that, given the utility function, the optimal solution is uniquely determined (as at A in Figure 2).

Figure 1. The Quadratic Utility of Income Function

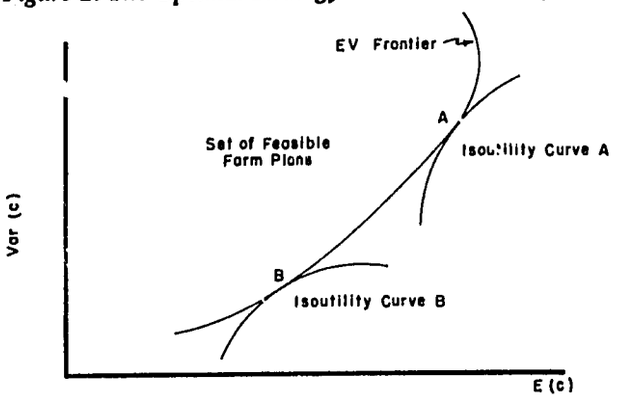


[20]Net returns is defined as gross returns minus variable costs.

[21]See Sipra Dasgupta, *Agriculture Producer's Rationality and Technical Change* (Bombay: Asia Publishing House, 1970), p. 77.

[22]Markovitz, *op. cit.*

Figure 2. The Optimal Strategy Under Uncertainty



The shape of the individual's utility function, determined by the willingness and ability of the individual to bear uncertainty, is shown in the relative size of the α and β coefficients in relation 1; this determines the point of tangency with the EV frontier. Those with a relatively high ability or willingness to bear uncertainty (with β relatively large and α relatively small) would have a steep utility function and a point of tangency as at A in Figure 2, while conversely, those less willing or able to bear uncertainty would have a flatter curve and find the unique optimum point at a lower var (c), and a lower level of E(c), (such as point B).

Assets

Willingness and ability to bear uncertainty are principally a function of an individual's wealth or assets. Willingness to bear uncertainty is related to ability to do so, as well as to other psychological factors which are difficult to quantify objectively. Ability to bear uncertainty is closely related to wealth because the greater the individual's wealth, the greater his ability to survive very low levels of farm income. Thus, farmers with a high level of assets may be expected to choose high income – high variance alternatives relative to low asset farmers; since land is the chief asset in rural areas, and is highly correlated with total assets,[23] low asset farmers are small farmers. On the basis of this type of analysis, Weeks[24] concluded that even under perfectly competitive market conditions, the distribution of income in society will become increasingly skewed in favor of the wealthy.

Supplementary Income

Supplementary income, as well as increasing availability of working capital, influences the shape of the farmer's

[23]Jakhade, *op. cit.*

[24]John Weeks, "Uncertainty, Risk and Wealth and Income Distribution," *Journal of Development Studies*, Vol. 7, No. 1 (October 1970), p. 28.

utility function in the same way as assets. A high level of supplementary income enables the individual to choose a relatively high income – high variance solution. There are three main sources of supplementary income – a non-agricultural occupation, work as an agricultural laborer on others' farms and income from dairying. Income from a nonagricultural occupation has the lowest degree of uncertainty, and in the short run may be regarded as "riskless." Using Tobin's separation theorem, Johnson has shown for farmers with risky and riskless alternatives that "the optimal strategy for combining risky options is uniquely and independently determined."[25]

Both income from work as an agricultural laborer and income from dairying involve greater uncertainty, and a variance positively correlated with the variance of net returns in crop enterprises. For example, in drought years when crop returns are at a minimum, the demand for hired labor is low, and the high price of purchased fodder also lowers net returns from dairying, and may even compel distress selling of milch animals. If work as agricultural labor, and dairying, are included as activities in the linear programming matrix, they form part of the EV surface. However, if they are considered as independent of decisions regarding the cropping pattern, they influence only the utility function, enabling the individual with his supplementary income to take a higher income – higher uncertainty solution in his choice of cropping combination.

Deriving the Efficient Set of Farm Plans

The "efficient" set of farm plans in terms of the EV criteria developed above may be estimated by two parameter models having the following general form:[26]

$$\text{Min } U = \phi\,(c_{hj}/h = 1, \ldots r), x_j/j = 1, \ldots n) \qquad \text{(ii)}$$

Such that

$$\sum_{j=1}^{n} f_j x_j = \lambda \qquad \text{(iii)}$$

and

$$\sum_{j=1}^{n} a_{ij} x_j \leq b_i,\ x_j \geq 0 \qquad \text{(iv)}$$

where

U is any distribution measure of uncertainty and ϕ denotes a set of functions defined on the sample data.

f_j is the forecasted net return for the jth activity (x_j).

c_{hj} is the net return of the jth activity in the nth year (or state of nature).

Thus the measure of uncertainty is minimized while the expected total net returns of the farm plan ($E = \sum_{j=1}^{n} f_j x_j$) is parameterized from zero to unbounded.

This model may easily be generalized to include working capital availability as an additional limiting resource so that the EV curve becomes an EVK surface in three dimensions where

$$f(E,V,K) = 0,\ K = \text{availability of working capital} \qquad \text{(v)}$$

For empirical estimation, capital would be no longer included in relation (iv) above, but would be specified separately, and parameterized from zero to unbounded, in the same way as income in (iii) above.

The Interaction of Credit and Uncertainty

On the basis of relation (v) a given level of net returns may be obtained from very intensive use of variable inputs on a low variance cropping combination, or a less intensive use of inputs and a high variance cropping combination. In reality, there is greater complementarity between capital and uncertainty than this suggests for the following reasons:

1. A greater capital input is likely to increase the variance of net returns, since net returns are more highly negative in the event of a crop failure.
2. Expenditure on variable inputs may increase or decrease uncertainty through the input itself. Expenditure on irrigation water, or pesticides, will reduce yield variability, whereas increased expenditure on chemical fertilizers increases yield variability under unirrigated conditions (see Chapter V).
3. If expenditure on variable inputs is increased, and the farmer remains on the same production function, the law of diminishing returns indicates that marginal returns to capital minus marginal costs will tend to zero. Thus, net returns become more sensitive to deviations in the price of output from the expected price, and to changes in yield from unpredictable causes (such as poor weather) near the harvest period.
4. Empirically, cropping combinations with high net returns are correlated with a high variance of net returns, and high expenditure on variable inputs,[27]

[25] S. R. Johnson, "A Re-examination of the Farm Diversification Problem," *American Journal of Agricultural Economics*, Vol. 49, No. 3 (August 1967), p. 610.

[26] For formulation of the model, we drew heavily on work by Hazell and use his notation. See Hazell, *op. cit.*, p. 139.

[27] See Chapter VII. Also, new varieties give lower yields at low levels of capital input. See, R. W. Cummings, Jr., R. W. Herdt, and S. K. Ray, "New Agricultural Strategy Revisited," *Economic and Political Weekly*, Review of Agriculture, Vol. III, No. 43 (October 23, 1968), p. A-15.

so that uncertainty and levels of capital input are also highly correlated.

5. Uncertainty and capital availability are linked in the farmer's utility function. Those with high supplementary income have greater ability to bear uncertainty as well as an addition to available capital as noted above. The level of a farmer's assets, which is important in determining a farmer's ability to bear uncertainty, is also a major determinant of farmers' ability to borrow from both institutional[28] and non-institutional[29] sources.

For all but extremely high levels of savings, an increased capital input leads to increased borrowing, and borrowing greatly increases uncertainty for a small farmer. When he uses his own funds, he may fear depletion of those funds but is in no danger of losing his productive assets such as land. However, if he borrows and the crop fails, then as debt increases his means of livelihood itself is put in jeopardy. Thus, for the small farmer the concern is for the trade-off not between capital and uncertainty but between credit and uncertainty.

Conclusions

Methods to raise the incomes of small farmers may be categorized under two headings:

1. Increase the capital input on the farmer's existing production function. This will probably increase the uncertainty of net returns as the difference between marginal return and marginal cost tends to zero.
2. Shift to a higher production function through changing the cropping combination, which includes change of crop variety, or improving breed of milk animal. This simultaneously increases optimal levels of capital (and labor) inputs and the degree of uncertainty.

Raising incomes of small farmers will involve increasing capital availability, and simultaneously increasing small farmers' ability to bear the additional uncertainty involved in greater capital use. In the conclusions, alternative policies to raise incomes of small farmers are presented which will meet the dual and related problems of capital shortage and inability to bear uncertainty.

[28]Borrowing from cooperatives is limited to eight times the borrower's share capital in the cooperative. Also, maximum credit limits are fixed by the societies on the basis of "repayment capacity" amongst other criteria. Jakhade notes the extremely close correlation between assets and borrowing from cooperatives in the All-India Rural Debt and Investment Survey. See Jakhade, *op. cit.*

[29]Reserve Bank of India, *op. cit.*, 1969, p. 116.

CHAPTER III

The Impact of Intensification on the Supply of Family Labor and Demand for Hired Labor on Small and Large Farms

Family farm income may be separated conceptually into returns to family labor used on the farm and returns to land. Methods of intensification which increase returns to family labor as well as to land are those best suited to the resource endowments of a small, relative to a large farm. In this chapter we examine factors influencing the family labor supply function on small farms, to analyze the effect of intensification on returns to family labor. We also examine factors influencing the demand for labor on large farms, as this determines employment opportunities and wage rates for small farmers who supplement their too-meager income with agricultural labor off their own farms.

The Theoretical Model

For the analysis we make the following assumptions:

1. The supply of hired labor to the individual farmer is perfectly elastic at the going wage.
2. Farmers decide first the family labor input on the basis of family labor available, and then hire labor to complete the labor input.
3. The marginal value product of labor, which is the demand curve for labor, is a function only of choice of cropping pattern, which exclusively determines the production relationship between the labor input and crop output.
4. As returns to labor rise, the family is willing to increase the number of days of work.

With these assumptions, we may illustrate the equilibrium input of family labor on a small farm. A "labor-deficit" small farm is shown in Figure 3, and a "labor-surplus" farm in Figure 4.[30]

In Figure 3, the demand curve for labor intersects the family supply curve at a wage above the agricultural laborer's wage (W_0). Thus, the family labor input is OL_1, and the farmer will hire labor from L_1 to L_2 to set the MVP_L equal to the wage.

In Figure 4, the farmer supplies labor on his own farm

[30]These diagrams are an extension of those by Mazundar. See Dipak Mazundar, "Size of Farm and Productivity: A Problem of Indian Peasant Agriculture," *Economica*, Vol. XXXII, No. 126, May 1965.

Figure 3. Demand and Supply of Labor on the 'Labor Deficit' Small Farm

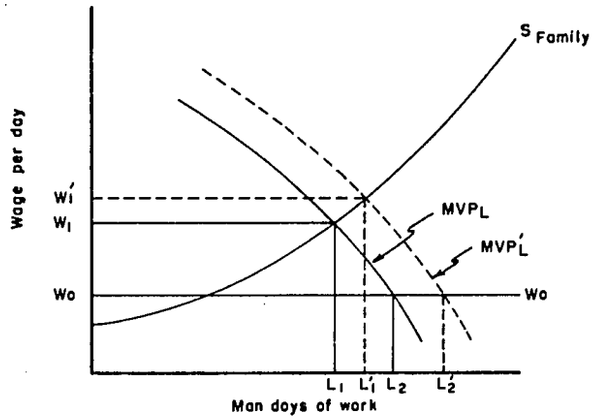
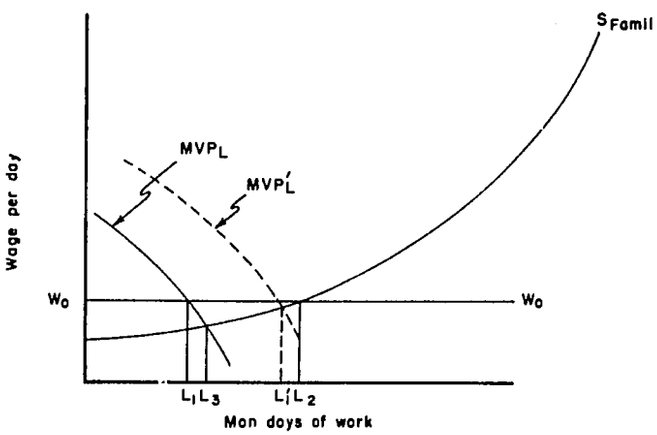


Figure 4. Demand and Supply of Labor on the 'Labor Surplus' Small Farm



to the point where $MVP_L = W$, at L'_1 and then hires out his labor between L_1 and L'_2 at the going wage. If small farmers find work on their own land more convenient or more congenial, they may put in work on the family farm to where $MVP_L = S_F$, at L_3, and then work off the farm between L_3 and L_2.

Under these assumptions, an upward shift in the production function would increase the input of both hired and family labor on a labor deficit small farm. This is illustrated in Figure 3. The family labor input increases from L_1 to L'_1, and the total labor input increases from L_2 to L_2. On labor-surplus small farms, the production function shift will only increase the family labor input under most conditions, as shown by the shift from L_1 to L_1 in Figure 4. Hence, a change in the cropping combination or the introduction of new enterprises like dairying, which raises the marginal productivity of labor, will increase not only returns to land on a small farm, but also the size of the labor input and hence labor income of the farm family.

This model assumes that all farms hiring-in labor will have the same optimal labor input provided they must pay the same wage, and have the same labor demand curve, i.e., they grow the same crops on land of similar quality. However, farms may have differing optimal levels of labor use with a given cropping pattern for any one of three reasons:

1. Under conditions of uncertainty, farmers may not set $MVP_L = W$. As marginal value product minus the wage rate tends to zero, returns per man day become increasingly sensitive to negative deviations from expected yields and prices. Small farmers using family labor may be more willing to bear the uncertainty of net returns than large farmers, who hire-in labor, because the opportunity cost of their labor may be lower than the prevailing wage rate; no time or effort is involved in finding work on their own farm and they may find it more congenial to work 'at home.' With a relatively elastic demand curve for labor, as in the case of weeding, total labor input for the operation may vary considerably.

2. Even with a single cross-sectional wage rate, the cost of hiring labor may differ between farmers. Large farmers may pay more for a day's work to be completed because they cannot supervise closely. Also, differences in interest rates for credit, and differences in levels of savings, change the real cost of hiring labor. For example, with a wage of Rs. 1.50 per day, the cost of hiring one day of labor for a farmer borrowing from a moneylender at 25 percent is Rs. 1.88, but only Rs. 1.64 for a farmer paying 9 percent on a cooperative loan.

3. Family and hired labor may not be perfect substitutes. Family labor may be concerned about aspects of plant care of no concern to a hired laborer. Also, family labor productivity may be less than that of hired labor when attention is divided between supervision of hired labor and manual work.

In the next section, we examine the effect of alternative cropping combinations on the total labor input, and then consider how the total is divided between family and hired labor. In a recursive system, we estimate first the family labor supply function, and then use the same variables and the family labor input to predict the demand for hired labor. The analysis is divided between the irrigated and unirrigated zones, because cropping pattern, and therefore growing periods, differ between the two zones.

Irrigated farms are classified into two groups for the analysis – those where family members perform manual work in farming operations, so that family and hired labor are substitutes, and farms where family labor is used only to supervise hired labor, so that hired and family labor are

complementary. The non-use of family labor for manual work reflects either a low man-land ratio, or cultural traditions of castes such as "Brahmin" and "Leva Patel."

Inter-Crop Differences in Labor Used per Acre[31]

Three situations are analyzed to illustrate the employment content of alternative crop combinations:

1. Sugarcane cultivation in Central Surat District.
2. Groundnut cultivation in Eastern Surat District.
3. Fruit and vegetable cultivation near the city of Surat.

The scope for manipulating the cropping pattern to achieve policy objectives is discussed in Chapter VII.

Sugarcane vs. Rice-Wheat

Sugarcane is grown on irrigated land in a four-year cycle. It is planted first between October and December, after a rice crop in the kharif season. It is cut 14 months later, and the first ratoon crop is planted immediately. This is cut 14 months later, and the second ratoon crop starts immediately, again to be cut 14 months later. The land then remains fallow for a few weeks before the cycle begins again. Rice followed by wheat or val[32] are the two main alternative annual combinations on irrigated acreage. Using estimates of per acre use of labor for each crop, shown in Appendix Table 3, total labor used over a four-year period, and the derived annual labor requirements for the alternative crop combinations, are shown in Table 1.

Sugarcane is very labor intensive relative to alternative crop combinations, requiring an additional labor input of 28 man days compared with even the most labor-intensive alternative. In 1972-73, the sugar factories in Surat District will require at least 39,000 acres under sugarcane; if we assume this entire acreage would otherwise have been under a rice-wheat combination, the factories will have generated additional employment of over one and a half million man days in the farming sector annually, compared with just over 300,000 days in the factory itself, Agro-industries may affect rural employment dramatically, primarily through the impact on the farming sector. The magnitude of this employment generation may be better appreciated if we consider that the Crash Scheme for Rural Employment aims to provide 333,000 man days of employment a year in each of the selected districts.[33]

[31]This section is based on an earlier paper, Gunvant M. Desai and Michael G. G. Schluter, "Generating Employment in Rural Area," *Seminar on Rural Development of Weaker Sections* (Bombay: Indian Society of Agricultural Economics, forthcoming).

[32]A pulse crop grown mainly in South Gujarat and Maharashtra.

[33]Government of India, *Crash Scheme for Rural Development, Guidelines for 1972/73* (New Delhi: Ministry of Agriculture, Department of Community Development, March 1972).

Table 1. Labor Requirements for Sugarcane and Alternative Crop Combinations Based on Per Acre Labor Use by Sample Farmers, Surat District, 1971-72

Crop Combinations	Labor Required Over Four-Year Cycle	Labor Required Per Year
Sugarcane	657	164
Paddy-wheat (HYV)	516	129
Paddy-wheat (Improved)	508	127
Paddy (HYV)-wheat (Improved)	544	136
Paddy (HYV)-val	484	121

The sugarcane factories also have an important impact on the seasonal distribution of the demand for labor. A shift from rice-wheat to sugarcane increases the demand for labor in the rabi season when the sugarcane crop is weeded, irrigated and harvested. Demand for labor in the kharif season is consequently reduced. However, as the kharif crop represents the annual peak in labor demand, the fall in labor use in the kharif season may be less than the increase in demand in the rabi season.

Groundnut vs. Cotton

Groundnut cultivation is highly labor intensive relative to the alternatives, cotton, jowar or tur. Labor requirements for each of these crops are shown in Appendix Table 4, and are similar to estimates of the farm management studies.[34] A study of dry land agriculture in Central Gujarat and Mysore States confirm that groundnut is labor intensive relative to any competing crop.[35]

In 1967-68, total acreage under groundnut in Surat District was 92,500 acres. If we assume that cotton would have been planted on this land in the absence of groundnut, then groundnut cultivation could be said to have generated additional employment of over 2.1 million man days per year. If we consider the alternative crop as jowar, then the estimate of additional employment would rise to almost 2.9 million man days per year. For a crop which accounted for only 8 percent of the total cultivated land, and which is cultivated almost entirely on unirrigated land, this is substantial.

The seasonal distribution of the labor requirement for groundnut is rather more concentrated than for jowar, tur, or cotton, but a large part still falls outside the peak period in most of the district. The harvesting of groundnut takes place in late October to early November, after the

[34]See Appendix Table 5.

[35]M. S. Krishnaswamy and K. V. Patel, "Status of Dry Land Agriculture" (Ahmedabad: Centre for Management in Agriculture, Indian Institute of Management, 1973).

harvesting of unirrigated varieties of rice. It may compete with harvesting of irrigated rice on irrigated farms, but groundnut is grown mainly in the unirrigated parts of the district. Thus, groundnut cultivation serves mainly to extend the peak period by four to six weeks. Jowar, tur, and cotton are harvested between January and March, in the middle of the non-peak period, but as can be seen from Appendix Table 4, the labor required to harvest these crops is much less.

Labor required in processing groundnut is extremely small compared to the additional employment generated on farms. We estimate, on the basis of a typical oil mill in the region, that for every 10,000 acres under groundnut, 10,000 man days of employment are generated by the mill.[36] This is less than 5 percent of the additional employment created on farms.

Fruit vs. Vegetables

Near Surat City, on irrigated sandy loam soils, there are two main fruit crops – mangoes, a typical orchard crop, and bananas. The chief vegetables grown are cabbage, cauliflower, brinjals, red yam, and bean. The data were collected from a village about eight miles away from the City of Surat in February 1973, and were consistent with the data collected in the main survey of 1971-72.

The labor requirements of alternative crop combinations, based on estimates of per acre use of labor by operation for each crop, shown in Appendix Table 6, indicate that vegetables are highly labor intensive relative to fruits (see Table 2).

Clearly, any change in cropping pattern from an orchard crop will increase employment dramatically. For example, for every acre put under a banana-wheat combination, the least labor-intensive alternative, instead of under mango orchard, an additional 57 man days of employment is generated. If the orchard is put under vegetables, 157 man days of employment per acre per year is created. In this area, the orchards occupy prime irrigable land close to the city, so that a banana-vegetable or pure vegetable crop combination are the most probable alternatives.

Vegetables are the most labor intensive of all crops considered in Surat District, and a pure vegetable crop combination provides additional employment of more than 50 man days per acre per year over even the most labor-intensive of the other crops considered – sugarcane around Bardoli. We now consider the family labor component in total labor used for each major agricultural operation.

[36]A typical oil mill in the region usually crushes 40,000 quintals of groundnut in a year, employing 100 men per day for 200 days. Average yield between 1964-65 and 1970-71 was 2 quintals per acre. Thus, we estimate that 20,000 acres are required to supply groundnut to the mill. The labor required for pressing and ginning of cotton is still lower. We estimate that for every 10,000 acres under cotton in this region, only 1700 man days are required for ginning and pressing.

Table 2. Labor Requirements for Fruit and Vegetable Crop Combinations for Sample Farmers near Surat City, Surat District, 1972-73

Crop Combination	Labor Required Over Two-Year Cycle	Labor Required Per Year
Red yam-cabbage-brinjals	420	210
Brinjals-summer banana[1]	323	162
Banana-cauliflower	265	133
Banana-wheat[2]	225	113
Mango	104	53

[1]The labor required for summer banana is assumed the same as for the monsoon crop.
[2]The wheat figure is taken from wheat cultivation near Bardoli.

Family Labor Supply on Unirrigated Farms

On unirrigated farms, the most labor-intensive agricultural operations are transplanting of rice, and the weeding and harvesting of each crop (see Appendix Table 7). We examine in this section each of these operations, but take harvesting of rice as a representative crop since each crop is harvested at a different time (see crop calendar in Appendix C).

As outlined above, we assume the family and hired labor components of total labor used are determined recursively; a farmer first decides the amount of family labor available, and on this basis considers how much he will hire with the given cropping pattern. In the following recursive system we predict first the family labor input on the basis of the predetermined variables, and then estimate the hired labor input.

The Model

The model is outlined in the following two equations:

$$Y_{i1} = A + b_1X_{i1} + b_2X_{i2} + b_3X_{i3} + \ldots + b_{i10}X_{i10} \quad (1)$$

$$Y_{i2} = C + b_1X_{i1} + b_2X_{i2} + b_3X_{i3} + \ldots + b_{i10}X_{i10} + Y_{i1} \quad (2)$$

where

Y_1 = Number of man days of family labor

Y_2 = Number of man days of labor hired

X_1 = Number of family members who participated in the operation

X_2 = Educational level of family decision maker

X_3 = Credit availability ('000 Rs.)
X_4 = Nonagricultural income ('000 Rs.)
X_5 = Agricultural labor income ('000 Rs.)
X_6 = Value of assets ('000 Rs.)
X_7 = Acreage under rice
X_8 = Acreage under cotton
X_9 = Acreage under jowar
X_{10} = Acreage under groundnuts

and A, C and the b_is are unknown parameters to be estimated.

For planting and harvesting, acreage under cotton, jowar and groundnuts are excluded. For harvesting, we substitute yield (in units of 20 kg) for acreage under rice; yield and acreage under rice could not be included together because they are so highly correlated (r = .85).

The number of family members available, and the cropping pattern, were obvious variables to include in the model. Value of assets, reflecting ability to bear uncertainty, non-agricultural income and credit availability may all be expected to lead to greater hired labor input and, to the extent that family and hired labor are substitutes, to lower family labor input. Educational level may also lead to a substitution of hired for family labor, since education is thought to lead to a dislike for manual work. Income from work as agricultural labor indicates the extent of "surplus labor" on the farm, and *a priori* may be expected to lead to higher levels of family labor input.

We use a linear model because a linear combination of crop acreages is required in the equation for weeding. An advantage of the linear form is that it provides directly a measure of the extent to which hired and family labor are substitutes in each operation. However, there is a logical weakness since there would still be a family labor input in the extreme case of zero family workers. This suggests that a log-log function would be more appropriate to examine planting and harvesting operations.[37] Table 3 on the following page provides a summary of the regression coefficients, indicating those statistically significant at the 5 percent level.[38]

[37] For a discussion of the implications and results of using alternative functional forms on these data, see Gillian Hart, "The Relationship between Family Labor Input and the Demand for Hired Labor on Irrigated and Unirrigated Farms," (unpublished paper, Department of Agricultural Economics, Cornell University, Ithaca, September 1973).

[38] For full details of the estimated equation, see Michael Schluter, *op. cit.*, 1973, pp. 154-156.

Table 3. Regression Coefficients of Predetermined Variables in Estimated Linear Regressions for Family and Hired Labor Input in Transplanting of Rice, Weeding, and Harvesting of Rice on Unirrigated Farms, Surat District, 1971-72

	Transplanting		Weeding		Harvesting	
Variables	Family	Hired	Family	Hired	Family	Hired
Number family members available	2.71*	–	20.03*	–	2.58*	–
Education[1]	0.33	1.06*	–8.27*	5.71*	–0.63*	0.38
Agricultural labor income[1]	5.50*	1.29	–20.23	–21.83	–3.38	–10.83*
Nonagricultural income[1]	2.54	4.75*	0.53	8.52	–1.93	–3.30
Crop income[1]	5.29*	4.29	–	–	2.14	–3.20
Credit available[1]	2.27	5.23*	27.77	–12.83	5.72*	0.89
Value of assets[1]	–0.83	–1.25*	–4.90	4.13	–0.40	0.38
Number family labor days used	–	–0.90*	–	–0.11	–	0.07
Rice yields (in mds)[2]	–	–	–	–	0.06	0.27*
Acreage under rice	4.70*	7.90*	0.03	13.75	–	–
Acreage under cotton	–	–	–7.01	20.87	–	–
Acreage under jowar	–	–	10.93	6.52	–	–
Acreage under groundnuts	–	–	12.31	5.47	–	–
Constant	–13.02	2.30	–26.03	–5.33	–6.67	11.23
r^2	0.76	0.63	0.64	0.80	0.61	0.53

*Significant at 5 percent level.
[1] Income, credit and assets are in '000 Rs.
[2] Omitted because crop income is almost a linear function of acreage under crops.

Transplanting Rice

Transplanting of rice occurs under a tight time constraint; this results from the need to plant at the right time of the month, and the need for adequate water to be in the field, with uncertain rainfall. The time constraint accounts for the small regression coefficient for number of family workers, indicating each family member involved worked only 2.7 man days. For transplanting, hired and family labor are almost perfect substitutes; the coefficient for family labor used in the equation for hired labor is not statistically different from minus one, indicating that an additional day of family labor input decreases the hired labor input by one man day.

High income results in a greater family labor input, from whatever source the income is derived. Thus, those with a labor surplus on their farms put in relatively large amounts of both hired and family labor for transplanting. Similarly, nonagricultural income, crop income, education and credit available increase family labor participation, as well as increasing the hired labor input. These results suggest that all these variables result in farmers taking greater care in transplanting. A high value of assets decreases the family and hired labor inputs, suggesting an inverse relationship between wealth and care in transplanting.

Weeding All Crops

Greater time flexibility in weeding is reflected in the high coefficient for number of family workers, indicating that each family worker put in 20 man days of weeding. Family decision makers with education substituted hired for family labor in weeding, as indicated by the significant positive coefficient in the family labor equation and negative coefficient in the equation for hired labor. A high value of assets similarly led to substitution of hired for family labor, although the regression coefficient is not statistically significant. Agricultural labor income results in a lower family and hired labor input for weeding. This underlines the great difficulties of those with large families and small pieces of land, who must go to work on others' land to buy food until harvest, rather than being able to tend to their own fields.

In weeding, family and hired labor do not act as direct substitutes. The estimated coefficients indicate that with an increase of ten family labor days, the hired labor input is reduced by only one day. This shows that a high family labor input results in a high total labor input. Family workers may push MVP_L closer to the wage rate than hired workers as noted earlier; there may also be some differentiation of function in weeding between family and hired workers, as family labor will be more concerned about care in weeding, and thus may perform slightly different tasks. If family members are both supervising and working, a man day of family labor may also have slightly lower productivity than that of a hired worker, although the opposite is probably the case if a day of family labor without the supervision responsibility is compared with a day of hired labor.

Harvesting

In harvesting, a time constraint is again indicated by the small input of family labor per family member – 2.6 days. The family labor input did not alter significantly the hired labor input (the coefficient for family days used in the equation for hired labor is not significantly different from zero at the 5 percent level). This is in sharp contrast to planting, where family and hired labor were almost perfect substitutes. The lack of substitution in harvesting may reflect again the greater care of family labor, leading to some differentiation in task performed. Education and assets result in some substitution of hired for family labor, as in weeding, and both agricultural labor income and nonagricultural income decrease the labor input for harvesting. The regression coefficients for yield suggest that one man day of labor is required to harvest and thresh three maunds of rice (= 60 kg).

Family Labor Supply on Irrigated Farms

For irrigated farms using family labor for manual work, we examine only two operations – weeding of khariff crops and harvesting of a rabi crop, wheat. For transplanting of irrigated rice in the kharif season and harvesting of kharif irrigated crops, the family labor input is too small to allow useful analysis (see Appendix Table 8); for sowing and weeding of rabi crops, the total labor used is so small that even with a high percentage of family labor, the absolute size of the family labor input is small (see Appendix Table 3). Clearly, on irrigated farms in Surat District, the family labor input overall is very small, even on small farms, so that there is little scope to raise incomes through increasing returns to family labor.

We use the same model for irrigated as for unirrigated farms, with the difference that dairying income is now included, because milk animals provide a significant part of total income in the irrigated zone. Agricultural labor income is excluded because it forms such a small part of total income in the irrigated compared with the unirrigated zone (see Appendix Tables 9 and 10). A "region" variable is also included, to distinguish between the high income and middle income villages in the irrigated zone. A summary of the regression coefficients is shown in Table 4.[39]

Kharif Weeding

The family labor input for kharif weeding is relatively small in the irrigated zone; whereas unirrigated farm families put in 20 man days per family worker, this figure

[39] For full details of the estimated equations, see Michael Schluter, *op. cit.*, 1973, pp. 159-160.

Table 4. Regression Coefficients for Predetermined Variables in Estimated Linear Regressions for Family and Hired Labor Inputs for Kharif Weeding and Wheat Harvesting on Irrigated Farms, Surat District, 1971-72

Variables	Weeding: All Kharif Crops		Wheat Harvesting	
	Family	Hired	Family	Hired
Number of family members available	4.63	–	1.01*	–
Region	–2.21	–19.81	–	–
Education	–1.43	0.33	–0.04	–0.30
Non-agricultural income	–4.91*	–1.47	–0.30	–0.11
Dairying income	–1.44	–4.09	–0.06	0.84
Credit available	–1.46	0.57	–0.35	–1.01
Value of assets	0.45	1.73*	–0.01	–0.07
Number of family days used	–	–0.53	–	–0.62
Acreage under				
Irrigated rice	11.15	15.40*	–	–
Unirrigated rice	3.77	47.24*	–	–
Cotton	0.68	27.84*	–	–
Jowar	3.21	3.50	–	–
Groundnuts	–5.00	14.95*	–	–
Wheat yields			0.06	0.49
Constant	11.68	6.73	1.03	4.44
r^2	0.44	0.86	0.56	0.80

*Significant at 5 percent level.

is only 4.6 for irrigated farm families. Also, there is much greater substitution of family for hired labor on irrigated farms; an additional family-labor man day reduces the hired labor input by half a man day on irrigated farms, compared with a tenth of a man day on unirrigated farms.

The lower family labor input on irrigated relative to unirrigated farms may be explained by higher incomes on the irrigated zone, and greater off-farm work opportunities, such as diamond cutting, which raise the level of returns necessary to induce family labor to do manual farm work. In terms of the theoretical model, the family labor supply curve is much steeper, and with a higher level of demand for labor, demand and family supply intersect at a much higher level of marginal value product.

Income and credit availability both decrease the size of the family labor input. Nonagricultural income, and to a lesser extent dairying and credit availability, lower both the family and the hired labor input, indicating less overall use of labor. Family farm workers may be willing to do less agricultural labor when there is the security of other sources of income available to the family. Value of assets has a small positive impact on the family labor input, but significantly increases demand for hired labor. This is consistent with the hypothesis outlined above, that as the marginal value product of labor approaches the wage rate with increasing levels of hired labor input, the uncertainty of net returns increases, so that farmers better able to bear uncertainty would be more willing to hire labor at the margin. As in the unirrigated zone, family decision makers with higher levels of education substitute hired for family labor on their farms.

The labor use on alternative crops is very different between the unirrigated and irrigated zones, as shown in Table 5. In the irrigated zone, the high labor input for unirrigated rice, for the six farmers growing the crop, may be due to these particular farmers having a large home consumption requirement relative to their total rice acreage, and therefore cultivating rice very intensively. A similar reason probably lies behind the greater labor intensity with which jowar is cultivated in the unirrigated relative to the irrigated zone.

In the unirrigated zone, groundnut weeding is done mainly by family workers, and the total labor input is high relative to the competing jowar and cotton crops; in the irrigated zone the few farmers growing groundnuts had large farms and were diversifying crop production, relying almost exclusively on hired labor. The relatively small total labor input on these farms may also indicate a less suitable soil type in the irrigated zone, where few farmers had land suitable for the crop.

In contrast to groundnuts, cotton is cultivated more intensively in the irrigated zone. This reflects in part

Table 5. Family and Hired Labor Input by Crop in the Irrigated and Unirrigated Zones, as Indicated by the Coefficients in the Estimated Regression Equations for Kharif Weeding, Surat District, 1971-72

	Irrigated			Unirrigated		
Crops	Family	Hired	Total	Family	Hired	Total
Irrigated rice	11.15	15.40	26.55	–	–	–
Unirrigated rice	3.77	47.24	50.95	0.03	13.75	13.78
Cotton	0.68	27.84	28.42	–7.01	20.87	13.86
Jowar	3.21	3.50	6.71	10.93	6.52	17.45
Groundnuts	–5.00	14.95	9.95	12.31	5.47	17.78

physical conditions more suitable for the crop and greater use of chemical fertilizers in the irrigated zone, but may also reflect a higher cotton price in the irrigated zone, where farmers sell directly to the cooperative gin rather than to an intermediary (see Appendix B).

Wheat Harvesting

For wheat harvesting, the number of days per family worker is only 1.01, less than half that for rice harvesting in the unirrigated zone. As in the case of weeding, family and hired labor are not perfect substitutes. The estimated family labor coefficient of –0.62 in the equation for labor hired indicates that two days of family labor input reduce the hired labor input by just over one man day. Again, this suggests some differentiation of function between family and hired workers, as in an extreme example where family workers collect grain left by careless harvesting of hired

Table 6. Estimated Linear Regression for Factors Influencing the Demand for Hired Labor for Kharif Weeding on Farms for Which Family Labor is Used Only for Supervision, Surat District, 1971-72

Factor	Regression Coefficient	Standard Error of Estimate	t-Value
Number of family members available to supervise hired labor in kharif weeding	15.3905	15.8278	0.97
Value of assets ('000 Rs.)	–0.7557	0.7368	–1.03
Value of nonagricultural income ('000 Rs.)	–1.2197	6.9928	–0.17
Value of dairying income ('000 Rs.)	3.9041	6.2451	0.63
Value of credit available[1] ('000 Rs.)	2.2804	2.5781	0.88
Region (Middle income = 1, High income = 0)	–93.7162	52.7137	–1.78*
Acreage under irrigated rice	29.4309	9.6515	3.05**
Acreage under unirrigated rice	21.0563	8.2169	2.56**
Acreage under bananas[2]	43.5290	22.4121	1.94*
Acreage under unirrigated crops (cotton, jowar, and groundnuts)[3]	8.9085	8.4995	1.05
Constant	47.1450		
$r^2 = 0.77$			
Number of observations (farmers) = 28			

[1]Estimated as the supply available from friends, relatives and traders as well as from cooperatives, for expenditure as variable inputs.
[2]Banana is included in this equation and not in Appendix Table 15 because the only farmers growing bananas use family labor only for supervision.
[3]Cotton, jowar and groundnuts are aggregated because the acreage under each of these crops is very small in this group of farms, and the labor input is similar for these crops relative to other crops included in the model.

labor. The coefficients for yield in the two equations indicate that one man day is required to harvest two maunds of wheat (= 40 kg), compared with three maunds of unirrigated rice.

Education and high income tend to lead to a substitution of hired for family labor, lowering the family labor input as in the case of weeding, although the coefficients are not statistically significant.

Demand for Hired Labor on Farms Using Family Labor Only for Supervision

For farms using family labor only to supervise, one equation is used to analyze the labor input for weeding. We estimate the demand for hired labor as a function of the number of family members available to supervise, and the other variables included in relation (2) above. The estimated equation for kharif weeding is shown in Table 6.

The complementarity of the family and hired labor input is shown in the positive coefficient for number of family workers, which indicates that with the same cropping pattern an additional family member available to supervise increased the demand for hired labor by almost 16 man days. As might be expected, education, assets and non-agricultural income decrease the demand for hired labor, whereas dairying income and credit availability both increase demand, although none of the estimated coefficients are statistically significant at the 5 percent level.

The effect of cropping pattern on the demand for labor is clearly illustrated in the model. Whereas an acre of bananas increases demand by 43.5 man days, compared with 29.4 for irrigated rice and 21.1 for unirrigated rice, acreage under other unirrigated crops – cotton, jowar or groundnuts – increases demand by only nine man days. We conclude that in a given region, demand for hired labor on these farms is a function primarily of the cropping pattern.

The demand for labor is much greater in the high-income villages, relative to the middle-income villages. This in part reflects higher quality soil, but may also indicate the higher income levels, taking all income sources together, since farms are larger in the higher income villages, and the high net returns crops, sugarcane and bananas, are also concentrated on "supervisory labor" farms in the high-income villages.

Conclusions

1. Choice of cropping pattern has a substantial impact on levels of rural employment. Crops such as vegetables (as well as activities such as dairying[40]) are labor-intensive relative to cereals, and have a high income-elasticity of demand. As incomes rise in development, or if a significant export market can be developed, these crops will contribute towards substantial labor absorption.
2. On the low-income unirrigated farms, higher incomes are associated with high levels of family labor input; on the high-income irrigated farms, the converse holds. This suggests that family labor participation increases initially in the course of development, but decreases as incomes rise beyond a certain level.
3. In irrigated areas, little family labor is used for cultivation, so that almost all labor required for

[40]See Chapter VI.

Table 7. Returns to Labor and Land per Acre for Unirrigated Crops, 1966/67-1971/72 and for Irrigated Crops in 1971/72, in Surat District

Crop/Returns	Returns to Labor[1]	Returns to Land[2]
	Unirrigated Crops, 1966/67-1971/72	
Rice (with fertilizer)[3]	129	202
Groundnuts	108	207
Cotton (without fertilizer)[3]	65	230
Jowar	50	163
	Irrigated Crops, 1971/72[4]	
Improved rice	242	507
HYV rice	265	608
Improved wheat	82	237
HYV wheat	68	473
Sugarcane	383[5]	2219

[1]Estimated at the market rate. The number of man days used for each operation is multiplied by the appropriate wage rate, with no distinction between the hired and family labor inputs. For unirrigated crops, we assume a wage of Rs. 2.00 per man day, except for weeding, for which we assume Rs. 1.50. For rice, we use Rs. 3.00 per day, except for weeding, irrigation and fertilizer application at Rs. 2.50. For wheat and sugarcane, we use Rs. 2.00 per day, but Rs. 3.00 for planting as this occurs during a peak period.

[2]Estimated as a residual. From gross returns, we subtract average total variable costs in 1971/72, including the imputed value of family labor. The only cost not subtracted is interest charges. Gross returns includes the value of the by-product.

[3]Most farmers in the unirrigated zone use fertilizer on rice, but no farmer uses it on cotton.

[4]For irrigated crops we use data for 1971/72 rather than for the six-year period, owing to the difficulties of obtaining time-series yield data for the new varieties (see footnotes to Appendix Table 23).

[5]Over 50 percent of this goes to migrant workers from Maharashtra, who are employed by the factory for harvesting.

Sources: Data for gross returns are in Appendix Tables 21-24. Labor use data are contained in tables earlier in this chapter. Data for other variable costs for irrigated crops are contained in Appendix Table 26 and for unirrigated crops in Appendix Table 20.

intensification will be drawn from laboring classes. Rabi vegetable cultivation or sugercane in the irrigated zone may thus contribute to the incomes of small farmers in the unirrigated zone, who travel daily to work on irrigated farms in the off-season.

4. Hired and family labor are not necessarily substitutes. They may be complementary or substitutes depending on the agricultural operation being performed, and the income level of the farm family.

Family Labor Participation and Choice of Cropping Pattern

On unirrigated small farms, where a significantly large part of the total labor input comes from within the family, returns to labor as well as returns to land are relevant in choice of cropping combination. The returns to labor and land for irrigated and unirrigated crops in Surat District for the period 1966/67-1971/72 are shown in Table 7. Groundnut gives higher returns than cotton to land plus family labor, if a substantial part of the total labor input comes from within the family. Factors influencing acreage under groundnuts relative to both cotton and jowar are discussed in Chapter VII.

On irrigated farms, the family labor input is so low even on small farms that to raise farm incomes, it is necessary to raise returns to land. Table 7 shows that a change from improved to new varieties of foodgrains may raise incomes of small farmers substantially; in Chapter IV we examine factors influencing adoption behavior for these crops. However, a change in cropping combination to sugarcane has a much more dramatic impact on incomes; factors affecting this change are outlined in Chapter VII.

CHAPTER IV

The Role of Cooperative Credit in Small Farmer Adoption of the New Cereal Varieties

In Chapter II, we argued on theoretical grounds that when there is a shift in the production function affecting a substantial segment of agricultural production, which increases the marginal productivity of working capital, the supply of capital from traditional sources, including savings, is likely to fall short of demand. This shortage would be felt most acutely on small farms. In this context, cooperative credit becomes an important policy tool to facilitate adoption of the new varieties on small farms, and thus may have a dramatic impact on income levels of small farmers.[41]

A large number of micro studies have shown that small farmers have lagged in adoption of the new seed varieties, and that there is a close relationship between adoption by small farmers and use of cooperative credit in many areas.[42] However, the importance of cooperative credit in adoption is not universal and many aspects of the relationship are ill-defined. This chapter will examine two main questions:

1. What is the place of cooperative credit in the overall demand and supply of capital on a small farm?
2. (a) In macro terms, is it possible to have rapid diffusion of the new varieties, especially on small farms, in the absence of a large increase in the supply of cooperative credit? (b) In micro terms, does availability of cooperative credit influence the adoption behavior of the individual small farmer?

The analysis is based on sample data from Surat District, and data for 225 farmers in Mehsana District, collected by the Gujarat State Cooperative Bank in 1969/70.[43] Studies published by the Agro-Economic Research Centres are used to make wider generalizations about the profitability of the new varieties.[44]

Cooperative Credit in the Small Farmer's Supply of Capital

The place of cooperative credit in the individual small farmer's demand and supply of capital is illustrated in Figure 5. This simple model rests on three propositions:

1. The supply of funds from savings and traditional sources is highly inelastic for small farmers (i.e. that BS_1 is close to being horizontal).
2. Small farmers generally find these sources adequate prior to technological change (i.e. they lie to the left of A on OZ).
3. Cooperative credit does not meet full costs of cultivation, although under the crop loan system the amount a farmer can borrow is related to costs of cultivation (i.e. BS_2 slopes upwards, but is not as steep as OD).

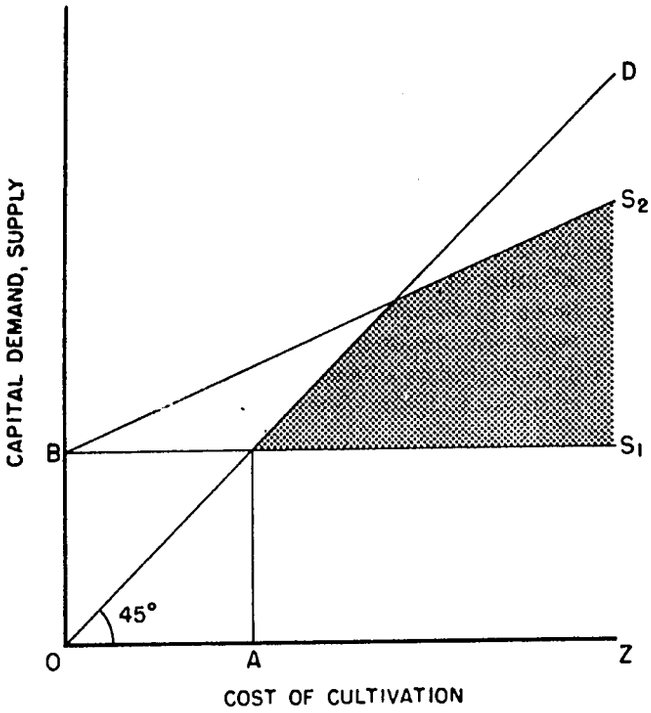
[41] V. S. Vyas, D. S. Tyagi, V. N. Misra, "Significance of the New Strategy of Agricultural Development for Small Farmers" (Agro-Economic Research Centre, Sardar Patel University, Vallabh Vidyangar, 1968).

[42] G. Muttiah, "The Green Revolution – Participation by Small Versus Large Farmers," paper presented at Seminar on Rural Development for Weaker Sections, Indian Society of Agricultural Economics and Centre for Management in Agriculture, Indian Institute of Management, Ahmedabad, October, 1972; and Michael G. G. Schluter and John W. Mellor, "New Seed Varieties and the Small Farm," *Economic and Political Weekly*, Review of Agriculture, March 25, 1972, p. A-31.

[43] See Michael G. G. Schluter and Gokul O. Parikh, "The Interaction of Co-operative Credit and Uncertainty in Small Farmer Adoption of the New Cereal Varieties" (unpublished paper, Gujarat State Co-operative Bank, Ahmedabad, 1973).

[44] See list of references in Appendix D for a list of studies used in the analysis.

Figure 5. The Place of Cooperative Credit in the Small Farmer's Demand and Supply of Capital



Where, OD is demand for capital

BS_1 is the supply of funds available from savings, and borrowable for production from friends, relatives, moneylenders and traders

OBS_2 is the total supply of capital, including what is available from the co-operatives

The shaded area shows the demand for co-operative credit.

Available empirical evidence indicates that both savings and credit from traditional sources such as moneylenders are likely to be highly inelastic for small farmers, even with the possibility of high rates of return. Small farmers' debt to income ratio is high.[45] They must borrow for a large part of both production and consumption requirements in the kharif season,[46] their level of consumption is generally so low that there is little scope to forego consumption to allow additional funds for production. Small farmers often cannot increase their loans from moneylenders; in a part of Surat District where moneylenders are still the main source of credit, over 50 percent of the farmers indicated they could obtain little or no additional credit from a moneylender, and could not increase borrowings from relatives. Government pressure is causing most moneylenders in the area to contract operations, so that supply from this source is unlikely to expand rapidly to meet a growing demand for adoption of new varieties.

Evidence from both Surat and Mehsana support the second proposition that small farmers borrow little from cooperatives until there is technological change, leading to a substantial increase in costs of cultivation. In Mehsana, only 50 percent of small farmers had joined the co-operatives, and only 29 percent had taken loans. The main reasons given by small farmers both for non-membership and non-borrowing were adequate income and past-saving, and non-farm sources of income (see Appendix Table 11). In Surat, two adjacent areas were surveyed, both well covered by efficient cooperatives, but with the difference that in one and not the other there were irrigation facilities and the new technology had been introduced. In the irrigated area, 77 percent of the small farmers had joined the cooperative, whereas only 28 percent had joined in the other area. It is in the context of technological change that traditional sources of finance are found wanting.

A recent study of short-term cooperative credit, in the terms of farmers' overall use of credit and their costs of cultivation, concludes that loans available under the crop loan system are far from adequate.[47] This is confirmed by the observation in Surat District that 50 percent of small farmers with access to cooperative credit (non-defaulters) used the maximum limit available to them from the society.[48]

As our model implies, the rate of interest is unlikely to account for the importance of cooperative credit in adoption. In order to argue that the rate of interest is a significant factor, it is necessary to demonstrate that rates of return on additional capital used to grow the new varieties are consistently close to the 10 percent to 50 percent range, which represents the difference in interest rates between moneylenders and cooperatives.[49] Therefore, we estimate the rates of return on additional capital employed in growing the new varieties from a large number of micro studies as shown in Tables 8 and 9. It is clear that in almost all cases the new varieties are either extremely profitable or extremely unprofitable. In only two of the 43 cases for which data were available was the rate of return between zero percent and 50 percent. On the basis of this evidence, it seems most unlikely that the low rate of interest is what causes farmers to rely so heavily on cooperative credit in adoption.

[45]Reserve Bank of India, *All-India Rural Credit Survey*, Vol. I The Survey Report (Bombay: 1956).

[46]Jakhade, *op. cit.*

[47]Gokul O. Parikh and U. S. Sharma, "Some Reflections on Co-operative Short-Term Credit," paper presented at Second Gujarat Economic Conference, Vallabh Vidyanagar, 1970.

[48]Defined as the maximum amount the Secretary of the Society said the Society would be willing to lend to the farmer, based on the farmer's shareholding in the society, assets, and character.

[49]Twenty-five percent was the maximum charged by a moneylender in the Surat sample. For an indication of interest rates in traditional agriculture, see Reserve Bank of India, *op. cit.*, 1956.

Table 8. Rates of Return on New Rice Varieties in India, 1966-1971

District and Year		Main Variety	Total Expenditure per Acre HYV 1	Total Expenditure per Acre Local 2	Net Returns per Acre HYV 3	Net Returns per Acre Local 4	Additional Working Capital Expenditures 5=1−2	Additional Net Returns 6=3−4	Additional Rate of Returns 7=6÷5
1966-67									
Thanjavur	(15)	ADT-27	139	118	395	227	21	168	800%
Karnal	(15)	TN-1	113	54	491	348	60	143	238
Cuttack	(7)	TN-1	296	82	646	377	214	269	126
Ernakulam	(15)	TN-3	365	266	692	792	139	−100	−72
Mahar. Dist.	(17)	TN-1	194	126	261	310	68	−49	−72
Krishna	(15)	TN-1	202	101	482	565	101	−83	−82
Mandhya	(23)	TN-65	426	293	789	1124	233	−335	−101
Kolaba	(15)	TN-1	128	68	132	269	61	−157	−224
1967-68									
Thanjavur	(16)	ADT-27	183	139	NA	NA	44	133	302
Sibsagar	(16)	TN-1	NA	NA	NA	NA	64	206	252
W. Godavari	(16)	IR-8	294	138	NA	NA	156	163	104
Sharanpur	(16)	TN-1	159	87	NA	NA	72	54	75
Birbhum[1]	(16)	TN-1	401	221	NA	NA	180	−60	−33
Varanasi	(16)	TN-1	159	125	NA	NA	34	−58	−171
Amritsar[2]	(16)	TN-1	214	169	NA	NA	45	−175	−389
Raipur	(16)	TN-1	104	110	NA	NA	−6	−340	–
1968-69									
Sibsagar (Aunt.)	(5)	TN-1	129	80	1195	316	49	879	1794
Sibsagar (Rabi)	(5)	TN-1	150	81	718	471	69	247	358
E. Godavari (Rabi)	(3)	IR-8	583	408	877	251	175	426	243
Sambalpur	(27)	TN-1	289	154	542	274	135	268	199
W. Godavari (Rabi)	(3)	IR-8	745	579	467	195	167	228	172
Amritsar	(22)	IR-8	284	157	618	382	127	236	126
Birbhum	(12)	IR-8	391	147	732	400	244	242	99
Saharanpur	(26)	IR-8	295	233	658	605	62	53	85
W. Godavari	(2)	IR-8	514	321	440	376	193	64	33
E. Godavari	(2)	IR-8	529	239	283	292	276	−7	−3
1971-72									
Surat	(20)	Masuri	353	290	608	507	63	101	160

[1]Refers to all HYV. IR-8 alone was considerably more profitable.
[2]Compared with Basmati.

NOTE: For each variety, net returns per acre is defined as average gross returns, estimated as average price multiplied by average yield, minus average expenditure on variable inputs as defined in each study (see Appendix D).

Table 9. Rates of Return on New Wheat, Bajra and Maize Varieties in India, 1966-1971

District and Year			Main Variety	Total Expenditure per Acre HYV 1	Total Expenditure per Acre Local 2	Net Returns per Acre HYV 3	Net Returns per Acre Local 4	Additional Working Capital Expenditures 5=1−2	Additional Net Returns 6=3−4	Additional Rate of Return 7=6÷5
Wheat										
Saharanpur	1967	(14)	Mexican	197	207	533	339	−10	194	–
Amritsar	1967	(26)	Lerma Rojo	137	124	353	204	13	149	1146%
Aligarh	1967	(11)	HYV	334	219	781	434	115	347	301
Tikamgadh	1967	(6)	HYV	318	150	520	93	168	427	254
Udaipur	1967	(4)	HYV	434	318	707	480	116	227	196
Karnal	1967	(25)	Mexican	225	110	607	460	115	207	180
Surat	1971	(24)	S-227	233	160	350	220	73	130	178
Kota	1968	(28)	S-227	338	221	264	140	117	124	105
Amritsar	1967	(20)	S-227	390	124	247	204	266	43	16
Bajra										
Karnal	1967	(16)	Hybrid	182	17	NA	NA	165	232	140
Kaira	1967	(16)	Hybrid	249	115	NA	NA	134	138	106
Nasik	1967	(16)	Hybrid	190	47	NA	NA	143	134	94
Mehsana	1967	(16)	Hybrid	174	93	167	121	82	66	80
Ahmedabad	1968	(10)	Hybrid	254	132	180	93	122	87	71
Maize										
Saran	1968	(8)	Hybrid	197	92	231	131	105	100	95
Aligarh	1966	(15)	Hybrid	257	119	78	226	138	−148	−107

NOTE: Definitions as in Table 8.

The Importance of Cooperative Credit at Different Stages of the Diffusion Process

Cooperative credit becomes important at the secondary stage of the diffusion process. An examination of a large number of micro studies, undertaken mainly in 1966 and 1967, concludes that "the owned funds of the sample cultivators needed to be supplemented only marginally by borrowings in order to meet the input expenses of the high-yielding varieties."[50] However, surveys of micro studies covering slightly later periods find "a close relationship between co-operative credit and adoption,"[51] and stress that "the increased cash expenditure on HYV paddy was met by a higher level of borrowing by participant farmers," much of it from the cooperatives.[52]

We suggest that cooperative credit plays an important role in adoption when small farmers begin to adopt new varieties, and large farmers expand their acreage under the new varieties beyond the initial trial stage. In Surat District, in the early stages of adoption, only large farmers experimented with the new varieties (see Table 10), and they put only a small proportion of their acreage under the new seeds, typically about 25 percent. Over a two- or three-year period, as the profitability of the new variety became clear, small farmers began to adopt and large farmers increased their acreage under the new variety to between 75 and 100 percent. Initially, farmers' additional credit requirement is small as a percentage of total credit used on the farm. It is only in the secondary stages of adoption that large and small farmers alike required a

[50]Mahendra D. Desai and Bharat D. Naik, "Prospects of Demand for Short-Term Institutional Credit for High-Yielding Varieties," *Indian Journal of Agricultural Economics*, Vol. XXVI, No. 4 (October-December 1971), p. 458.

[51]Schluter and Mellor, *op. cit.*

[52]Mutthiah, *op. cit.*

Table 10. Percentage of Farmers Adopting High-Yielding Rice Varieties on Any Part of Their Irrigated Rice Acreage, by Farm Size, Among Sample Farmers in Surat District, 1968/69 to 1972/73

Net Cultivated Acreage	1968/69	1969/70	1970/71	1971/72	1972/73
	←		(Percent)		→
0-2	0	0	50	65	55
2-5	4	46	74	65	74
5-10	21	43	61	61	71
Over 10	20	36	82	82	82

quantity of capital that represents a significantly large proportional increase.

Macro data for Gujarat State confirm that rapid extension in acreage under new varieties occurs only with huge expansion in the supply of cooperative credit. Ninety-four percent of HYV acreage in Gujarat was under new wheat or bajra varieties in 1970/71. Therefore, in Table 11 we rank districts by percentage of area under bajra and wheat sown to new varieties in 1970/71, and estimate for each district the growth in advances from primary credit societies over the period of the HYVP, 1965/66-1970/71. Table 11 shows that spectacular growth of advances may occur in the absence of rapid diffusion of the new varieties. For example, in Bhavnagar, Surendranagar and Junagadh districts, where less than 25 percent of bajra and wheat acreage was under new varieties in 1970/71, growth in advances over the period of HYVP was over 90 percent.

However, Table 11 also indicates that rapid diffusion of the new varieties has not occurred without rapid expansion

Table 11. Increase in Acreage under New Bajra and Wheat Varieties as a Percentage of Total Bajra and Wheat Acreage and Percentage Increase in Advances from Primary Credit Societies from 1965/66 to 1970/71, by District for Gujarat State (Excluding Dangs and Ghandinagar)

District	Percent of Bajra and Wheat Acreage, Under HYV 1970/71	Percent Increase in Advances, 1965/66-1970/71
Bulsar	65.16	296.18
Ahmedabad	62.32	89.94
Surat	59.79	51.66
Kaira	55.33	88.04
Rajkot	52.21	258.40
Amreli	42.04	115.38
Baroda	37.75	30.84
Panchmahals	35.42	59.96
Mehsana	35.15	43.55
Sabakantha	31.84	176.40
Jamnagar	27.87	91.69
Surendranagar	24.00	136.86
Junagadh	23.93	134.44
Bhavnagar	23.34	85.16
Broach	9.40	70.29
Kutch	9.19	27.00
Banaskantha	8.04	–59.37

Sources: Gujarat State Co-operative Bank; Office of the Director of Agriculture, Gujarat State; and State Income Unit, Bureau of Economics and Statistics, Gujarat State.

of cooperative credit. In all the six districts where over 40 percent of bajra and wheat acreage was sown to new varieties, there was a huge expansion in advances of cooperative credit, ranging from 52 to 296 percent. With membership almost static, this expansion reflects an increase in the percentage of members borrowing, an increase in the size of loan per borrower, or both.

Factors Influencing Small Farmers' Decision to Adopt

Profitability and some degree of certainty are preconditions for small farmers to *decide to adopt.* Cooperative credit then becomes significant in determining *ability to adopt.*

The importance of both profitability and uncertainty emerges from the analysis of nine districts in Table 12. In all three cases of a high level of small farmer adoption (Thanjavur, W. Godavari (rabi) and Surat), the rate of return on additional capital employed was in excess of 65 percent. However, the high profitability and low small farmer adoption in Cuttack District in 1966 underlines that the degree of uncertainty is also important. The recent introduction of the new variety, and the weather variability of the kharif season may both have contributed to a high degree of uncertainty in that situation. The higher levels of adoption in both East and West Godavari in the rabi season may be due not only to greater profitability but also to lower uncertainty, as disease and adverse weather conditions are less prevalent in the rabi season.

To examine more closely the role of cooperative credit in situations where it was profitable to adopt, we analyze farmers' adoption behavior for hybrid bajra in Mehsana, and HYV rice and wheat in Surat, using a linear regression model. Area under the new variety is the dependent variable; independent variables used in the model and the results of the estimated equations are shown in Table 13. We also examine adoption of HYV wheat in Mehsana using tabular analysis because a regression model is not feasible (see Table 14). Value of non-farm assets is used in the Surat data as a measure of a farmer's capacity to bear uncertainty. For Mehsana, these data were not available.

Cooperative Credit and Uncertainty in Surat and Mehsana

Availability of cooperative credit was especially important for small farmers for crops involving a high degree of uncertainty. The significant negative coefficient for gross cropped acreage (a proxy variable for farm size) in the equation for the new rice variety, shows that a relatively high proportion of small farmers had adopted the new variety. The significant coefficients for both availability of cooperative credit and value of non-farm assets suggests that it was mainly those small farmers able to bear uncertainty and with access to cooperative credit who had adopted. In contrast for wheat, which involves much less uncertainty as a rabi crop, neither value of assets nor availability of cooperative credit were positively related to adoption. Greater availability of funds in the rabi season, after the year's main crop sales at the end of the kharif season,[53] may be another reason for the lack of

[53]Ninety-five percent of the value crop sales of sample farmers in Surat in 1971-72 took place at the end of the kharif season.

Table 12. Capital Requirement, Profitability and Small Farmer Adoption of New Rice Varieties in Nine Districts, 1966-71

District		Year and Season[1]		Main Variety	Percent Increase of Working Capital for HYV	Rate of Return on Additional Working Capital Used	Percent Small Farmers Adopting[2]
Thanjavur	(16)	1967	K	ADT-27	31	302	High
Surat	(24)	1971	K	Masuri	22	160	63
W. Godavari	(2)	1968	R	IR-8	41	172	59
E. Godavari	(2)	1968	R	IR-8	50	243	39
A district of Maharashtra	(17)	1966	K	TN-1	54	−72	36
Varanasi	(1)	1967	K	TN-1	27	−171	23
E. Godavari	(3)	1968	K	IR-8	45	−3	16
W. Godavari	(3)	1968	K	IR-8	54	33	10
Cuttack	(7)	1966	K	TN-1	261	126	10

NOTES: 1. K = kharif; R = rabi
2. A small farmer "adopted" if he put any part of his rice acreage under a new variety.
Other definitions are the same as those used in Tables 8 and 9.

Table 13. Estimated Regression Equations Showing Factors Influencing Adoption of Hybrid Bajra in Mehsana District, 1969-70, and High-Yielding Rice and Wheat Varieties in Surat District, 1971-72

District	Mehsana		Surat			
Crop	Bajra		Rice		Wheat	
Factor Influencing Acreage Under HYV	Regression Coefficient	Estimated t-Value	Regression Coefficient	Estimated t-Value	Regression Coefficient	Estimated t-Value
Acreage under crop	0.406	5.24**	0.661	6.59**	0.541	3.84**
Gross cropped acreage	−0.034	−1.43	−0.056	−2.17*	0.006	0.29
Credit available from cooperative[1]	0.324	4.05**	0.182	2.02*	−0.114	−1.57
Non-agricultural income ('000 Rs.)	0.210	1.33	0.089	1.38	−0.016	−1.28
Dairying income ('000 Rs.)	2.890	4.85**	0.100	1.54	0.073	1.53
Non-farm assets ('000 Rs.)	–	–	0.020	2.52**	−0.005	−0.89
Number family members available for farm work[2]	0.010	0.55	0.011	0.10	−0.009	−0.74
Educational level of family decision maker[3] (in years)	0.775	2.13*	−0.005	−0.12	0.076	3.23**
Home consumption requirement (in mds)[4]	0.007	4.59**	0.005	0.53	0.009	0.55
Value of kharif crop sales	–	–	–	–	−0.030	−0.75
Number of observations (farmers)	n = 212		n = 59		n = 50	
Multiple correlation coefficient	$r^2 = 0.43$		$r^2 = 0.76$		$r^2 = 0.54$	

*Significant at 5 percent level. **Significant at 0.5 percent level.

[1]For Mehsana, defined as the maximum amount a farmer can borrow from the cooperative under the crop loan system with his existing cropping pattern, assuming he puts all bajra and wheat acreage under HYV. For Surat, defined as the maximum amount the cooperative society said it would be willing to lend the farmer for variable inputs based on acreage, cropping pattern, assets, and character of the farmer.

[2]For Mehsana, number of family members was used as a proxy variable.

[3]For Mehsana, literate (=1) or illiterate (=0) was used as a proxy variable.

[4]In Gujarat, 1 maund is equal to 20 kg approximately.

significance of cooperative credit in adoption of HYV wheat, but was not itself a significant factor in adoption.

In Mehsana, availability of cooperative credit was a significant factor in adoption of hybrid bajra and new wheat varieties, both of which involved a high degree of uncertainty. For bajra in Mehsana, the uncertainty involved in cultivation of the new variety has been demonstrated to be high.[54] For wheat, uncertainty was due to the recent introduction of the variety, and a well irrigation system largely dependent on an uncertain electricity supply.

Why is cooperative credit of special importance for adoption in situations involving a high degree of uncertainty? The *inability* of farmers to borrow from traditional sources to finance innovation was argued above. Small farmers also may be *unwilling* to use traditional credit sources, even when they are able to. In the event of crop failure, a farmer often falls back on a moneylender to finance essential production and consumption expenditure until the next harvest. If the farmer borrows additional capital from a moneylender to finance the adoption of new varieties, and the crop fails, he may not be able to borrow any more from this source, and may have no other source of credit with which to meet an emergency. In contrast, repayment of cooperative loans are more flexible, as loans are frequently changed from short- to medium-term in the event of crop failure, and traditional credit sources are still available until the next harvest.

Home Consumption Requirement

Farmers with a relatively large home consumption requirement, who are willing to consume inferior varieties of cereals, benefit substantially from the new technology, especially when the prices of the new varieties are considerably lower than for traditional varieties. This may

[54]Michael G. G. Schluter and Richard W. Longhurst, "Some Aspects of the Suitability of High Yielding Rice and Bajra Varieties for the Small Farm, Thanjavur and Mehsana Districts, India," Occasional Paper No. 57, Department of Agricultural Economics, Cornell University, USAID-Employment and Income Distribution Project, 1972.

Table 14. Factors Influencing Adoption of High Yielding Wheat Varieties in Mehsana District, 1969-70

Farm Size (G.C.A.)	0-5		Over 5	
Factors	Adopters	Non-Adopters	Adopters	Non-Adopters
Credit available from cooperative	469	213	1196	811
Non-agricultural income	558	268	364	279
Dairying income	185	164	295	213
Home consumption requirement (in mds.)	6.0	8.5	54.0	46.8
Percent of farmers adopting	48.15		16.30	

[1]An adopter is defined as any farmer with some part of his wheat acreage under HYV.
Other variables are defined as in Table 13.

be illustrated for Kollam (local improved) and Masuri[55] (high-yielding) varieties for Surat District as follows:

	Yield/Acre (in kgs.)	Price per 100 kgs. (Rs.)
Masuri	1500	70
Kollam	1000	90

Gross Income from Crop Sales	Kollam	Masuri
If no home consumption	9,000	10,500
If 500 kg for home consumption	4,500	7,000
If 1000 kg for home consumption	0	3,500

The greater the market orientation of the local economy, the less this holds, for farmers may sell the higher quality cereal and buy the inferior variety.

Home consumption requirement was a significant variable for adoption of both new varieties in Mehsana, and for neither in Surat. There may be two reasons for this. The Mehsana data relate to an earlier point in the adoption process when a large home consumption requirement gives greater incentive to take the risk of adoption. Also, the villages in Mehsana are much more subsistence oriented than in Surat, so that the advantage of a yield increasing technology for those willing to consume inferior quality cereals is most clearly apparent.

Supplementary Income

Non-agricultural income did not emerge as a significant variable in any of the estimated regression models. However, dairying income did play a relatively important role for both kharif season crops. Dairying income is important both as a source of income to finance the purchase of variable inputs during the kharif season and may also increase ability to bear uncertainty, which is especially important for small farmers. Non-agricultural income is concentrated among very small farmers, who must use it to finance essential consumption requirements.

Family Labor Availability

In none of the above functions was availability of family labor found to be a significant factor in adoption behavior. We may note that the new varieties require additional labor mainly for harvesting and threshing operations, and for transplanting in the case of paddy.[56] These are generally time-bound so that farmers have to hire the additional labor required rather than being able to take advantage of their underemployed family labor. The additional labor requirement thus becomes largely a capital cost and increases the demand for credit on all farms. Partial exceptions to this are cases such as Thanjavur, where adoption of new varieties facilitates a change to double cropping, substantially increasing the opportunity for small farmers to use available family labor. With the new variety, ADT-27, also being a very hardy variety, it is not surprising that small farmers adopted very quickly and on a large part of their rice acreage in Thanjavur.[57]

[55]Masuri is not included in the Government of India's list of high-yielding varieties. However, local research stations indicated it has all the characteristics of high-yielding varieties.

[56]See G. O. Parikh and R. D. Sevak, "Relative Profitability of Improved and Deshi Wheat: A Case Study," *Industrial March*, January-March 1971, pp. 48-50 and R. N. Tripathy and B. Samuel, "Economics of High-Yielding Varieties in I.A.D.P. A Study of Sambalapur District in Orissa," *Economic and Political Weekly*, Vol. IV, No. 43 (October 25, 1969), p. 1719.

[57]See Schluter and Longhurst, *op. cit.*

Conclusions

Our analysis suggests that cooperatives may be an especially effective policy instrument to accelerate diffusion of the new varieties to small farms under the following conditions:

1. Where a profitable innovation has been introduced.
2. In the second phase of the diffusion process, when small farmers begin to adopt.
3. In the kharif season, when crop diseases and weather variability lead to high levels of uncertainty, and capital available from own funds is at a minimum.

In areas without technological change, the role of cooperative credit for small farmers is limited by an absence of demand. Small farmers can meet costs of cultivation from traditional sources and in many cases find the disadvantages of changing to cooperative credit greater than the advantages.[58] In areas with technological change, supply constraints may inhibit adoption; attention should be focused in these areas on improvement in management practices of the primary credit societies.

The importance of cooperative credit in situations of high uncertainty suggests that cooperative institutions should take account more explicitly of uncertainty in policy regarding the repayment of loans. To the extent that cooperatives follow a flexible policy, they allow individuals to shift uncertainty from themselves onto an institution which is well placed to balance risks between regions and over time. However, a more flexible policy will increase the need for careful supervision of loans, and may increase the number of bad debts which have to be written off, especially in the event of an unsuitable variety being introduced, or extremely adverse weather conditions. To pay for these policies, the normal interest rate could be raised; we have argued above that in most cases this would make little difference to borrowing, as the returns on the new varieties are so high, and supply from other sources highly inelastic.

Stimulus to demand for cooperative credit from small farmers by more flexible repayment policies, and more ready access in areas where demand exists, would accelerate diffusion of the new varieties to small farms. Thus the credit cooperatives would become a more effective mechanism both to increase the production of foodgrains, and to reduce income disparities in rural areas.

[58] See Table 17. Also R. K. Sharma, "Co-operative Credit in the Package Programme. A Study in Aligarh District, Uttar Pradesh," Agro-Economic Research Centre, University of Delhi, 1966.

CHAPTER V

The Effect of Capital Constraints and Uncertainty on the Demand for Chemical Fertilizers

Chemical fertilizers may have a dramatic impact on yields, and hence on incomes. As with the new varieties, the main effect is to raise returns to land. Fertilizer use increases labor use in weeding and harvesting, but probably does not have a substantial impact on total labor used, so that there is little change in returns to family labor.

Three factors determine an economic optimum level of fertilizer use – the physical production function, determined by the crop or crop variety, price of the crop and price of fertilizer. Using cross-sectional data for one year for a small region, expected prices of crops and fertilizer vary little between cultivators. Thus, assuming a single cross-sectional production function for a given crop and variety, the economic optimum is the same for all cultivators. In this chapter, we analyze differences in rates of fertilizer application between farmers with the same economic optimum; that such differences exist has been widely observed.[59] These observed differences may be due to one of two factors:

1. *A Capital Constraint.* Two farmers with equal but scarce capital availability may use different rates on crop A because one grows crop B, which has a very high response to chemical fertilizers, while the second grows crop C with a very poor response. Thus, the first farmer allocates funds to crop B, so low levels are observed on crop A, while the other uses high levels on crop A. Even analysis of use of chemical fertilizers on all crops remains partial because capital is allocated not only between fertilizer for different crops, but also between labor and other variable inputs, on each of the crops grown. So a farmer's rates of fertilizer application on crop A may be influenced by the marginal value product of a man day of hired labor on crop Z, if capital is inadequate to equalize marginal costs and marginal returns for all inputs on all crops.
2. *Uncertainty.* At the time fertilizer is applied, yields and prices are uncertain, which leads to uncertainty in returns to fertilizer use. Thus, factors influencing a farmer's willingness or ability to bear uncertainty, such as value of assets or farm size, are likely to lead to differing rates of fertilizer appli-

[59] For example, Gunvant M. Desai, P. N. Chary and S. C. Bandyabadhya, "Dynamics of Growth in Fertilizer Use at the Micro Level" (Ahmedabad, India: Centre for Management in Agriculture, Indian Institute of Management, February 1973).

cation. Uncertainty is likely to play a more important role under unirrigated conditions, where yields fluctuate much more widely than under irrigated conditions, and in early stages of the adoption process, when uncertainty of yield and price is compounded by uncertainty of how to use the input and the nature of its response. Price uncertainty is a particular problem for cash crops, as illustrated in Chapter VII. Since small farms are relatively ill-equipped to bear uncertainty, this factor may be expected to lead to slower adoption of chemical fertilizers on small farms, and lower rates of application, especially on unirrigated crops.

Evidence that Shortage of Working Capital Constrains the Demand for Fertilizer on Irrigated Farms

To analyze the effect of capital availability on levels of fertilizer application, taking into account a farmer's cropping pattern, we use a linear regression model. Total expenditure on chemical fertilizer in the kharif season, when capital is most scarce, is the dependent variable; independent variables included in the equation are cooperative credit availability, which is defined as the maximum a farmer *could* borrow if he wants to,[60] value of assets, which is correlated very highly with value of land (r = .95), education, and value of supplementary sources of income.

Cropping pattern is a major factor determining levels of fertilizer use.[61] For the Surat sample this is illustrated in Appendix Table 12. To minimize the effect of cropping pattern in the regression model, we use a subsample of 56 farmers, who grew only five crops in the kharif season; the acreages under each of these crops are included as independent variables in the model.

The results of the estimated equation, shown in Table 15, confirm that capital availability – from cooperative credit, dairying and to a lesser extent from nonagricultural income – does have a substantial impact on levels of fertilizer use. The regression coefficient indicates that farmers with access to an additional 1000 Rs. of cooperative credit use Rs. 83 more fertilizer than those

[60] A correlation between borrowings and fertilizer use does not clarify whether low fertilizer use is due to inability to borrow or unwillingness to use fertilizer. By using *availability* of credit, a one-way line of casualty is established between credit and fertilizer use.

[61] Desai *et al.*, *op. cit.*

Table 15. Estimated Linear Regression for Factors Influencing Demand for Chemical Fertilizers on Sample Farms, Surat District, 1971-72

Factor	Regression Coefficient	Standard Error of Estimate	t-Value
Education	–4.9516	5.1290	–0.97
Availability of cooperative credit[1]	82.6760	19.3375	4.28**
Non-agricultural income[1]	8.5748	7.2964	1.18
Dairying income[1]	25.6555	10.2975	2.49**
Assets[1]	–0.5847	1.7007	–0.34
Region (1=medium income, 0=high income)	–33.5019	39.6559	–0.84
Acreage under high yielding rice varieties	66.9975	14.0624	4.78**
Acreage under improved rice (irrigated)	54.3586	21.9142	2.48**
Acreage under traditional rice varieties (unirrigated)	46.2817	18.5130	2.50**
Acreage under unirrigated crops (cotton, jowar)[2]	–7.9983	8.9908	–0.89
Constant	28.9715	–	–
Number of observations (farmers) = 56		$r^2 = 0.74$	

**Significant at 1 percent level.
[1] In '000 Rs.
[2] Cotton and jowar acreage is aggregated because the production response on the two crops is similar relative to other crops included in the model.

without this credit available; 1000 Rs. of dairying income increases fertilizer expenditure by Rs. 25.70 and 1000 Rs. of nonagricultural income increases expenditure by Rs. 8.60. However, there is no evidence that demand for chemical fertilizers is constrained by uncertainty, as value of assets is negatively related to demand for fertilizer. Appendix Table 12 also suggests that fertilizer use is slightly higher on small farms.

To analyze more closely the effect of credit availability on levels of fertilizer use, we examine expenditure on chemical fertilizers among farmers in the middle-income villages. This subsample is relatively homogeneous in terms of geographic location and crops grown, and in access to cooperative credit. The percentage of farmers in each farm size group,[62] claiming they were using less than what they regarded as the economically and technically feasible maximum, owing to a shortage of credit, is shown below:

0-2 acres	33%
2-5 acres	47%
5-10 acres	57%
Over 10 acres	0%

The credit shortage is concentrated on farms with between 2 and 10 acres. The relatively small percentage of those with less than 2 acres claiming a credit shortage indicates in part the very small demand for production credit on farms with hardly an acre of land. Farmers with over 10 acres are able to obtain substantial and apparently adequate credit from the cooperatives under the crop loan system.

Table 16 below shows a profile of those claiming a shortage of working capital in terms of level of fertilizer application and provides clear evidence that their rates of application are lower. Of 15 farmers claiming a credit shortage, two are not members of the cooperative, although one joined in the reference year, and so could borrow in the following year. Eight of the 15 had defaulted on an earlier cooperative loan, and the remaining five of the 15 had used the maximum available to them under the crop system. This evidence strongly suggests that credit may act as an important constraint on demand for chemical fertilizers, and equally underlines that the credit shortage may persist even after cooperative credit has been made available.

Farmers with a credit shortage also tended to be those with low dairying income; 40 percent had no dairying income, compared with 23 percent of those not claiming a credit shortage. This adds to the evidence of the linear regression model that dairying income is an important source of capital to finance purchase of chemical fertilizers in the kharif season.

[62] Defined in terms of net cultivated acreage.

Table 16. Expenditure on Chemical Fertilizers by Farmers Claiming Credit Shortage as the Reason for Not Increasing Fertilizer Use, Surat District, 1971-72

Crops	Expenditure per Acre: With Credit Shortage	Expenditure per Acre: Without Credit Shortage
	Rs/acre	
Improved rice	52.4	105.3
HYV rice	98.7	119.1
Cotton	14.7	11.7
Jowar	1.98	4.7
	%	
Percent of farmers fertilizing cotton	44.4	58.3
Percent of farmers fertilizing jowar	12.5	42.9

Evidence that Uncertainty Constrains the Demand for Fertilizer

Use of chemical fertilizers increases the uncertainty of net returns on unirrigated crops in three ways:

1. If fertilizer is applied and rain does not follow, the crop may be "burnt," resulting in lower yields.
2. If fertilizer is applied and the rains following are substantially greater than expected, the effect of the fertilizer is neutralized by the volume of water, so that the expected increase in yields does not materialize.
3. If fertilizer has been used, and the crop fails owing to disease, paucity of rain or some other factor, net returns will be lower than if fertilizer had not been used. Such a situation is illustrated in Appendix Table 20 for unirrigated rice and cotton.

The poor rainfall in 1966/67 meant that the additional yield of the fertilized crop was inadequate to offset the additional fertilizer and labor costs. In using fertilizer, one may lose not only the value of fertilizer, but a large part of the value of the crop.

The uncertainty associated with fertilizer use under unirrigated conditions may be inferred from the relatively slow spread of fertilizer use from irrigated to unirrigated crops on partially irrigated farms. On average, farmers adopted on unirrigated crops initially more than six years after they had adopted on irrigated crops. Appendix Table 12 indicates the low levels of use of fertilizers on unirrigated crops (cotton and jowar) compared with irrigated crops (rice and wheat).

Uncertainty and Adoption

To analyze the effect of uncertainty on adoption of chemical fertilizer, we examine the year of first use of chemical fertilizers in the middle-income villages on rice and wheat, the only irrigated crops grown at the time, in the middle-income villages. Then we consider the spread onto the two unirrigated crops, jowar and cotton, which are grown in rotation on 90 percent of the unirrigated acreage. In a second zone, with no irrigation, rice is the only crop fertilized, so that these farmers also form a relatively homogeneous subgroup for analysis.

The relationship between value of assets[63] and year of first adoption of fertilizer suggests that uncertainty is a major factor in adoption behavior. Value of assets is related to year of adoption of fertilizer on the irrigated crop, rice, and is also related to first adoption on an unirrigated crop, cotton or jowar (see Appendix Table 13). In addition, there is a significant relationship between those adopting early on irrigated crops and those adopting on unirrigated crops by 1971-72. In the unirrigated zone, whether or not a farmer uses fertilizer on rice in 1971-72 is significantly related to farm size (net cultivated acreage) but not to other assets (see Appendix Table 13.)[64]

Uncertainty and Rates of Application

To analyze the effect of uncertainty on rates of fertilizer application, we use the results of estimated Cobb-Douglas production functions for cotton and jowar (see Appendix Tables 17 and 18). The size and significance of the coefficients for nitrogen in these two equations suggest that use of nitrogen was extremely profitable on these two crops, but that levels of use were far below the economic optimum. In a Cobb-Douglas world, the optimal level of application of an input is defined by the following relation:

$$P_y \bullet MMP_N = P_N \qquad (N = \text{nitrogen}, y = \text{output})$$

From the estimated Cobb-Douglas production functions, and given crop prices and the price of a kilogram of nitrogen from Urea, we may estimate the above relation as follows: (in Rs.)

Cotton		Jowar	
P_y	= 55.60	P_y	= 17.73
MPP_N	= 0.2071	MPP_N	= 0.2753
P_N	= 2.04	P_N	= 2.04
$P_y \bullet MPP_N$	= 11.59	$P_y \bullet MPP_N$	= 4.88

What is striking from these estimates is how far farmers are from the economic optimum. For cotton, the estimated returns are 600 percent on a kilogram of nitrogen; the high incidence of uncertainty,[65] discussed in Chapter VII, is a plausible explanation of this vast "irrationality" in farmer's behavior, defined in terms of profit maximization.

Lipton has argued that under conditions of uncertainty farmers will maximize expected marginal value product (MEVPE) rather than the marginal value product indicated by a cross-sectional production function.[66] Appendix Tables 21 and 22 give data for cross-sectional average yields and prices for cotton and jowar from 1966/67 to 1971/72. Since yields in 1971/72 were substantially below average yields for the period, but prices close to the average prices, the MEVPE should be greater than the MVP estimated above for 1971/72, so that farmers are even further away from the economic optimum.

Implications for Policy

On irrigated crops, uncertainty is a factor in determining levels of use when fertilizers are first introduced, but in 1971-72, when almost all farms had adopted, capital availability is the main factor influencing rates of application for a given cropping pattern. This suggests that increasing credit available under the crop loan system, which is clearly inadequate at present,[67] would lead to higher levels of use of chemical fertilizers, especially on farms with between 2 and 10 acres because they suffer most acutely from a shortage of working capital. The credit difficulties of defaulters on cooperative loans underline the need for care in loan supervision, and the need for greater flexibility in loan repayment, as suggested in Chapter IV. Policies to raise dairying incomes on small farms, discussed in Chapter VI, may also raise level of fertilizer use in the kharif season, as high dairying income is correlated with high levels of fertilizer use.

On unirrigated crops, and especially in the unirrigated zone where there is no demonstration effect from irrigated crops, extension must play an important role to reduce perceived and actual uncertainty, through improving knowledge of appropriate cultivation practices. The practice of application of nitrogen without phosphorus on groundnuts on sample farms, which has been shown to be inappropriate under Indian conditions,[68] is an example of

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[63]Defined as value of farm and non-farm, excluding only value of land owing to problems of measurement.

[64]Net cultivated acreage is a close proxy variable for value of total assets in the unirrigated region, where land is the chief asset, but is not such a good proxy in the irrigated tract, where irrigation availability may double land value, and other assets such as dairy animals are much larger.

[65]Uncertainty involved in use of fertilizers relative to other changes in cropping pattern is analyzed in Chapter VII.

[66]Michael Lipton, "The Theory of the Optimizing Peasant," *The Journal of Development Studies*, Vol. IV, No. 3 (April 1968), p. 327.

[67]Parikh and Sharma, *op. cit.*

[68]P. R. Raheja, A. G. Kavitkar, and P. P. Mehta, *Fertilization of Crops*, Research Bulletin No. 2 (New Delhi: Division of Agronomy, Indian Agricultural Research Institute, 1965). Also, see the estimated production function for groundnuts for farmers in this sample (Table 23).

lack of information on fertilizer practices. A surplus supply position of chemical fertilizers might also help disseminate information, as private companies would probably undertake extension work as part of sales promotion.

CHAPTER VI

Increasing Milk Production on Small Farms

Dairying is recognized as a principal means of raising incomes on small farms, and generating employment in rural areas.[69] The high prices and income elasticities of the demand for milk indicate that even with substantial increases in milk supply, there will be a relatively small decline in milk price.

The high labor input for dairying indicates it is well suited to the resource endowments of small farmers. To the extent that dairying raises the marginal value product of family labor, an increased family labor input may be expected (see Chapter III). Thus, small farmers' incomes are raised both through an increase in returns to land (returns after payments to all other factors), and an increase in the returns to family labor. If facilitating dairying or adoption of the new varieties are considered as policy alternatives, the increased returns to both land and family labor of dairying must be compared with the increased returns to land alone of the new varieties.

Increasing milk production on small farms may be achieved in one of three ways:

1. Increase feed levels for buffaloes. Conceptually, this is the same as increasing use of chemical fertilizers as it represents a shift along a given production function.
2. Improve buffalo quality. Replacing a "desi" buffalo with an improved breed represents a shift in the production function similar to that of adoption of the new varieties, and increases optimal levels of application of variable inputs – especially concentrates.
3. Increase the number of buffaloes. In terms of the parallel with crop production, this is the equivalent of increasing a farm's acreage.

Different policies are required to increase milk production by each of these methods. In this chapter we analyze which is the most appropriate method for the small farmer, and therefore, which are the most appropriate policies to raise dairying incomes on small farms.

In the analysis following, we examine first the profitability of dairying and evidence for increasing returns to scale. Then we consider factors constraining the expansion of milk production on small farms in terms of the categories listed above, and consider what scope exists to relax land and labor constraints by substituting buffaloes for bullocks on small farms.

The Profitability of Dairying

Dairying provides a major part of the incomes of farmers with 2 to 5 acres in the irrigated zone, which has cooperative marketing facilities (see Appendix Table 10). Farmers with 2 to 5 acres obtained nearly 45 percent of their income from dairying, compared with only 10 percent on farms of 0 to 2 acres and 24 percent on farms of over 5 acres. In unirrigated areas, dairying is of relatively small importance, owing to marketing problems, and the difficulties of obtaining green fodder in the summer months (see Appendix Table 9).

The net returns per buffalo for different herd sizes are shown in Table 17. Family income (returns to land and family labor) increases by Rs. 450 a year if a first buffalo is purchased, and by Rs. 700 if the herd size increases from one to two. In the context of returns from crop cultivation of Rs. 541 on 0 to 2 acre farms, and Rs. 1228 on 2 to 5 acre farms, this increase is substantial.

Table 17 also indicates that returns per buffalo are substantially greater in the larger herds. To account for this, in Table 18 we examine concentrates, fodder and labor costs as percentages of total cost by herd size. For herds of four and above, the share of labor declines substantially, but for farmers with one to three buffaloes, the share of labor in total cost is remarkably stable at almost 40 percent. In the irrigated zone, family and hired labor form equal parts of the total labor cost; in the unirrigated zone, the labor cost is an even greater proportion of total cost, but over 95 percent of the labor input is family labor. The increasing returns per buffalo with increasing herd size from one to three buffaloes arise partly from a reduction in expenditure per buffalo, but mainly from increased productivity on the larger herds, as shown later in the chapter.

For small herds, 60-66 percent of the labor input was from family labor, but only 25 percent of the labor input for herds of four and above, was from the farm family. This is because smaller herds are concentrated on small farms, where the family labor input is relatively high.

A fall in the price of milk, as might occur with very large increases in aggregate supply, would tend to move small farmers, rather than large farmers, out of dairying. In Table 19, we consider returns to land and family labor by herd size for a fall in the price of milk of 20 percent, and all else the same. For any given herd size, small farmers tend to have a higher income owing to a greater family

[69] National Commission on Agriculture, *Interim Report on Milk Production Through Small and Marginal Farmers and Agricultural Laborers* (New Delhi: Ministry of Food and Agriculture, Government of India, December 1971).

Table 17. Net Returns per Buffalo for Different Herd Sizes Among Sample Farmers in Surat District, 1971-72

Net Returns		Herd Size 1	2	3	4
NR_1	(Gross returns minus all variable costs except the imputed value of family labor)[1]	585	704	915	1116
NR_2	(NR_1 minus depreciation[2] of dairy herd, i.e. returns to land and family labor)	454	579	771	1043
NR_3	(NR_2 minus imputed value and family labor, i.e. returns to land and residual)[3]	158	335	512	861

[1]Annual milk yields are estimated by multiplying the milk yield per day by the ratio of months in milk to months dry, reducing the total cycle to a twelve-month period. This annual yield is then multiplied by an annual average milk price to derive gross returns. Gross returns minus labor, concentrate and fodder costs give net returns. The value of the labor input is derived from farmers' estimates of the number of hours taken per day of family and hired labor in care of milk animals; the total number of hours spent in a year are reduced to eight-hour man-days. Since the short working time each day for dairying is quite intensive, we value each eight-hour period at Rs. 3.00 for family labor; for hired labor the wage is usually explicit.

[2]Buffaloes were depreciated linearly over 7 years, and cows over 10 years, on the basis of the normal milking period of the animal in this region.

[3]Interest charges have not been included. With cooperative credit at 9 percent, interest charges would be Rs. 81 on a desi buffalo valued at Rs. 900.

labor input. However, differences between returns per buffalo in different herd sizes are now proportionally greater, so farmers with large herds, who have high productivity per buffalo and enjoy certain economies of scale, will remain in business. Farmers with large herds are those with large farms.

Increasing Buffalo Productivity

To analyze factors influencing buffalo productivity, we examine factors influencing milk production per day for 80 buffaloes in the sample. The value of concentrates given per day to a buffalo in milk, breed, age, the ratio of the number of months in milk to the number dry, and availability of grassland and green fodder in the summer were all included as independent variables in the model. Results of the estimated linear regression are shown in Table 20.

Breed of buffalo is a significant variable in explaining variation in milk yields per day. Improved buffaloes, costing an average of Rs. 1414, as against Rs. 896 for a desi buffalo, yielded over a liter more milk per day, and were in milk a relatively high proportion of the time. However, the value of concentrates given per day in milk was also relatively high, Rs. 2.59 compared with Rs. 2.07. If we assume fodder and labor costs are the same for the two types of buffalo, and a herd size of two, net returns are 64 percent greater for improved buffaloes (see Appendix Table 14). A farmer buying an improved buffalo would recover the difference in price between the improved and desi buffalo in two years. Improved buffaloes are concentrated in larger herds, which accounts

Table 18. Concentrates, Fodder and Labor as Percentages of Total Variable Cost by Herd Size in the Irrigated Zone for Sample Farmers, Surat District, 1971-72

Herd Size	Concentrates		Fodder		Labor Value[1]		Total Cost
	Value	Percent	Value	Percent	Value	Percent	
1	482.4	38.6	270.5	21.7	495.8	39.7	1248.7
2	834.9	41.4	376.7	18.7	804.5	39.9	2016.1
3	1405.0	44.0	536.4	16.8	1248.7	39.1	3190.1
4 and above	3222.5	57.9	951.9	17.1	1388.7	25.0	5563.1

[1]Includes imputed value of family labor.

Table 19. Returns to Land and Family Labor by Herd Size, Assuming a 20 Percent Fall in the Price of Milk, for Large and Small Farms in Surat District, 1971-72[1]

Farm Size	Herd Size 1	2	3	4 and above
Small (0-5 acres)	184	285	431	402[2]
Large (over 5 acres)	125	286	403	498

[1]These estimates are based on data used in Tables 17 and 18, but imputing the value of hired labor for each herd size for large and small farms separately.
[2]Only one farmer with less than five acres had a herd size of four or above.

to a great extent for increasing returns in large herds, noted above.

Value of concentrates is also a significant factor affecting milk yields. An additional rupee spent on concentrates increased milk yields by 0.73 liters; with the price of milk between Rs. 1.10 and Rs. 1.30 per liter, this estimate suggests farmers use close to optimal quantities. The only variable found to influence levels of concentrate given per day is the number of buffaloes owned by the farmer.[70] This is due mainly to the greater proportion of improved buffaloes in larger herds. It may reflect, also, greater capital availability for those with large herds. Income from dairying may be the chief source of capital in financing dairying operations, especially in the kharif season, so that high dairying income leads to a high feed input, and thus greater income.

Increasing the Number and Quality of Buffaloes on Small Farms

The value of buffaloes per farm reflects both quality (breed) and quantity, so we use this as the dependent variable in a regression framework to analyze factors influencing small farmers' decisions about the number of buffaloes to keep and their breed. Small and large farms are analyzed separately for this owing to differences expected in the nature of constraints in dairying. On small farms, we expect primarily a land constraint, and on large farms primarily a labor constraint. Factors included no independent variables in the model and results of the estimated equations are shown in Table 21.

Land

The significant regression coefficient for grassland and positive coefficient for net irrigated cultivated acreage indicate that availability of land for grazing buffaloes in the monsoon season, and hay to supplement foodgrain

[70]See Appendix Table 15.

Table 20. Estimated Linear Regression[1] for Factors Influencing Buffalo Milk Production per Day for Farmers in the Irrigated Zone, Surat District, India, 1971-72

Factor	Regression Coefficient	Standard Error of Estimate	t-Value
Breed (Improved=1, Desi=0)	1.3053	0.5933	2.20*
Value of concentrates per day	0.7312	0.2559	2.86**
Ratios of months in milk versus months dry	−0.2182	0.2264	−0.96
Age	0.0611	0.0809	0.75
Grass acreage per buffalo	0.0632	0.1086	0.58
Green fodder given in summer (in maunds)[2]	0.0023	0.0072	0.29
Constant	4.1371	–	–
Number of observations (buffaloes) = 80		$r^2 = 0.23$	

*Significant at .05 level.
**Significant at .01 level.
[1]A linear model gave a better fit than a log-log function, with no change in which variables had significant coefficients.
[2]1 maund = 20 kg.

Table 21. Estimated Linear Regression for Factors Influencing the Value of Buffaloes per Farm for Sample Small Farmers, Surat District, 1971-72

Factor	Regression Coefficient	Standard Error of Estimate	t-Value
Availability of family labor[1]	250.1375	86.4863	2.89**
Number of acres grass (waste)[2]	125.1434	43.4857	2.88**
Irrigated net cultivated acreage	44.9796	44.3278	1.01
Non-agricultural income	−32.0057	42.5891	−0.76
Availability of cooperative credit	15.8259	16.9278	0.93
Value of assets (excluding value of dairy herd)	11.5158	11.2519	1.02
Constant	−139.68	—	—
Number of observations (farmers) = 49		$r^2 = 0.51$	

**Significant at .01 level.
[1]Defined as the number of women available for this kind of part-time work, but includes permanent farm servants for four Brahmin families, because they do the work of family labor.
[2]Land not suitable for crops.

stalks as dry fodder for the rest of the year, are important in a small farmer's decision of how many buffaloes to keep. The high purchase costs of green fodder, which is highly perishable and therefore involves high marketing margins, acts as a constraint on the number of buffaloes a small farmer is able to maintain. Those with small irrigated farms, who wish to keep large buffalo herds, put their small rabi acreage under lucerne rather than wheat, to provide the green fodder required. This may increase income uncertainty considerably, as farmers must sell milk at uncertain prices, and buy their wheat requirement in the market, at prices also subject to fluctuation.[71]

However, availability of dry fodder may be the most binding constraint. The supply of fodder is highly inelastic at prevailing prices. An increase in the supply would require changes in crop production towards fodder crops, resulting in a substantial fall in crop net returns, unless a large increase in fodder prices occurs.

Family Labor

Availability of family labor is a second constraint on expanding the number of buffaloes owned by small farmers. The number of women available is important, as women do most of the work in dairying in Surat District. In this context, two categories of small farmers do not keep buffaloes – those too old to take care of the animals, with no children available, and those agricultural labor households in which the woman goes out to work. Total returns, although not necessarily returns per hour of work, are greater working as a laborer than in dairying on small farms which must buy a substantial part of the fodder requirement. For 2 to 5 acre farms, the labor required for feeding, watering, milking, grazing, and for general care for buffaloes, puts a strain on a womar who is also required to keep house, look after the children and help in the fields in peak periods. It is difficult to use hired labor as a substitute for family labor in dairying, because the labor requirement is spread over a long period with short times of intense activity, such as for feeding and watering. Thus, hired labor must be paid for a full day's work, when employed actively for no more than a few hours.

Working Capital

Credit available from the cooperative and non-agricultural income, which reflect working capital availability, are not significant in determining the value of owned by a small farmer. Dairying is not working-capital intensive; it is only when the buffalo is in milk, and therefore providing income, that concentrates are given, and concentrates form the major part of cash costs on small farms. With payment to the farmer each month, and some cooperatives even allowing part of the payment to be drawn before the end of the month, the working capital needed is very small, but requires careful management.

Assets

Assets is positively but not significantly related to the value of a small farmer's dairy herd. The uncertainty

[71]Wheat prices between 1966/67 and 1971/72 are shown in Appendix Table 24.

involved in keeping a buffalo is considerable. More than 10 percent of farmers with buffaloes reported a death in the herd over the period 1968/69-1971/72. To lose Rs. 900 for a desi buffalo or Rs. 1500 for an improved buffalo, is the equivalent of losing a year's crop income for a 2 to 5 acre farm in the irrigated zone (= Rs. 1228). Since the incidence of death is much greater among improved buffaloes, it is not surprising that 83 percent of improved buffaloes are owned by farmers having more than 5 acres. Buffaloes may also exacerbate the conditions of a drought year when a farmer must either sell his buffaloes at very low prices, or buy fodder at high prices from depleted savings and overstretched credit.

The same model is also used for large farmers, and indicates that none of the above factors is significant in explaining variation in the value of buffaloes owned (see Appendix Table 16).

Fixed Capital

There is no evidence for shortage of funds to buy an animal being the reason for not increasing herd size. Farmers give shortage of fodder, shortage of family labor or shortage of space in the house as reasons for not keeping buffaloes. In the region with cooperative coverage, almost all farmers state that they could obtain a buffalo on credit from the cooperative if they applied; it is other factors which make them unwilling to apply.

Substitution of Buffaloes for Bullocks

If buffaloes could replace bullocks on small farms, labor, fodder and space in the farmer's house used to maintain bullocks could be transferred directly to buffaloes. Also, there would be no increase in the value of livestock, and thus no increase in probability of loss through death of an animal. Bullock labor is very underutilized on small farms. The cost per day used is relatively low on farms of 2 to 5 acres but extremely high on farms of 0 to 2 acres (see Table 22). The additional income from dairying would easily cover the additional cost of hiring in bullock labor or tractor services at existing rates. So why not replace bullocks with buffaloes on small farms?

Under present conditions, hiring-in bullocks is a low uncertainty, low-income alternative. Uncertainty is low as there is no fear of loss through death or disease of a bullock; income is low because the seasonal peaks in demand for bullock labor frequently result in late sowing and low yields. Those hiring-in bullocks on 0 to 2 acre farms paid about Rs. 75 less a year for bullock labor used than those maintaining bullocks, but used them 75 percent less; on 2 to 5 acre farms those hiring paid the same as those keeping bullocks, and used them 85 percent less.

The seasonal peaks in demand for bullock labor occur mainly in the early part of the kharif season (see Table 23), when the heavy clay soils make the fields inaccessible to tractors. To meet this seasonal demand, even small farmers keep bullocks. It is doubtful if any agency, or even large farms, could keep bullocks as cheaply as small farmers, so if buffaloes replaced bullocks, the cost of hiring in bullocks would increase sharply.

Analysis of the demand for tractor services indicates that under present conditions demand is highly seasonal. Over 65 percent of total demand from farmers not owning

Table 22. Total Number of Days Bullocks Used and Cost Per Day of Maintaining and Hiring Bullocks, by Farm Size for the Irrigated and Unirrigated Zones Among Sample Farmers, Surat District, 1971-72

Farm Size (Net Cultivated Acreage)	Owned: Number Days Used[1]	Owned: Cost[2]	Owned: Cost Per Day Used	Hired: Number Days Used	Hired: Cost	Hired: Cost Per Day Used
			Irrigated Zone			
0.1 - 2.0	23	147	6.30	6	107	17.80
2.1 - 5.0	88	149	1.69	18	180	10.00
5.1 - 10.0	120	300	2.50	–	–	–
Over 10	125	426	3.40	–	–	–
			Unirrigated Zone			
0.1 - 2.0	28	115	4.10	9	74	8.20
2.1 - 5.0	38	35	0.90	11	109	9.90
5.1 - 10.0	92	88	1.30	23	141	6.10
Over 10	110	81	0.70	–	–	–

[1]Includes use for non-agricultural purposes, such as transport to the nearest town.
[2]Does not include imputed value of family labor, which is particularly high in the unirrigated zone on small farms.

Table 23. Seasonal Demand for Bullock Labor for Agricultural Operations in the Irrigated and Unirrigated Zones Among Sample Farmers, Surat District, 1971-72

Farm Size/Season	June-August[1]	September-November[2]	December-May[3]	Total
		Irrigated Zone		
0.1 - 2.0	6.5	4.3	2.0	12.8
2.1 - 5.0	9.3	15.4	5.2	29.9
5.1 - 10.0	15.1	29.4	5.4	49.9
Over 10	19.4	40.3	6.6	66.3
		Unirrigated Zone		
0.1 - 2.0	11.0	13.0	0	24.0
2.1 - 5.0	18.6	14.9	1.7	35.2
5.1 - 10.0	33.3	21.5	2.7	57.5
Over 10	49.6	24.7	7.6	81.9

[1]Includes plowing, and intercultivation of kharif crops.
[2]Includes harvesting, threshing, harrowing and transport of kharif crops, and plowing and intercultivation of rabi crops.
[3]Includes harvesting, threshing, harrowing and transport of rabi crops.

tractors was for plowing of sugarcane at the beginning of the rabi season, which farmers believe results in enhanced yields owing to the depth of plowing. A further 20 percent was for plowing for other rabi crops. An estimated regression model of factors influencing the demand for tractor services, measured as expenditure on hired-in tractor services in the rabi season by farmers with irrigated land, indicates that the number of tractors in the village, and the number of acres being planted to sugarcane are significant factors in demand (see Table 24). Value of

Table 24. Log-Log Function for Factors Influencing the Demand for Tractor Services[1] on Sample Farms with Irrigated Acreage, Surat District, 1971-72

Factor	Regression Coefficient	Standard Error or Estimate	t-Value
Number of areas planted to sugarcane in 1971-72	0.8115	0.2320	3.50**
Value of assets	0.4299	0.2670	1.61
Non-agricultural income	0.0109	0.0706	0.15
Dairying income	0.0607	0.0882	0.69
Credit available[2]	–0.0930	0.1406	–0.66
Number of bullocks per irrigated acre	0.0724	0.5009	0.14
Region	–0.5638	0.2651	–2.13*
Constant	3.7154	–	–
Number of observations (farmers) = 66		$r^2 = 0.46$	

*Significant at .05 level.
**Significant at .01 level.
[1]Excludes the four farmers owning tractors.
[2]Includes funds borrowable from the sugarcane factory.

assets is also positively correlated with demand for tractor services. Availability of bullock labor per irrigated acre is not significant, nor is the regression coefficient large, suggesting that tractors are not being used primarily as a substitute for bullocks, even on large farms.

Conclusions

Dairying provides the possibility of substantially increasing small farmers' incomes. The chief constraints are land, owing to the cost of purchased fodder, and female labor to look after the animals, owing to the cost of hiring labor for dairying. High prices of fodder in drought years, and fear of death of an animal, greatly add to uncertainty, which is a third important constraint. With substitution of buffaloes for bullocks being infeasible, we conclude that it will be extremely difficult to increase the size of a small farmer's dairy herd through policy intervention.

These conclusions underline the importance of raising productivity per buffalo on small farms. Our analysis suggests that this may be achieved primarily by improving buffalo breeds. However, improving the breed adds substantially to uncertainty, because improved breeds are highly susceptible to disease and result in greater loss if death occurs. To overcome these difficulties, veterinary services at the village level need to be improved, or more disease resistant improved breeds should be developed. In addition to these services, dairies could make available a buffalo insurance scheme, under which farmers could recover some part of their capital (perhaps 50%) in the event of a buffalo dying, thus substantially reducing uncertainty.

Raising levels of concentrate given per day may also lead to increased milk yields for some farmers. This may be achieved primarily by relaxing the credit constraint, both for the purchase of feed directly, and for the purchase of farm inputs. At periods of peak credit requirements in the kharif season, with credit constraining purchase of variable inputs for crops, the marginal value product may be greater in crops than in dairying, so that funds are diverted away from buffalo feed to hiring labor, or purchase of chemical fertilizers. Thus, greater availability of credit for crop enterprises may lead to more intensive feeding of buffaloes at certain times of the year.

These policies would meet the small farmer's general constraint of credit and uncertainty, within the constraints specific to dairying of a small land base and, in some cases, inadequate female labor.

CHAPTER VII

Choice of Cropping Pattern on Unirrigated and Irrigated Farms

Choice of crop or crop variety determines the relationship between input and output, i.e., the production function on which the farmer operates; thus, it determines the productivity and levels of use of variable inputs, including the input of family labor. A change of cropping combination alters returns to labor as well as returns to land.

Availability of resources has long been recognized as a primary determinant of choice of cropping pattern.[72] However, as argued in Chapter II, uncertainty is also a crucial variable in determining the nature of alternative cropping combinations available and a farmer's ability or willingness to choose those with a high income. Uncertainty may inhibit farmers from optimal resource allocation, and more specifically, may prevent small farmers from using their relatively abundant resource – labor – to the maximum in crop production on their own farms.

In this chapter we examine factors influencing choice of cropping pattern on unirrigated and irrigated farms. In particular, we examine the relationship between variance of net returns and expected net returns – the EV frontier – using Hazell's MOTAD model.[73] This leads to a discussion of policies which may be used to help small farmers bear uncertainty, or reduce the uncertainty of those cropping combinations best suited to their resource endowments. We also consider the relationship between capital input per acre and net returns per acre in the EV model.

Part A. Unirrigated Farms

In the zone without canal irrigation, 95 percent of the acreage is under four main crops – rice, which is grown on deep clay soil, and cotton, jowar and groundnuts, which are grown on lighter soils. To examine choice of cropping combination amongst these alternatives, we estimate the EV frontier for each of 33 farms. We then examine each farmer's actual cropping pattern in relation to the normatively derived EV frontier, to assess how well the model predicts farmers' observed behavior. By changing coefficients and constraints for a representative farm, some insight is gained into the impact of various policy alternatives on incomes of small farmers.

[72] D. K. Desai, *Increasing Income and Production in Indian Farming* (Bombay: Indian Society of Agricultural Economics, 1963).

[73] Hazell, *op. cit.*

For linear programming, the objective function is as follows:

$$\text{Min } A = \frac{1}{r} \sum_{h=1}^{r} \left| \sum_{j=1}^{n} (c_{hj} - \bar{c}_j) X_j \right|$$

In words, we minimize the mean absolute deviation, defined as the mean over (h=1, ... r) years, of the sum of deviations of gross returns (C_{hj}) from the sample mean gross return ($\bar{c}_j$), multiplied by activity levels x_j (j=1, ... n).

This is minimized subject to the following constraints:

$$E = \sum_{j=1}^{n} f_j x_j = \lambda \qquad (1)$$

Such that the expected net return (E), the sum of the activity levels times their expected gross returns (f_j) minus costs, equals λ, a parameter to be parameterized to the maximum level of income. And

$$\sum_{j=1}^{n} A_{ij} x_j \leq b_i \qquad (2)$$

Total fixed activity requirements for the ith constraint, the sum of the unit activity requirements A_{ij} for the constraint i times the activity levels x_j, do not exceed the level of the ith constraint b_1 for all i.

and

$$x_j \geq 0 \qquad \text{All activity levels are non-negative} \qquad (3)$$

The MOTAD model has been shown to be nearly as efficient as quadratic programming for estimation of the EV frontier.[74]

In this model, a farmer decides between possible crop combinations on the basis of expected net returns and the absolute deviation of gross returns for each crop from its expected value.[75] Data availability results in expectations being based on the previous six years' experience. The decision is made in this model prior to the beginning of the agricultural season. Later decisions which may affect the cropping combination, such as decisions on levels of fertilizer application based on actual rainfall during the season, are not considered in the model. Also, we assume the farmer is maximizing returns to land and family labor, so there is no imputed cost to use of family labor available.

The relationship between expected income and the absolute deviation of income from its expected value is based on observed field and price data for 1966/67 to 1971/72, and we consider choice of cropping combination for the 1972/73 crop year. Data to derive time-series estimates of gross returns for each crop are based on three overlapping studies – "Studies into the Economics of Farm Management in Surat District 1966-1968." "Changing Farm Production and Organization in Developing Agriculture, 1968-1970" and the author's own study, which includes data for 1970/71 and 1971/72 and farmer's expected and actual cropping pattern for 1972/73; yield data for Surat District from the Office of the Director of Agriculture for Gujarat State, and price data from the Bureau of Economics and Statistics, Gujarat State, are used in the absence of alternative sources.[76]

In the model, farmers maximize *cash* income and minimize a measure of its associated variation. Home consumed crops do not add to cash income, but only help to meet the home consumption requirement. The difficulty of including home consumed activities in value of farm output is placing a price on home consumption. Since this does not enter the market, and assuming constant marginal utility of a unit of food from year to year, the value of a maund (20 kg) of rice consumed at home remains constant even when market price changes. For this reason, we attached average (expected) price to home consumption, however, this resulted in home consumed activities having greater fluctuations in gross returns than marketed activities, because price fluctuations tend to offset yield fluctuations, and thus help to stabilize income (see further discussion below). We finally conclude that farmers do not consider there is either yield or price variation for home-consumed crops. Farmers decide how many acres of food crops to plant on the basis of expected yields; they then even out yield fluctuations by storage of excess in good years, which they consume in poor years.

The only cost to farmers of storage are storage losses, which are probably small,[77] and the interest cost of holding this food. The latter may lead farmers to discount future consumption a little, so that they consume more in years of excess than they allow for in fixing acreage for home consumption, and consequently eat less than average in poor agricultural years. Farmers who discount future consumption very heavily may be compelled to buy food in bad years.

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[74]K. J. Thomson and P. B. R. Hazell, "Reliability of Using the Mean Absolute Deviation to Derive Efficient EV Farm Plans," *American Journal of Agricultural Economics*, Vol. 54, No. 3 (August 1972), p. 503.

[75]Since costs are assumed fixed between years, deviations of gross returns from the expected value are equal to deviations of net returns from their expected value.

[76]The author is grateful to the following for making data available for this analysis: Directorate of Economics and Statistics, Government of India; Department of Agricultural Economics, Baroda University; Office of the Director of Agriculture; State Income Unit, Bureau of Economics and Statistics, Government of Gujarat. Data from these sources are used only to estimate time series yields and prices for crops used in the linear programming matrix. The model could not have been used without access to these data.

[77]Uma J. Lele, *Food Grain Marketing in India* (Ithaca, N.Y.: Cornell University Press, 1971), p. 138.

Thus, in the matrix a farmer may produce food crops with no variance in his cash income, up to his home consumption requirement. After that, he must face uncertainty in selling the crop. The farmer, if he wishes to grow only cash crops, may meet the home consumption requirement through purchase of the crop in the market, but he is then subject to food price uncertainty in buying.

Activities

Cotton, jowar (often mixed with pulses or coarse rice), groundnuts and rice are the only crops grown among sample farmers on unirrigated land. For each of these crops, we estimated Cobb-Douglas production functions using data from unirrigated acreage in both the irrigated and unirrigated tracts (see Appendix Tables 17 and 18).[78] For rice and cotton, levels of fertilizer use have large and significant coefficients in the estimated production functions, so these crops are each divided into high and low fertilizer activities. For groundnuts, the number of man days for weeding has a large and significant coefficient, so high and low labor intensive activities are defined for this crop. Chemical fertilizer is used on cotton by only one farmer in the unirrigated tract, for which the model is being used; however, a high fertilizer activity is included in the model on the assumption that the reason for non-use is economic rather than technical (also see Chapter V).

For jowar and rice, which are the staple foods in the region, buying activities are included in the model for maximizing cash income, as outlined above, and the expected price and absolute deviations from the expected price are used as a measure of uncertainty in food purchase. A low price results in a positive income deviation in buying the crop, and if the yield were constant, would result in a negative income deviation in selling the crop. Both rice and jowar are subdivided into a home-consumption and selling activity, the former helping to meet a home-consumption constraint, and the latter adding to cash income.

For each activity, including different levels of fertilizer use on rice and cotton, gross returns are available for the six-year period. However, for groundnuts, a single series of price and yield data are used to estimate deviations in gross returns from the expected value for both the high and low labor intensive activities.

Constraints

Land. Heavy clay soil suitable for rice, and land suitable for other crops, are the two types of land specified in the model. For individual farmers, an additional constraint is sometimes added because particular fields had been found unsuitable for a certain crop. Details of constraint levels for each individual farmer are contained in Appendix Table 19.

Working Capital. In the capital row, the working capital requirement for each crop is specified. Capital may be drawn from three capital supply activities – savings, borrowing from the cooperative or from a moneylender, which in turn draw on three constraints. After the rice harvest, we assume farmers can finance the remaining part of production expenses out of rice sales, since all farmers grow some rice. The maximum amount the farmer can borrow from the cooperative is based on the assessment of the secretary of the cooperative society, and from the moneylender on the farmer's own judgment of his maximum credit limit. Interest on cooperative loans is 9 percent. Fifty percent of small farmers and 20 percent of large farmers paid 25 percent on moneylender loans, and the remainder paid 12½ percent (see Appendix Table 19). To derive net cash income and net value of farm output, capital used plus interest are deducted from gross returns, as well as expenditure incurred on inputs after the rice harvest.

Labor for Weeding. The weeding requirement of the cropping combination is constrainted to be less than or equal to the number of days of family labor used for weeding in 1971/72. However, the supply of labor may be augmented by hiring-in labor. This assumption of the model is contrary to the labor model and empirical findings of Chapter III which indicate that changes in cropping combination, by shifting the marginal value product curve of labor, would affect the size of the family labor input. We use a simplifying assumption because it is not possible to make the family labor input a function of choice of cropping combination, as well as the other variables affecting the shape and position of each individual's family labor supply curve for weeding. The effect of not accounting for the potential increase or decrease in family labor input for weeding is to slightly bias farmers against labor-intensive crop combinations if they were not growing these in 1971/72, or to bias them in favor of these if they were growing them in 1971/72.

Labor may be hired-in at Rs. 2 or Rs. 1½. Over 67 percent of small farmers hiring-in labor paid the higher wage, but only 40 percent of large farmers (over five acres). The reason for the difference in wage rate may reflect differences in length of day worked, but small farmers may pay relatively high wages because they can offer less days of employment. Many small farms do not hire-in labor, but exchange labor with neighboring farmers. This "cooperative" labor input is included as part of the family labor input.

Harvesting

For each crop we assume a maximum period per acre in which harvesting takes place; this implies that for large acreages it is possible to stagger harvesting periods. Thus,

[78] Per acre production functions are used. Constant returns to scale are imposed on the function as the scale coefficient is not significant for any of the four crops.

the family labor input for harvesting an acre is the number of family members available for farm work multiplied by the number of days allowed for harvesting the crop. Based on field data, two days are allowed to harvest (and thresh) an acre of rice and jowar, four for cotton (once a week for four weeks) and five for groundnuts.

The assumption of a fixed period to harvest an acre is reasonable if any of three conditions hold:

1. There is flexibility in date of sowing, or transplanting, so date of harvesting can be staggered.
2. Farmers require all family members to be present, owing to labor shortage at peak periods, or from fear of theft or spoilage by hired workers.
3. Farmers can extend the length of day used for harvesting by paying hired labor an additional wage.

Home Consumption

Family's home consumption requirements of rice and jowar may be met by growing the crop or by purchase. The requirement is based on farmers' information on weekly consumption levels in 1971/72, and confirmed by data on crop sales and purchase between the harvests in late 1971 and late 1972. Since 1971/72 was not a good agricultural year, there may be a slight downward bias in these estimates.

In the model, home consumption of rice and jowar are fixed, but in practice, small farmers probably substitute one foodgrain for another depending on relative prices. In the model we assume only that farmers' decisions regarding cropping pattern for the coming season are based on a fixed home consumption requirement, i.e., that they know how much they want to consume of each commodity.

Dry Fodder

Dry fodder is needed to maintain livestock between monsoons. In this short-run model, the farmer's livestock and thus fodder requirements are assumed to be the same in 1972/73 as in 1971/72. We assume that cropping pattern does not determine farmer's choice of livestock activity, but fodder requirements of livestock may influence choice of cropping pattern and level of cash income. Cows and buffaloes rely mainly on grazing for fodder, so that fodder is required primarily for bullocks.

Rotation

Cotton and groundnuts are not grown in a field two years in succession;[79] farmers rotate crops because they each make different demands on the soil. Thus, farmers were constrained to grow cotton-groundnuts, cotton-jowar, jowar-groundnuts or just jowar. To examine farmers' actual behavior, we use the 1972/73 cropping pattern, assuming a rotation based on the 1971/72 cropping pattern.[80]

Coefficients

To derive the input-output coefficients for each crop, farmers growing the crop are divided into subgroups on the basis of labor and fertilizer use. Subgroup mean levels of seed, fertilizer and weeding labor are obtained and the associated yield level in 1971/72 derived from the per acre constant returns to scale production functions (see Appendix Tables 17 and 18). Levels of labor used for harvesting are also obtained from subgroup averages. The grain to stalks ratio is estimated for each crop, and then applied to expected yields, to derive the value of fodder available from alternative crops.[81] All coefficients are based on *expected* costs of inputs, as the model considers the farmer's decision prior to the season.

The levels of gross returns for 1966/67 to 1970/71 are based on price and yield data for each crop from the sources listed above, as shown in Appendix Tables 21 and 22. Years in which the different studies overlap indicate the compatibility of the data. To construct a single series of prices and yields, we assume the samples are drawn from a single population, and take the mean of all available observations. Where sample data are not available, we use Gujarat Government data for Surat District with some additional assumptions.[82]

A single set of coefficients are used for all farms, except for the wage for weeding and the interest rate. Constraint levels are changed for each farmer to calculate each individual EV frontier. A complete matrix of a sample farm used for estimation, which also illustrates the form of the MOTAD model, is shown in Appendix Table 20. Constraint levels for each of the 33 farmers are shown in Appendix Table 19. Using Appendix Tables 19 and 20, anybody with access to a linear programming computer code with a parameterizing option could readily reproduce the results in the following pages.

The Estimated EV Frontier and Farmers' Observed Behavior

The EV frontiers for nine representative farmers, indicating the minimum possible uncertainty for each feasible

[79] The only exception was one farmer who grew groundnuts two years in succession in one field.

[80] Farmers' statements on expected cropping combination, made three months before the onset of the monsoon, are used for the 1972/73 cropping pattern. For the five farmers who could not give a complete expected cropping pattern, actual cropping pattern for 1972/73, noted several months after the monsoon, is used.

[81] For cotton, gross value of output is raised 6 percent to account for value of output, on the basis of estimates of the Farm Management Studies in Surat District.

[82] See notes to Appendix Tables 21-24.

level of cash income, are shown in Figure 6, together with farmers' actual choice of cropping pattern.

The minimum point on the EV frontier is not shown at the origin because land used is constrained to equal land available, to confine the range of relevant solutions. The point showing farmers' actual behavior is obtained by forcing the actual acreage under each crop into the model, and finding the income and associated sum of absolute deviations under these additional constraints. Farmers' actual cropping pattern and nearest points in terms of income and income variation are shown in Table 19.

Farmers allocate resources so as to be very close to the estimated EV frontiers. Of 33 farmers, four have cropping combinations on the frontier itself, and 25 could increase incomes less than 10 percent if they shifted cropping pattern onto the EV frontier; only two farmers could increase incomes more than 10 percent by a change in their cropping combinations. The gap between observed behavior and the normatively derived EV frontier probably reflects the use of average input-output coefficients, and also lack of individual farm data on yield and price fluctuations. The latter results in the lack of a true measure of a farmer's perception of the uncertainty involved in growing each crop. Further, the uncertainty in adopting chemical fertilizer on cotton may be greater than indicated in the model, which reflects only yield and price variability. In adoption of a new input, the "management uncertainty" resulting from lack of knowledge of cultivation practices, is an additional component, and is especially relevant for cotton among sample farmers, only one of whom used fertilizer on this crop.

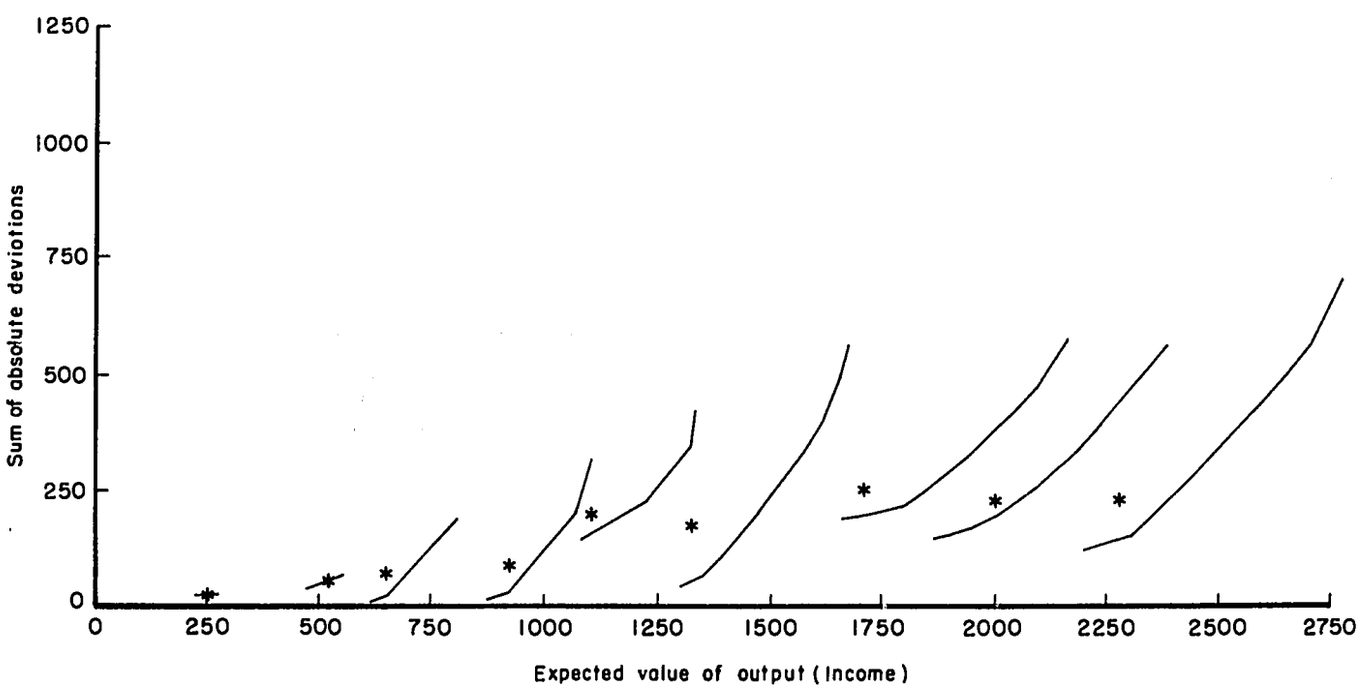
Our analysis is relevant in the context of both choice of cropping pattern and levels of use of variable inputs, bringing both into a single framework within the EV model. When moving to a higher income level, farmers may choose between increasing levels of fertilizer use or a change in cropping combination, both of which increase the uncertainty of net returns. In terms of choice of cropping combinations, Desai's finding that farmers do not choose optimal cropping patterns in terms of the linear programming solution[83] is the equivalent of our finding that farmers do not operate at the highest point on the EV frontier, which is the linear programming solution unconstrained by uncertainty. However, we do not conclude that farmers could increase incomes through greater efficiency of resource allocation, but rather that uncertainty is what constrains farmers from choosing maximum income cropping combinations.

In terms of Hopper's thesis,[84] that farmers act efficiently by setting the marginal value product of factors of production equal to their price, our analysis clearly presents a contrasting viewpoint. In terms of fertilizer use, the model indicates that to maximize income, farmers would have to increase levels of this input considerably.

[83]Desai, *op. cit.*

[84]W. David Hopper.

Figure 6. Estimated EV Frontiers and Choice of Cropping Combination for Nine Sample Farmers



*SHOWS FARMER'S CHOICE OF CROPPING PATTERN FOR 1972-73

Table 25. Farmers' Choice of Cropping Pattern Relative to Their Normatively Derived EV Frontier, for 33 Unirrigated Farms, Surat District, 1972-73[1]

Number	Farmer's EV Point: Income[2]	Farmer's EV Point: Sum of Absolute Deviation	Maximum Income (with the Farmer's Sum of Absolute Deviation)	Minimum Sum of Deviations (with the Farmer's Income)
1	276.6	35.9	319.7	10.07
2	247.3	21.8	266.8	20.99
3	275.5	29.03	285.34	27.06
4	398.7	61.03	398.7	61.03
5	425.44	67.39	428.2	43.15
6	511.84	58.92	517.6	40.92
7	454.44	67.83	489.92	47.72
8	574.7	63.9	627.04	13.21
9	643.96	73.22	696.64	19.16
10	494.3	24.1	514.48	21.15
11	651.9	36.0	686.52	28.41
12	510.95	122.81	512.33	122.23
13	748.27	132.51	748.27	132.51
14	688.7	48.2	699.87	41.29
15	745.6	27.9	760.39	12.34
16	781.4	105.3	815.03	85.54
17	849.7	103.3	987.83	54.58
18	1097.5	116.1	1210.85	11.39
19	1028.1	108.2	1092.91	59.61
20	705.6	98.2	779.17	49.14
21	916.6	90.1	969.55	32.93
22	1105.8	205.8	1183.93	158.55
23	1041.5	98.6	1041.5	98.6
24	1706.2	252.9	1838.59	198.05
25	1598.0	219.3	1675.86	161.73
26	1321.8	174.7	1447.96	48.57
27	2002.6	226.9	2043.60	198.10
28	1986.56	366.34	2080.97	308.64
29	2270.1	226.0	2379.02	144.57
30	2312.9	581.7	2467.14	485.44
31	2617.5	552.0	2804.51	438.68
32	3521.0	480.9	3636.65	385.84
33	5602.0	1037.8	5660.61	1015.97

[1]One farmer whose EV frontier did not reach the EV point at which he operates, according to the model specification, was omitted from the final group. Three farmers with part of their land irrigated are also omitted.

[2]The income used is value of output. If value of home consumption is subtracted, using Appendix Tables 19 and 20, cash income could be estimated for the same absolute deviation points.

However, with Hopper we conclude that farmers are rational decision makers, as the model indicates that given the uncertainty constraint, farmers cannot increase their incomes through increasing levels of fertilizer application. In terms of labor use, our model provides an explanation of an apparent major misallocation of farm resources. With groundnuts being a highly labor-intensive crop, a high man-land ratio should be associated with its cultivation. However, the man-land ratio of groundnut growers is lower than for those growing cotton, the alternative cash crop. This may readily be understood in terms of uncertainty; since groundnuts tends to enter the EV solutions at higher levels of income variation than unfertilized cotton, farmers with large families and small farms prefer the low-uncertainty crop although it is ill-suited to their resource endowments.

To increase net returns per acre towards the maximum level, farmers have to shift towards 100 percent cash crops, as shown in Table 26 for a representative farm. This leads to huge increases in uncertainty as farmers are compelled to enter the market not only to sell the cash crop, but also to buy food. For this reason, a Rs. 100 increase in net cash or real income typically requires a more than Rs. 100 increase in the absolute deviation of income from its expected value. Under these circumstances, a farmer's decision to include jowar, a low-income food crop, in his cropping combination, may be readily understood.

In contrast to the increase in uncertainty, capital requirements in moving to optimal cropping combinations do not increase dramatically. Typically, a Rs. 100 increase in value of *net* cash income needs a Rs. 50 increase in capital requirement. This figure would increase slightly if post rice-harvest capital was included, but still remains very much lower than under irrigated conditions, as shown in Part B below.

Effects of Changing Resource Availability

We now consider the effect of changing levels of farm resource availability on a representative farmer's cropping pattern decisions, as well as on the form of the income-uncertainty relationship he is facing.

Land

The representative farm has 0.9 acres suitable for rice and 6.0 acres suitable for cotton, jowar and groundnuts. The effect of halving each type of land, and doubling each type, on the EV frontier is illustrated in Figure 7.[85] Returns to land and family labor increase very slightly less than in proportion to farm size because, with a fixed family size, the hired labor component becomes an increasing part of the total labor input. Conversely, the uncertainty increases more than in proportion to farm size because home consumption activities, which involve no uncertainty, take up a decreasing proportion of total acreage as the man-land ratio diminishes.

Family Size

An increase in family size leads to an increase in family labor availability for both weeding and harvesting, as well as increasing the home consumption requirement. Here we examine a shift from four family members down to two and up to six, assuming proportional changes in number of man days of family labor available for weeding, and in home consumption requirement of rice and jowar.[86] The results are shown in Figure 8.[87]

With land constant, a larger family size leads to steeper EV frontiers, because an indicated under "land" above, a high man-land ratio allows a relatively high proportion of land to be under uncertainty-free home consumed crops. In other words, farmers with large families must pay a

[85]The cropping pattern changes along each EV frontier are shown in Michael G. G. Schluter, *op. cit.*, 1973, p. 178.

[86]The implicit assumption is that family workers are a constant proportion of family size.

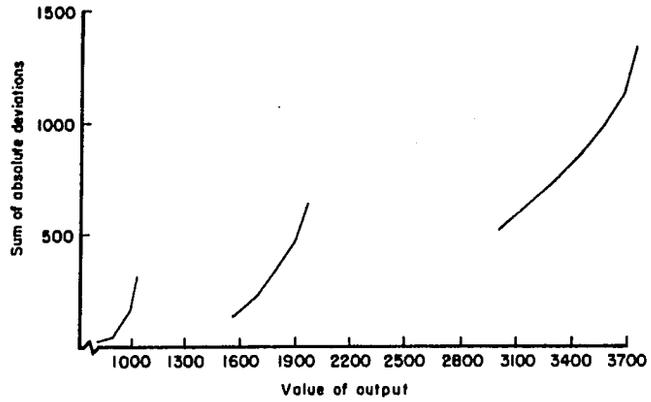
[87]For cropping pattern changes along the EV frontier, see Michael G. G. Schluter, *op. cit.*, 1973, p. 179.

Table 26. Crop Sequences Along the EV Frontier for the Representative Unirrigated Farm

Cash Income	Value of Farm Output	Absolute Deviation	Area Under					
			Rice 1	Rice 2	Jowar	Cotton 1	Cotton 2	Groundnuts[1]
250	1530.5	138.9	.90		4.37	1.63		
300	1580.5	150.9	.90		4.42	1.10	.08	.40
350	1630.5	181.9	.90		4.73	.23	.61	.43
400	1680.5	223.9	.45	.45	4.75		1.19	.06
450	1730.5	274.9	.45	.45	3.97		1.49	.54
500	1780.5	327.0		.90	3.82		2.18	
550	1830.6	389.1		.90	3.31		2.69	
600	1880.7	456.4		.90	2.54		3.00	.46
650	1930.9	567.6		.90	.83		3.00	2.17
667	1948.4	629.4		.90			3.00	3.00

[1]This is the low labor-intensive groundnuts activity. The high labor-intensive activity does not enter any of the solutions for this farmer. At low levels of income, groundnuts enters as part of a groundnuts-jowar rotation; at high income levels, it enters as part of a groundnuts-cotton rotation.

Figure 7. Effect on EV Frontier of Changing Farm Size



relatively high price in terms of uncertainty in moving to maximum income solutions.

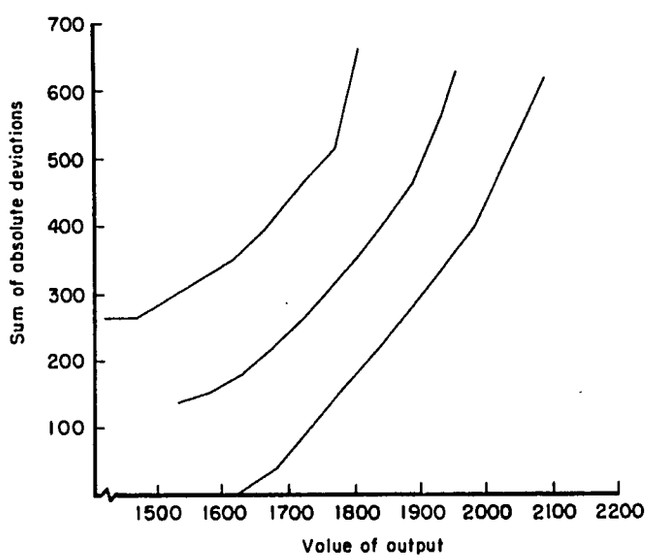
Low Wage Rate

The representative farm paid Rs. 2 for kharif weeding, so we examine changes in cropping combination on the EV frontier if the wage rate becomes Rs. 1.50. The results indicate that the EV frontier shifts to the right and down slightly, as groundnuts displace cotton throughout the middle sections of the EV frontier.[88]

Farmers can obtain higher incomes with the same variance, or the same incomes with lower variance. Acreage of cotton relative to groundnuts is sensitive particularly to the cost of weeding the crop. With an interest rate of 25 percent, the effective wages are Rs. 2.50 and Rs. 1.875, so we then examine whether a change in interest rates would equally affect groundnut acreage.

[88] *Ibid.*, p. 180.

Figure 8. Effect on EV Frontier of Changing Family Size



Changing Interest Rates

The representative farm used only credit available from the moneylender to meet working capital expenditure in the kharif season. He pays 25 percent to the moneylender, so we lower this to 9 percent, which is the interest rate on cooperative loans. As expected, this also increases groundnut acreage throughout the middle part of the EV frontier and shifts the curve to the right.

Cotton versus Groundnuts: A Regression Model

The linear programming analysis leads us to expect acreage under groundnuts to be a function of total acreage under cash crops, assets and non-agricultural income reflecting a farmer's ability to bear uncertainty, the wage rate and the interest rate. Therefore, we use these as independent variables in a linear regression model, with groundnut acreage as the dependent variable. The problem with a linear model is that with cash crop acreage equal to zero, groundnut acreage could still be positive, so that, there are dangers in extrapolating from the model beyond the range of the data. The results of the estimated equation are shown in Table 27.

Value of assets is a significant factor in explaining variation in groundnut acreage between sample farmers. This may be explained in terms of the EV model, that farmers relatively well able to bear uncertainty are those who grow the high value-high uncertainty crop. However, non-agricultural income, which also increases ability to bear uncertainty, does not lead to an increase in groundnut acreage. This is probably because non-agricultural income tends to be concentrated on smaller farms, which rely on supplementary income to meet essential consumption requirements, and thus cannot rely on this source of income to meet crop income fluctuations.

A high interest rate and wage rate lead to a lower acreage under groundnuts. As the EV model indicates, both may be traced to the cost of hiring-in labor. The high labor requirement for groundnuts makes its profitability relative to cotton sensitive to changes in farmers' real cost of hiring labor, as indicated in the section above.

Part B. Irrigated Farms

Sources of uncertainty are different on irrigated farms. Weather uncertainty is considerably reduced but uncertainty may increase for three reasons.

Disease

Crops in Surat especially prone to disease are vegetables, bananas and to a lesser extent sugarcane. Five out of six

Table 27. Estimated Linear Regression for Factors Influencing Acreage Under Groundnuts on Sample Unirrigated Farms, Surat District, 1971-72

Factor	Regression Coefficient	Standard Error of Estimate	t-Value
Acreage under cash crops	0.1703	0.0926	1.84**
Value of assets ('000 Rs.)	0.116	0.0521	2.14*
Non-agricultural income ('000 Rs.)	-0.1090	0.2602	-0.42
Wage paid for weeding[1]	-0.8780	0.3899	-2.25*
Interest rate for capital[2]	-0.7669	0.4399	-1.74**
Constant	0.4474	—	—
Number of observations (farmers) = 25		$r^2 = 0.63$	

*Significant at 5 percent level.
**Significant at 5 percent level with one-sided t-test.
[1]Rs. 2 = 1, Rs. 1.50 = 0
[2]25% = 1, 12-1/2% (or 9% to cooperative) = 0

farmers in the sample near Bardoli growing kharif vegetables lost the crop owing to disease. The only cases of low sugarcane yields in the sample were the result of disease.

Price

Bananas and vegetables are again the most susceptible crops. Average monthly prices from 1966/67 to 1970/71 in the Surat market, for brinjals which is one of the main vegetable crops grown in the region, fluctuated up to 1000 percent from the lowest point within a year, and up to 300 percent in the same month between years (see Appendix Table 25). In contrast, wheat prices were never more than 50 percent above the 1970/71 price, which was the lowest in this period (see Appendix Table 24).

Technological Change

Up to 1972, technological change has had an impact primarily on yields of irrigated crops. The uncertainty involved in moving to a new variety has been discussed in Chapter IV.

Each of these sources of uncertainty is difficult to quantify. They do not fit conveniently into an uncertainty model based on *annual* yield and price fluctuations, as they act partly between time periods of less than a year and often affect inter-farm differences in yields to a greater degree than inter-temporal differences. Further, no objective estimate is available of a farmer's perception of yields of new varieties prior to their introduction, so that data for the MOTAD model rest heavily on assumptions about farmers' yield perceptions, rather than on objective data regarding yield variability.

In this section, we analyze the impact of irrigation on the EV frontier of the representative farm. We assume there is no change in resource availability, except in changing unirrigated land to irrigated land.

Activities for improved and high yielding rice and wheat varieties, and sugarcane, are the only irrigated crops included in the model. Sugarcane is planted after rice and harvested 12 months later. Two ratoon crops follow, with substantially lower costs and slightly lower yields. In the matrix we consider only the first planting of sugarcane, displacing wheat, and assume 50 percent of income and 50 percent of income deviations from the expected value may be attributed to the rabi pa.. of the crop. Since the ratoon crop is not considered, returns to sugarcane are underestimated in the model. Data for yields and prices for each crop, and the assumptions on which the values are based, are shown in Appendix Tables 23 and 24. Coefficients used in the matrix for irrigated farms are shown in Appendix Table 26.

The EV Frontier for the Representative Farm

Cropping combinations along the EV frontier for the representative farm are shown in Table 28. As incomes and uncertainty rise, high-yielding rice replaces traditional rice varieties, and sugarcane replaces high-yielding wheat varieties.

The absolute deviation of income (and therefore variance of income) increases slowly as incomes rise on irrigated relative to unirrigated farms. A Rs. 100 increase in income results in a Rs. 25 increase in absolute deviation of income from its expected value on an irrigated farm, compared to Rs. 100 under unirrigated conditions.

However, the capital requirement increases relatively rapidly on irrigated farms. A Rs. 100 *net* income increase requires an additional Rs. 150 increase in capital input, compared to Rs. 50 under unirrigated conditions. These

Table 28. Crop Sequences Along the EV Frontier for the Representative Irrigated Farm

Cash Income	Value of Farm Output	Absolute Deviation	Acres Under				
			Kollam	Masuri	Wheat	Wheat HYV	Sugarcane
4200	5568.2	888.4	6.00			5.48	.52
4300	5644.5	895.1	6.00			5.29	.71
4400	5744.5	903.9	6.00			5.03	.97
4500	5844.5	912.8	6.00			4.78	1.22
4600	5944.5	921.6	6.00			4.52	1.47
4700	6044.5	930.4	6.00			4.27	1.73
4800	6144.5	939.7	6.00			4.00	2.00
4900	6244.5	949.6	6.00			3.71	2.28
5000	6344.5	959.4	6.00			3.43	2.57
5100	6444.5	969.3	6.00			3.14	2.86
5200	6544.5	979.2	6.00			2.86	3.14
5300	6644.5	989.1	6.00			2.57	3.43
5400	6744.5	999.0	6.00			2.29	3.71
5500	6844.5	1008.9	6.00			2.00	4.00
5600	6944.5	1024.6	6.00			1.54	4.46
5700	7044.3	1046.8	5.73	.27		1.34	4.66
5800	7145.5	1074.5	5.53	.47		1.05	4.95
5900	7248.7	1102.6	5.53	.47		.59	5.41
6000	7349.8	1130.6	5.53	.47		.12	5.88
6100	7450.4	1165.2	4.07	1.93			6.00
6157.6	7508.0	1186.5	2.93	3.07			6.00

results are illustrated in Figures 9 and 10, which underline that a small farmer's greatest problem under unirrigated conditions is uncertainty, but under irrigated conditions is shortage of capital availability.

Capital availability is of crucial importance to raise incomes of small farmers under irrigated conditions. However, the increase in uncertainty which accompanies increased capital input and incomes may result in small farmers being unwilling to use available capital. The role of cooperatives is critical not only in making credit available, but also in allowing some flexibility in repayment. In contrast, lack of demand for production credit in unirrigated zones is likely to make cooperatives an ineffective tool to help small farmers under such conditions.

Sugarcane versus a Rice-Wheat Combination

The linear programming model indicates that sugarcane is a high income, high uncertainty, high capital using activity. Therefore, in a linear regression model we examine factors correlated with a large acreage under sugarcane relative to rice and wheat. Acres under sugarcane is the dependent variable, independent variables, included in the model, and the estimated coefficients and t-values are shown in Table 29.

Value of assets is an important explanatory variable in the model for two reasons. The sugarcane factory extends credit to grow sugarcane on the condition that the land is mortgaged to the factory. Most farmers growing sugarcane rely on this source of credit to finance purchased inputs and to release other sources of funds for use in consumption or on other crops. However, inability to gain access to this source of credit owing to the low value of a farmer's land, or unwillingness to mortgage land because it is the only means of livelihood, precludes many small farmers from meeting the high costs of cultivation with credit from the factory. Assets and credit availability are closely linked in this case.

Secondly, a low value of assets makes it difficult for many small farmers to obtain a share in the factory. Rs. 1000 may represent 50 percent of net annual income to a farmer with three irrigated acres growing rice and wheat, or 10 to 20 percent of the gross value of assets other than land. Since shares are scarce when first issued, wealth, reflecting local influence, may also play a role in the allocative mechanism, so that small farmers pay a relatively high price for shares.

Region is an important variable because villages in the region with a relatively large sugarcane acreage are relatively close to a factory, and have been growing sugarcane

Figure 9. Uncertainty and Capital Requirement Along the EV Frontier of the Representative Unirrigated Farm

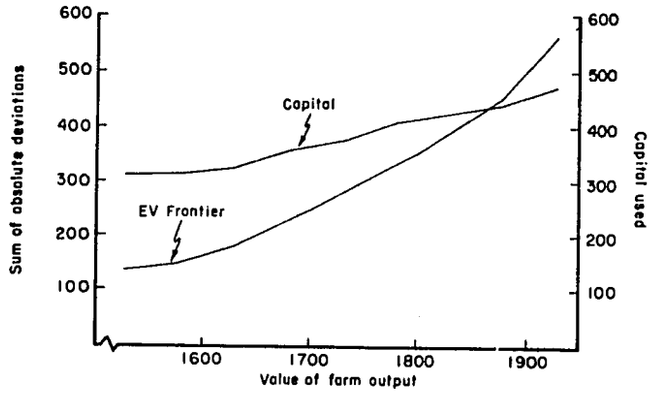
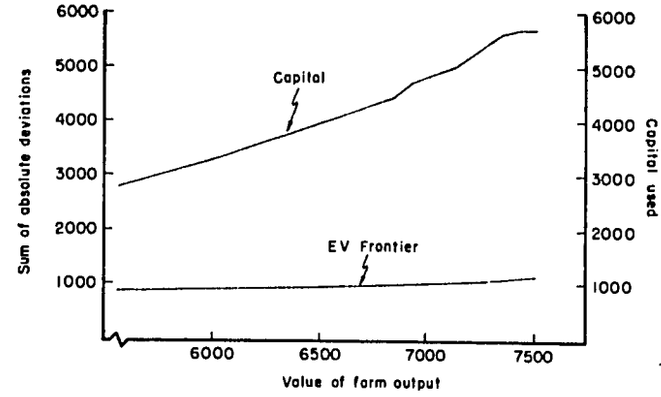


Figure 10. Uncertainty and Capital Requirement Along the EV Frontier of the Representative Irrigated Farm



for a longer period.

Supplementary sources of income did not increase acreage under sugarcane. The small coefficient and t-value indicate there is little correlation at all between acreage sown to sugarcane and dairying income.

Policies to Reduce Uncertainty

Stabilizing Prices

Having demonstrated the effect of income variation in preventing small farmers maximizing income from available resources, price stabilization seems an obvious policy tool to help small farmers. To analyze, the effect of price stabilization policies on income uncertainty, we use the coefficient of variation as a measure of fluctuations of yields, prices and gross returns, as shown in Table 30.[89]

Table 29 indicates that variation in yields is similar for all crops, but that prices of cash crops have much greater variation than for food crops. This is in contrast to what might have been expected – that greater inelasticity of demand for food crops would result in greater price fluctuations for these crops. However, demand for an individual food crop is likely to be more elastic than for foodgrains in aggregate, as consumers may switch consumption from one foodgrain to another. Also, prices in one small region may not reflect national price movements, although Lele's work indicates that rural markets

[89]The coefficient of variation shows the standard deviation in terms of the mean value, and thus the effect of the absolute size of the variation is removed.

Table 29. Estimated Linear Regression for Factors Influencing Acreage Under Sugarcane on Sample Farm, Surat District, 1971-72[1]

Factor	Regression Coefficient	Standard Error of Estimate	t-value
Acreage suitable for sugarcane[2]	0.6305	0.0662	9.53**
Non-agricultural income ('000 Rs.)	-0.0166	0.0980	-0.17
Dairying income ('000 Rs.)	0.0313	0.0885	0.35
Value of assets ('000 Rs.)[3]	0.0209	0.0132	1.58
Region	-1.0432	0.3736	-2.79**
Constant	0.9356	–	–
Number of observations (farmers) = 64		$r^2 = 0.73$	

**Significant at .01 level.
[1]Includes acreage put under sugarcane for the 1970/71 crop or for the 1971/72 crop, but without double-counting.
[2]To be suitable for sugarcane, land needed to have access to perennial irrigation, and to be accessible to bullock carts or trucks to allow transport of the harvested cane.
[3]Includes value of farm and non-farm assets, but not the value of the land itself.

are reasonably well integrated.[90] If the assumption of relatively inelastic demand for foodgrains is accepted, we must conclude that supply of foodgrains supplied to markets fluctuated very much less than yields, so that farmer's storage acts as an important buffer stock and reduces the effect of yield fluctuations enormously.[91]

Uncertainty probably prevents farmers storing cash crops in the same way that they store foodgrains. Stored foodgrain may be used for home consumption primarily, with some additional sales if prices become especially favorable. However, cash crops would be stored only in the hope of obtaining a better price the following year. Prices of cash crops may go down for more than one year in succession,[92] so that as well as storage and interest costs, there may be a loss on value of sales for cotton and groundnuts, which cannot be readily stored in farmers' houses for years at a time. Data in Appendix B indicates that small farmers tended to sell at harvest rather than several months after harvest, probably owing to uncertainty regarding future price movements; prices sometimes fall several months after harvest. If this holds within the agricultural season, it is likely to hold to a much greater extent between seasons as storage costs are greater.

Price policy has greatest scope for crops where yields and prices are positively correlated, or least highly negatively correlated. The correlation between prices and yields of each crop are shown in Table 31. Groundnuts and jowar yields and prices are relatively uncorrelated, and this accounts for the relative efficacy of price stabilization policies in stabilizing gross returns, indicated in Table 30. For cotton and rice, the more highly negative correlation of yields and prices means that to stabilize prices removes an important influence offsetting the effect of yield fluctuations on incomes. Hence, price stabilization policies result in an increase in the coefficient of variation for gross returns of these crops.

The extent to which price will vary inversely with yields depends on five factors:

1. The elasticity of demand. The greater the elasticity of demand, as indicated above, the less effect yield fluctuation will have on price.
2. The supply available from earlier periods which may cushion a shortfall in supply in a given year.
3. For a given region, the more closely yields vary with main sources of supply, the more its prices will move inversely with yields. In the case of groundnuts, yields in main growing areas of Saurcshtra, Uttar Pradesh and South India will not necessarily be closely correlated with yields in Surat; in contrast, cotton yields in Surat move closely with those in other parts of Southern Gujarat, which is one of India's main growing regions; thus, cotton prices tend to move closely and inversely with yields.
4. The extent to which the market for the crop is integrated into a national market for the crop. Poor communications lead to lower income fluctuations, as supplies from other areas do not cushion price increases due to locally poor yields.
5. Technological change. Yield increasing technological

[90] Lele, *op. cit.*

[91] John W. Mellor and Ashok Dar, "Determinants and Development Implications of Foodgrain Prices in India, 1949-64," *American Journal of Agricultural Economics*, Vol. 50, No. 4 (November 1968), p. 962.

[92] See Appendix Table 28.

Table 30. Coefficients of Variation[1] for Yields, Prices, Gross Returns, and Gross Returns with Price Stabilization, for Major Unirrigated Crops, Surat District, 1966/67-1971/72[4]

	Rice			Cotton		
Factor/Crop	Low Fert.	High Fert.	Jowar	Low Fert.	High Fert.	Groundnuts
Yield	0.40	0.42	0.39	0.42	0.51	0.37
Price	0.09	0.09	0.13	0.24	0.24	0.26
Gross returns	0.36	0.36	0.43	0.30	0.43	0.42
Gross returns: Prices partially stabilized[2]	0.39	0.39	0.40	0.36	0.47	0.34
Gross returns: Prices completely stabilized[3]	0.40	0.42	0.39	0.42	0.51	0.37

[1] Coefficient of variation is standard deviation divided by mean.
[2] Gross returns with price deviations from the expected value reduced by 50 percent in each year.
[3] Gross returns with constant prices.
[4] Price and yield data for each crop for 1966/67–1971/72 are contained in Appendix Tables 27 and 28.

Table 31. Correlation of Yields and Prices of Major Unirrigated Crops, Surat District, 1966/67–1971/72[1]

Fertilized rice	-0.75
Unfertilized rice	-0.81
Jowar	0.26
Fertilized cotton	-0.68
Unfertilized cotton	-0.54
Groundnuts	-0.53

[1]Data in Appendix Tables 27 and 28.

change on irrigated land may increase aggregate production, leading to lower prices, in years of poor yields on unirrigated crops. Thus the dramatic impact of Hybrid-4 irrigated cotton on aggregate cotton production in Gujarat in 1970/71 and 1971/72 resulted in low cotton prices despite low yields on unirrigated land.[93]

We conclude that price stabilization policies are unlikely to be effective in reducing uncertainty for major crops, in areas of major production, but may stabilize incomes in special cases, where yields of the crop do not move closely with the national aggregate. Groundnuts in Surat District is such a case.

Stabilizing Yield

The above analysis indicates that the main source of income fluctuations is yield and not price uncertainty, and hence underlines the importance of policies to stabilize yields. The most obvious means to do this is to lessen the weather effect on yields through irrigation, either directly through canal schemes, or indirectly by ensuring adequate and reliable electric power to areas of well-irrigation potential. There may also be scope for increased fertilizer use with deep placement to increase yields in years of poor rainfall. But the primary emphasis again rests on research, to develop high yielding varieties which require very low rainfall.

Stabilizing Incomes Directly

As an alternative to stabilizing prices or yields, a third approach would be to stabilize incomes directly, by taxing farmers in a good agricultural year, and returning the funds to them in a poor agricultural year, in the form of a subsidy. Such a policy shifts the whole EV curce down to the right, so that farmers can obtain the same income with lower uncertainty, or higher income with the same uncertainty. This is due to the high correlation of yields of the four major crops, which all decline in years of low rainfall. Thus, the tax provides a form of crop insurance against the drought year.

The main argument against the policy, apart from the cost of its administration, is that it would exacerbate problems of food shortages in drought years. Farmers would probably use the subsidy in part to buy food, and might also carry less stocks, if they were sure of the government subsidy for a poor year. To the extent that a subsidy increases purchases by the rural poor, causing food prices to rise further, the burden of the rural poor is increased.[94] Thus, the tax-subsidy policy would need to be accompanied by policies to increase the food supply available to the government for the drought year. If the food is to be supplied from within the Indian economy, an increased acreage under food crops is probably necessary, and this will have a substantial and negative effect on levels of rural employment, as argued in Chapter III. If the government imports foodgrains and stores against the bad year, this problem is avoided, but there is a high cost in terms of scarce foreign exchange resources.

Conclusions: Helping Farmers Bear Uncertainty

In unirrigated zones, income uncertainty consequent upon yield variation inhibits farmers from maximizing income from available resources. Owing to the inefficacy of price stabilization, and the administrative and other costs of stabilizing incomes directly, attention must be focused on finding means to raise yields and reduce yield variability under conditions of uncertain rainfall.

The alternative to reducing uncertainty is to increase farmers' capacity to bear uncertainty. In the absence of any immediate opportunities to substantially raise assests of small farmers, or to provide a large number of non-agricultural jobs, flexibility in repayment of cooperative loans might be thought desirable. However, with alternative sources of capital available to farmers, and occasions of successive drought years, the performance of cooperatives in unirrigated areas would be unlikely to rise above the present ineffectual level.

In the irrigated zone, where capital requirements are much greater, and farm incomes are higher and relatively stable, cooperative credit may play a much greater role in enabling small farmers' to bear uncertainty. Our analysis indicates the importance of making adequately large loans available, to enable small farmers to grow high-income crops, and allowing sufficient repayment flexibility for farmers not to be deterred by uncertainty. As argued in Chapter IV, such flexibility is especially important in the context of new varieties, where the capital requirement increases substantially, and yield variability is compounded by management uncertainty.

[93]See Appendix Tables 21 and 22.

[94]John W. Mellor, "The Functions of Agricultural Prices in Economic Development," *The Indian Journal of Agricultural Economics*, Vol. XXIII, No. 1 (January-March 1968).

CHAPTER VIII

Conclusions and Implications for Policy

The Problem of the Small Farm

On irrigated farms, we have argued the problem is primarily a shortage of working capital. This shortage arises from an imbalance between the demand and supply of capital in the agricultural sector; however, the small farmer faces the problem most acutely because his small assets limit his ability to borrow, even from institutional sources, and make him unwilling to use available credit, for fear that crop failure or death of an animal will lead to loss of his assets. The roots of the credit problem lies in uncertainty.

On unirrigated farms, we suggest uncertainty is the dominant constraint to increasing incomes. Our analysis indicates that farmers' incomes can be raised hardly at all without substantially increasing income uncertainty. Inability to bear uncertainty is a consequence of low assets and income; the roots of the uncertainty problem lie in inadequate capital resources to sustain the losses of a poor agricultural year, and inadequate collateral against which to borrow in emergencies.

Increasing Incomes Through Intensification

Farm incomes may be divided conceptually between returns to land and returns to family labor. In the irrigated zone, intensification of the cropping combination is unlikely to increase the family labor input significantly, so the criterion to judge the suitability of a cropping pattern change for small irrigated farms is the same as for large farms, i.e. does the change increase returns to land, defined as a residual after payment of all variable costs. Both high-yielding varieties and sugarcane may raise returns to land significantly. Only in dairying is a significant proportion of the total labor input from within the family on irrigated small farms, increasing returns to both land and family labor. On unirrigated small farms, intensification of the cropping combination will increase the family labor input. A change from cotton to groundnuts is an example of substantially increasing returns to labor without significantly affecting returns to land. Some scope exists on both irrigated and unirrigated farms to raise returns to land through increases in levels of use of chemical fertilizers.

In the preceding chapters we have identified the chief constraints on four possible ways to raise incomes on small farms:

1. *Adoption of new varieties.* The chief constraint soon after the introduction of the new variety is uncertainty. Later in the adoption process, shortage of working capital becomes the critical constraint, especially for small farmers; we find adoption of kharif crops highly correlated with access to cooperative credit.

2. *Increasing levels of application of chemical fertilizers.* On irrigated farms, the chief constraint is identified again as a shortage of working capital. Those with dairying income and access to relatively large amounts of credit use significantly higher levels of fertilizer with a given cropping combination. On unirrigated crops, levels of fertilizer use are low owing to uncertainty, which stems in part from inadequate information of fertilizer cultivation practices.

3. *Dairying.* This potential exists only in the irrigated zone, where cooperative marketing facilities have been developed, and green fodder is available in the summer months. Milk production may be expanded by more intensive use of concentrates, increasing the number of buffaloes or improving buffalo quality. Credit may be a constraint on use of concentrates, especially in the kharif season. The small quantity of home-produced fodder on small farms, together with high market prices of green fodder and an inelastic supply of dry fodder, inhibit expansion of herd size for most small farmers. Improving buffalo breed is identified as the most feasible way to increase milk production on small farms, but uncertainty is an important constraint on adoption of improved breeds of buffalo, which are more highly susceptible to disease.

4. *Changes in cropping pattern.* Net returns per acre differ substantially between crops in the irrigated zone. A change of cropping pattern from foodgrains (rice and wheat) to sugarcane could more than double net returns per acre. The capital requirement, both for the purchase of variable inputs and to finance consumption during the extended growing period, prevent small farmers from growing this high-income crop.

   On unirrigated farms, a change in cropping pattern from foodcrops (jowar) to cash crops (groundnuts or cotton) could increase net returns per acre by 50 percent. However, our analysis makes evident the huge increase in uncertainty consequent upon growing only for the market, and then buying food in the market. Inability to bear uncertainty is the chief constraint to maximizing income under conditions of high income variability. Between cash crops, a change from cotton to groundnuts raises returns to family labor, as indicated above, but also increases income variation, so that inability to bear uncertainty again acts as the critical constraint, and prevents small farmers using their comparative advantage of a high man to land ratio for the labor-intensive crop.

   An indication of the magnitude of changes in income which may result from each of the above for farmers in Surat District is shown in Table 32. Although the high-yielding varieties do increase incomes substantially, especially wheat, a change from

Table 32. Increase in Incomes Resulting from Alternative Forms of Intensification, for Small Farmers, Surat District, 1971-72

Changes in Cropping Combination[1]	Increase in Income per Annum
Irrigated Farm	
Adoption of HYV rice (per acre)	101
Adoption of HYV wheat (per acre)	236
One acre from HYV rice and wheat to sugarcane[2]	1136
Dairying[3]	
Purchase of one desi buffalo	322
Purchase of one improved buffalo	560
Exchange a desi for an improved buffalo	218
Unirrigated Farm[4]	
One acre from jowar to groundnuts	100
One acre from cotton to grounnuts[5]	18
Application of chemical fertilizer (24 kgs of N) to one acre of cotton	52

[1]Net returns for cash crop are estimated as average gross returns minus average total variable costs, including the imputed value of family labor, since the family labor input is so small.

[2]Slightly less than this over a four-year cycle.

[3]Returns over all variable costs excluding the imputed value of family labor, and assuming a 9 percent interest rate on cooperative loans.

[4]Based on six years data, 1966/67-1971/72 to eliminate the weather effect of a particular year. We assume for unirrigated crops that all labor is from within the family, so the figures show returns to land and family labor.

[5]Assuming average labor input. At high levels of family labor input, returns to groundnuts are substantially greater than for unirrigated cotton (see Chapter VII).

new varieties to sugarcane has a far greater impact on incomes. On unirrigated farms, the scope for raising farm incomes is very limited in the absence of technological change, or provision of irrigation facilities. Intensification on large irrigated farms in adjacent areas, which draw on agricultural labor from unirrigated areas in winter and summer months in the Surat sample, may alleviate the problem in the short run; in the long run, research must play a vital role if small unirrigated farmers are to participate in the growth process.

Policy Measures to Raise Incomes of Small Farmers

Increasing Credit Availability

On irrigated farms, expanding the amount of cooperative credit available to small farmers under the crop loan system would facilitate a change in cropping pattern to new varieites, or even to sugarcane, and lead to higher levels of application of chemical fertilizers. Relaxing the credit constraint on crops may lead also to higher levels of concentrate given to buffaloes. Our analysis indicates that the shortage of credit is primarily in the kharif season; in the rabi season kharif crop sales make the problem less acute. However, a change in cropping pattern to a perennial crop like sugarcane would extend the period of credit shortage.

In unirrigated area, expanding availability of cooperative credit will not lead to higher levels of fertilizer use on small farms, nor change in cropping pattern, because reallocation of resources to higher income alternatives is constrained primarily by uncertainty rather than by a shortage of working capital.

Flexibility in Loan Repayment Policy

Flexibility in loan repayment is necessary if small farmers are to be willing to use the credit made available, especially in the context of a high degree of uncertainty, such as in adoption of new varieties, and fertilizer use on unirrigated crops. Problems of default on cooperative loans have been widely noted,[95] and a more flexible policy on loan repayment is likely to exacerbate these difficulties in the short run. However, in the long run such a policy is likely to make the cooperative a more feasible credit source for the small farmer. To finance closer loan supervision, a flexible policy could be accompanied by higher interest rates (perhaps an increase from 9 percent to 12 percent a year), which our analysis suggests would have little effect on the profitability of using credit.

Research

Research has an especially important role in raising incomes of the small farmer, who must rely on increasing output per acre or per buffalo. Disease resistance of improved strains of crops (or buffaloes) is an especially important characteristic governing small farmers' response, as illustrated in the case of ADT-27 in Thanjavur.[96]

[95]For example, R. K. Sharma, "Co-operative Credit in the Package Programme, A Study in Aligarh District, Uttar Pradesh" (Delhi: Agro-Economic Research Centre, University of Delhi, 1966).

[96]Schluter and Longhurst, *op. cit.*

For unirrigated farms, there can be little increase in income per acre without technological change. Since income per acre is already five or six times greater on canal irrigated land compared with unirrigated land, and with technological change favoring irrigated crops almost exclusively to the present time, income disparities between small farmers with some irrigated land, and those with only unirrigated land are already immense and will increase. This underlines the need to direct an increasing part of scarce research towards finding yield-increasing varieties for unirrigated crops, and developing varieties or cultivation techniques to minimize yield losses in years of low rainfall.

Buffalo Insurance Scheme

Our analysis indicates that improving the breed of buffalo is the most feasible way to raise dairying income on small farms, and that the chief constraint is uncertainty. A buffalo insurance scheme could substantially alleviate this problem. To ensure farmers continue to take proper care of their animals, a heavy penalty would be necessary in the case of death—perhaps even 50 percent of the value of the animal would not be reimbursed. But even under these circumstances, the potential negative deviation of income from its expected value would be greatly reduced. Since cooperatives are the main funding agency for purchase of buffaloes on small farms, especially under the SFDA scheme, they could slightly increase interest charges on loans for buffaloes for the insurance payment from the farmer. They might also consider employing veterinarians to keep incidence of disease to a minimum, which would also decrease uncertainty for the small farmer.

Extension

The primary scope we have identified for extension services to increase a small farmer's income and reduce income uncertainty is in information concerning fertilizer cultivation practices. The absence of information, even relating to appropriate nutrients for a crop, is illustrated from the sample (see Chapter V). Creating surplus fertilizer availability may compel fertilizer companies themselves to undertake extension work as part of sales promotion.

Investment in Processing Facilities

Certain changes in productive enterprises on small farms may occur only with a change in basic infrastructural facilities. For example, growth of sugarcane acreage in Surat District has been dependent on factories at Bardoli, Madhi and Charlthan, and the high proportion of small farmers' income from dairying in the irrigated zone has been possible only with the huge investment in milk processing facilities in Surat.

These investments are especially important because they benefit the irrigated small farm, by raising returns to land, and many unirrigated small farmers and landless laborers, by increasing employment opportunities on farms in the irrigated zone. Further research is required to examine the employment-generating potential of such investment, both on and off the farm, relative to investment in public works programs such as road-building.

Manipulation of the Trade Pattern

A change in the structure of imports away from labor-intensive crops which can be produced domestically, and in the structure of exports towards labor-intensive agricultural commodities, may make an important contribution to levels of rural employment. This is important for the poorest of small farmers, who supplement their incomes as agricultural laborers, as well as for the landless laboring classes. Examples of labor-intensive crops feasible for export are vegetables and sugar; quotas on cotton exports and groundnut imports might also shift acreage from cotton to groundnuts through a change in domestic price relationships. Further research is required to analyze the size of the employment impact on alternative trade policies, and the extent to which it is economically and politically feasible to export cash crops, which tend to be highly labor-intensive, and import foodgrains, which tend to be labor extensive.

Growth and Social Justice

The policies outlined above would not only contribute towards social justice, by raising the incomes of the "weaker sections," but would make an important contribution to aggregate agricultural output. To achieve greater social justice by raising incomes of small farmers need not compete with objectives of growth, but may make an important contribution to those objectives. And growth isn't all that matters.

APPENDIX A

Table 1. Selected Economic and Social Indicators of the Selected Subdistrict (Bardoli *taluka*), Compared with Surat District, Gujarat State and India

Indicator	Bardoli	Surat	Gujarat	India
Percent of farmers with less than five acres (1961)	97	55	33	57
Percent of gross cropped acreage irrigated (1963-64)	55[1]	58[2]	48[2]	n.a.
Percent of gross cropped acreage under food-grains (1968-69)	29	4	8	n.a.
Percent literate (1961)[3]	36	41	36	24
Percent living in urban areas (1961)	15	23	26	n.a.
Percent scheduled tribes to total population (1961)	50	75	13	7
Population density (persons per square mile) (1961)	691	461	290	358

[1]in 1967-68
[2]in 1970-71
[3]Excludes those in age group 0-4.

Source: *Census of India*, 1961, Vol. 1, Part II-A(i), p. 69; Vol. I, Part II-C(i), Table C-III; and Vol. I, Part III(i), Table B-X. *Gujarat State Census Atlas*, Census of India, 1961. *Gujarat State Agricultural Atlas*, published by the Office of the Director of Agriculture, Government of Gujarat, Ahmedabad, 1961. *Official Records*, Office of the Director of Agriculture, Government of Gujarat, Ahmedabad, 1961/62-1970/71. *Surat District Census Handbook*, Census of India, 1961.

Table 2. Family Workers to Land Ratio by Size of Farm Group in India 1960-61

Farm Group Size (acres)	Number of Family Workers Classified as Cultivators	Number of Acres Owned[1]	Man-Land Ratio
Less than 1	7,449,590	533,794	13.955
1-2.4	19,817,735	2,828,900	7.005
2.5-4.9	22,088,580	8,218,095	2.688
5.0-9.9	23,001,280	15,173,160	1.516
10.0-29.9	22,028,215	29,104,815	0.757
30.0-49.9	3,893,761	110,537,825	0.352
50 and above[2]	1,978,645	9,758,475	0.203

[1]Estimated as the number of households by farm size group multiplied by the mid-point of the farm size group. This may lend to slightly inflated estimates of acreage owned, and thus slightly deflated estimates of the man-land ratio.
[2]We assume 75 acres as the average size of farm in this group.

Source: *Census of India*, Part II(A), Table B-I and Vol. III(ii), Table B-X.

Table 3. Per Acre Use of Human Labor by Operation of Irrigated Acreage for Sample Farmers in Surat District, 1971-72 (in man days)

Crop	Number of Farmers	Ploughing	Planting	Weeding	Intercultivation	Harvesting and threshing	Harrowing	Fertilizer Application	Irrigation	Total
Sugarcane	39	1	21[1]	38	3	105[2]	–	6	28	202
Improved rice	42	3	20	28	0	29	1	2	3	86
HYV rice[3]	40	2	23	35	0	28	1	2	4	95
Improved wheat	25	3	2	11	0	19	0	1	5	41
HYV wheat[4]	13	2	2	7	0	18	0	2	3	34
Val	36	1	4	8	–	13	–	–	–	26

[1] For first cutting only. For second and third cutting, total labor used is 202 - 21 = 181 man days.

[2] The factory at Bardoli employs 6,000 laborers for about 160 days each, to harvest sugarcane from 9,000 acres, over a period of 200 days. During the 200 days it crushes 1,600 tons of sugarcane. This information is consistent with the coefficient of 105 man days required to harvest one acre of sugarcane, estimated on the rule of thumb basis that it takes three adults, usually two men and one woman, to cut one ton of sugarcane in a day and transport it to the factory, with average yields at 35 tons per acre.

[3] For HYV rice, the longer duration results in a greater labor requirement for irrigation and weeding, but the upright short stem reduces the labor requirement for harvesting.

[4] For HYV wheat, the lower weeding requirement reflects less labor intensive cultivation on farms growing this variety, and a lower harvesting requirement reflects the short stem of the new varieties.

Table 4. Per Acre Use of Human Labor by Operation on Unirrigated Acreage Among Sample Farmers in Surat District, 1971-72 (in man days)

Crop	Number of Farmers	Ploughing	Planting	Weeding	Intercultivation	Harvesting and threshing	Harrowing	Fertilizer Application	Irrigation	Total
Groundnut	34	1	4	24	3	25	3	–	–	60
Cotton	46	2	3	19	3	9	1	–	–	37
Jowar	23	1	2	16	3	5	2	–	–	29
Tur	6	1	2	10	1	6	0	–	–	20

Table 5. Per Acre Use of Human Labor by Operation for Rice and Cotton from Farm Management Studies in Surat and Bulsar Districts of Gujarat in 1966-67

Crop	Ploughing	Manuring	Harrowing and Preparatory Tillage	Sowing Transplanting	Inter-Culturing and Weeding	Irrigation	Watching	Harvesting and Threshing	Others	Total
Rice[1]	2.0	2.8	3.0	16.3	10.0	0.5	–	23.3	3.8	61.7
Cotton[2]	0.9	1.3	0.4	2.3	11.0	0.1	0.1	10.0	5.0	33.1

[1]The rice data are for all varieties of rice, a large proportion being grown on unirrigated areas. The shorter duration of unirrigated varieties results in a lower weeding requirement, and lower yields result in a much lower harvesting and threshing requirement. Also, the farm management data include very course varieties which are sometimes drilled rather than transplanted. In 1966-67, the main variety of irrigated paddy was Kollam, since the high-yielding varieties had not been introduced in this area at that time.

[2]The cotton data relate almost exclusively to unirrigated cotton (see the labor requirement for irrigation). The slightly higher figure for weeding in our data may reflect the quantity and duration of rainfall for 1971-72 relative to 1966-67.

Source: Government of India, Directorate of Economics and Statistics, "Studies in the Economics of Farm Management in the IADP Region of Surat and Bulsar (Gujarat State)" (unpublished).

Table 6. Per Acre Use of Human Labor on Irrigated Acreage for Sample Fruit and Vegetable Farms Near Surat City in 1971-72 (in 8-hour man days)

Crop/ Operation	Number of Farmers	Ploughing	Planting	Weeding	Application and FYM and Fertilizers[1]	Application of Pesticides	Irrigation	Harvesting	Transport[2]	Total
Banana	15	1	4	91	8	–	33	40[3]	7	184
Brinjal	5	1	4	37	9	29	10	45	4	139
Cabbage	10	1	19	26	4	27	19	39	3	138
Cauliflower	7	1	11	19	3	12	6	26	3	81
Red Yam	3	1	17	76	8	–	6	29	6	143
Mango[4]	1	–	–	–	2	33	7	10[5]	1	53

[1]For several farmers where data were not available for this operation, we assumed 1 man put one bag of fertilizer on one acre in one hour, and 1 man put 1 tractor trolley of night soil on 1 acre in one 8-hour day.

[2]For a return trip to Surat, we assumed a tractor took 4 hours (including unloading) and a bullock-cart 8 hours. With information on the number of trips, it was possible to estimate labor used for transport.

[3]Of the 40, 13 was for picking the fruit and loading it onto the bullock cart or tractor trolley, and 27 was for plant removal. For other crops, plant removal occurs during the period of harvesting.

[4]This labor requirement is for a fully-grown orchard. In the growing period, the labor requirement will be much greater, as often vegetables and other crops are grown between the rows.

[5]Data from the 1971-72 sample near Bardoli indicate that about 20 man days are required per acre for harvesting.

Table 7. Labor Used for Transplanting, Weeding and Harvesting as Percentages of Total Labor Used by Crop, for Sample Farmers, Surat District, 1971-72

Crop	Transplanting[1]	Weeding	Harvesting and Threshing
		Irrigated Crops	
Kharif			
Paddy (Improved)	22.0	34.6	32.9
Paddy (HYV)[2]	20.5	41.0	28.7
Rabi			
Wheat (Local and Improved)	–	35.1	38.5
Wheat (HYV)	–	18.3	54.7
Sugarcane	–	18.8	52.0
		Unirrigated Crops	
Kharif			
Paddy	25.36	36.6	29.1
Groundnut	–	40.0	41.6
Cotton	–	50.5	25.2
Jowar	–	53.7	21.4
Tur	–	52.7	29.5
Rabi			
Val	–	29.3	47.4

[1]Sowing of crops other than rice has a neglibible labor requirement in terms of total labor used.

[2]For HYV rice, the weeding percentage is higher because it is a longer duration variety, and the harvesting percentage is lower because it stands more erect and is easier to cut.

Table 8. Family Labor as a Percentage of Total Labor Used for Each Main Operation by Crop for Sample Farmers, Surat District, 1971-72

Crop	Transplanting	Weeding	Harvesting
Kharif			
Rice (Improved)	10	15	12
Rice (HYV)	6	13	7
Rice (Unirrigated)	35	46	33
Jowar	—	41	30
Groundnuts	—	39	29
Cotton	—	23	28
Rabi			
Sugarcane	10	5	0[2]
Wheat (Local and Improved)	—	18	59
Wheat (HYV)	—	16	10
Val	—	29	35

[1]Crops left blank have a very small total labor input for sowing, so that even a high family labor input in percentage terms would be small in absolute terms.
[2]Harvesting of sugarcane is undertaken by the sugarcane factory, so that family labor is used only to supervise.

Table 9. Income per Household by Source for Sample Farmers in the Unirrigated Zone, Surat District, 1971-72

	Farm Size (Net Cultivated Acreage)			
Source	0-2	2-5	5-10	Over 10
Crop income	245	670	1582	2560
Dairying income	860	280	246	836
Non-agricultural income	181	104	339	856
Agricultural labor income	1067	395	29	11
Total	2353	1449	2196	4263

Table 10. Income per Household by Source for Sample Farmers in the Irrigated Zone, Surat District, 1971-72

Source	0-2	*Farm Size (Net Cultivated Acreage)* 2-5	5-10	Over 10
Crop income	541	1228	6018	8713
Dairying income	220	903	1986	3288
Non-agricultural income	1405	1039	702	1154
Agricultural labor income	239	19	0	0
Total	2405	3189	8706	13155

Table 11. Reasons Given by Sample Farmers for Non-Membership and Not Borrowing from Cooperatives, Mehsana District, 1969-70

	Percent of farmers reporting this reason for							
	Non-membership				*Non-borrowing*			
Reasons	Small	Medium	Big	Total	Small	Medium	Big	Total
No need								
Adequate income and past savings	67	69	87	72	75	78	80	77
Non-farm source of income	42	23	13	30	31	–	–	11
Other source of finance	8	23	27	17	13	28	20	20
Land leased out	17	8	20	14	19	22	–	16
Disliked for cooperative credit								
No faith in cooperatives	–	4	7	3	–	–	–	–
Inadequate finance	8	8	13	9	6	–	–	2
Inefficient management	8	12	–	8	–	33	20	18
Dislike for recovery procedure	36	27	33	23	23	23	20	25
Credit limit related to security	14	12	33	17	–	11	–	5
Defaulter of the society	–	–	–	–	13	17	20	16

Table 12. Average Levels of Nutrient Application per Acre from Chemical Fertilizers by Crop and by Farm Size Group for Sample Farmers, Surat District, 1971-72

Crop/Nutrient	*N*		*P*		*K*	
Farm Size[1]	0-5	Over 5	0-5	Over 5	0-5	Over 5
Irrigated						
Improved rice	28.4	30.6	17.5	26.9	5.0	6.1
HYV rice	41.4	36.2	15.9	19.0	7.0	9.6
Desi wheat	33.2	14.9	7.9	10.3	3.6	5.5
Improved wheat	30.9	28.7	0.0	11.1	5.2	13.8
HYV wheat	28.2	27.8	6.0	5.2	0.0	2.4
Sugarcane	88.2	86.0	9.3	19.6	7.9	8.0
Unirrigated						
Rice	9.8	10.4	0.4	0.6	0.0	0.6
Cotton	8.4	4.8	0.8	0.8	0.0	0.6
Jowar	0.2	1.6	0.1	0.4	0.1	0.0
Groundnuts	0.0	4.7	0.0	1.0	0.0	0.1
Val[2]	0.0	0.0	0.0	0.0	0.0	0.0

[1]Net cultivated acreage.
[2]A pulse crop grown without irrigation, following an irrigated or unirrigated rice crop.

Table 13. The Relationship of Year of First Adoption of Chemical Fertilizer with Value of Assets and Farm Size in the Irrigated and Unirrigated Zones, Surat District, 1960/61-1972/73

Irrigated Zone

Assets and Adoption

Assets Value (Rs.)	*Rice–Wheat* Year Adopted 1961-63	1964-66	1967 +	*Cotton–Jowar* 1972–73 Adopter	Non-adopter
0–5000	3	1	7	3	5
5001–10000	4	2	4	3	6
Over 10000	8	4	0	11	2
		$X^2 = 10.82$*			$X^2 = 7.33$*

Farm Size and Adoption

Net Cult. Acreage	Year Adopted 1961-63	1964-66	1967 +	1972–73 Adopter	Non-adopter
0–5	8	4	10	9	9
Over 5	7	4	1	8	4
		$X^2 = 4.95$			$X^2 = 2.26$

Spread from Irrigated to Unirrigated

Year of First Use on Irrigated Crop	1971–72 Adopter	Non-adopter
1960–63	10	4
1964–66	4	3
1967 +	3	6
	$X^2 = 10.57$**	

Unirrigated Zone

Assets Value	*Rice* 1971–72 Adopter	Non-adopter
0–3000	8	13
Over 3000	5	7
	$X^2 = 0.04$*	

Net Cult. Acreage	1971–72 Adopter	Non-adopter
0–5	4	15
Over 5	9	5
	$X^2 = 6.34$*	

*Significant at 5 percent level.
**Significant at 1 percent level.

Table 14. Net Returns[1] for Desi and Improved Buffaloes for Sample Farmers, Surat District, 1971-72

	Value of Milk[2]	Value of Concentrates[3]	Fodder[4]	Labor[4]	Depreciation[5]	Net Returns
Desi	1610.8	469.3	188.4	402.3	128.0	422.8
Improved	2133.0	645.7	188.4	402.3	202.0	694.6

[1]Net returns after subtracting all costs (except interest charges), including the imputed value of family labor.
[2]Estimated value for Improved is 7.13 liters per day at Rs. 1.20 per liter for 8.31 months in milk per 12 months. Estimated value for Desi is 5.95 liters per day at Rs. 1.20 per liter for 7.52 months in milk per 12 months.
[3]Average value of concentrates given per day in milk for an Improved buffalo is Rs. 2.59 and for a Desi buffalo is Rs. 208.
[4]Fodder and labor costs are based on a buffalo herd size of two, which is the modal size of herd.
[5]Based on the average value of an Improved or Desi buffalo, depreciated linearly over 7 years.

Table 15. Estimated Linear Regression for Factors Influencing Value of Concentrates Given per Day to One Buffalo in Milk Among Sample Farmers, Surat District, 1971-72

Factor	Regression Coefficient	Standard Error of Estimate	t-Value
Number of buffaloes	0.2820	0.1118	2.51**
Irrigated net cultivated acreage	–0.0648	0.0495	–0.16
Value of assets ('000 Rs.)	0.0061	0.0085	0.72
Non-agricultural income	–0.0740	0.0872	–0.82
Region	0.0526	0.3382	0.16
Constant	1.4652	———	———
Number of observations (farmers) = 45	$r^2 = 0.18$		

**Significant at 1 percent level.

Table 16. Estimated Linear Regression for Factors Influencing the Value of Buffaloes per Farm for Sample Large[1] Farmers, Surat District, 1971-72

Factor	Regression Coefficient	Standard Error of Estimate	t-Value
Availability of family labor[2]	−11.5621	128.6197	−0.09
Number acres grass (waste)[3]	40.7167	76.9900	0.53
Irrigated net cultivated acreage	4.0828	34.3975	0.12
Non-agricultural income ('000 Rs.)	−103.6715	97.5443	−1.07
Availability of cooperative credit ('000 Rs.)	23.5902	107.5070	0.22
Value of assets ('000 Rs.)	− 1.9871	8.1961	−0.24
Constant	2206.5440	———	———
Number of observations (farmers) = 29	$r^2 = 0.12$		

[1]Large farms are defined as those with over five acres of net cultivated acreage.
[2]Defined as the number of women available for this kind of part-time work, and includes permanent farm servants.
[3]Land not suitable for crops.

Table 17. Estimated per Acre Cobb-Douglas Production Functions with Constant Returns to Scale for Unirrigated Rice and Groundnuts for Sample Farmers in Surat District, 1971-72

	Unirrigated Rice			*Groundnuts*		
Input per Acre	Regression Coefficient	Standard Error of Estimate	t-Value	Regression Coefficient	Standard Error of Estimate	t-Value
Seeds (kg)	0.3071	0.1394	2.20*	0.3272	0.1986	1.65
Farm yard manure (600 kg units)	0.0080	0.0482	0.17	——	——	——
Nitrogen (kg)	0.0645	0.0311	2.07*	0.0192	0.0442	0.43
Man days of weeding	0.0323	0.0883	0.37	0.1416	0.0713	1.99*
Region (=1 or 0)[1]	−0.1690	0.0848	−1.99*	−0.1422	−0.0923	−1.54
Constant	10.3229	——	——	2.8940	——	——
Number of observations (farmers)	= 42			= 34		
	$r^2 = 0.33$			$r^2 = 0.26$		

*Significant at 5 percent level.
[1]Unirrigated zone = 1; irrigated zone = 0.

Table 18. Estimated per Acre Cobb-Douglas Production Functions with Constant Returns to Scale for Unirrigated Cotton and Jowar for Sample Farmers, Surat District, 1971-72

Input per Acre	*Cotton*			*Jowar*		
	Regression Coefficient	Standard Error of Estimate	t-Value	Regression Coefficient	Standard Error of Estimate	t-Value
Seed (kg)	0.3517	0.1973	1.78	0.3912	0.2683	1.46
Farm yard manure (600 kg units)	0.0845	0.0425	1.99*	—	—	—
Nitrogen (kg)	0.0928	0.0374	2.48**	0.1828	0.1053	1.74
Soil type (=1 or 0)[1]	–0.1384	0.7268	–1.90*	0.1438	0.1426	1.01
Man days for weeding	0.0625	0.0853	0.73	0.2177	0.1355	1.61
Number of times intercultivation	0.1396	0.0950	1.47	–0.1528	0.2027	–0.75
Region[2]	0.0544	0.0812	0.67	0.3332	0.1448	2.30*
Grown with Tur (=0) or not (=1)	—	—	—	0.3111	0.3012	1.03
Constant	1.9579	—	—	1.2025	—	—
Number of observations (farmers)		= 46			= 42	
		r^2 = 0.36			r^2 = 0.36	

*Significant at 5 percent level.
[1]Black = 1; less black and sandy soils = 0.
[2]Unirrigated zone = 1; irrigated = 0.

Table 19. Resources Available for Production and Selected Cropping Combinations for 33 Farmers on Unirrigated Land, Surat District, 1972/73

Family number	Number of family members for harvesting	Interest rate to moneylender	Wage rate for weeding	Land for rice	Land for cotton, jowar, groundnuts	Number of man days family labor for weeding	Home consumption of rice (in 20 kg. units)	Home consumption of jowar (in 20 kg. units)	Value of fodder requirements	Savings	Capital available: Co-operative	Capital available: Moneylender	Capital available: Cotton	Maximum acreage suitable: Jowar	Maximum acreage suitable: Groundnuts	Maximum acreage suitable: Low fertilizer	Expected acreage for 1972/73: Rice: High fertilizer	Rice: Low fertilizer	Cotton: High fertilizer	Cotton: Low labor	Groundnut: High labor	Groundnut	Jowar
1	1		2.0+	0.45	0.9	6	21.0	21.0	127	182	0	0	0.9	0.9	0.9	0.45		0.45				0.45	
2	3		1.5	0.5	0.5	36	20.8	26.0	140	150.5	0	0	0.0	0.5	0.5	0.50				0.25		0.25	
3	3	12.5	2.0+	0.45	0.75	15	37.0	37.0	100	69	50	100	0.0	1.2	1.2	0.45*				0.375*		0.375*	
4	4	25.0+	2.0+	0.125	1.2	100	9.1	9.1	18	48	0	25	0.0	1.2	1.2		0.125				0.6	0.6	
5	2	25.0	2.0+	0.125	1.8	0	25.0	25.0	18	0	300	275	0.0	1.8	1.8	0.125				0.9		0.9	
6	4		2.0+	0.25	1.8	21	15.0	45.6	35	60	0	0	0.0	1.2	1.2	0.25				0.9		0.9	
7	1	25.0+	2.0	0.3	1.8	5	10.0	12.0	40	177	0	90	1.8	1.8	1.8	0.30		0.3		0.6		0.9	
8	4	12.0	2.0+	0.6	1.8	36	34.0	34.0	130	0	250	1000	1.8	1.8	1.8	0.60		0.9				0.9	
9	3	12.5	1.5+	0.6	1.8	102	33.0	27.5	61	175	150	700	1.8	1.8	1.2	0.60		0.9			0.3	0.6	
10	3	25.0	2.0+	0.9	1.15	48	26.5	26.5	34	0	200	200	1.15	1.15	1.15	0.90				0.41		0.74	
11	2	12.0	1.5	0.6	2.4	4	39.0	57.0	100	131	0	500	2.4	2.4	2.4	0.6						2.4	
12	2	25.0+	2.0	2.0	1.0	4	10.0	13.0	46	241	400	1000	1.0	1.0	1.0	2.0						1.0	
13	1		2.0	0.6	3.0	0	12.0	10.0	0	142	500	0	3.0	3.0	0.0	0.6		1.2				1.8	
14	4	25.0+	1.5	1.8	1.2	32	47.0	45.0	75	187	75	75	0.3	1.2	1.2		1.8*	0.15*		0.45*		0.6*	
15	3	24.0	1.5+	0.15	3.0	23	2.0	26.0	69	27	0	800	3.0	3.0	0.0	0.15		0.45				2.55	
16	2	12.5	2.0	0.45	3.0	13	18.0	21.0	171	223	0	100	3.0	3.0	3.0	0.45*				0.75*		2.25*	
17	7	12.5+	2.0+	1.8	1.8	48	65.0	73.0	197	319	0	50	1.8	1.8	1.8	1.8		0.9				0.9	
18	3	12.0	2.0	0.6	3.6	111	26.0	52.0	100	259	0	100	3.6	3.6	3.6	0.6		1.8				1.8	
19	6	12.5	1.5+	0.6	3.6	27	26.0	31.0	97	68	0	500	3.6	3.6	3.6		0.6	1.8				1.8	
20	3	25.0	1.5	1.2	1.8	33	36.4	60.0	94	0	400	300	1.8	1.8	0.6		1.2	0.9			0.3	0.6	
21	3	25.0	1.5+	1.2	3.0	21	31.7	34.3	204	117	0	1000	3.0	3.0	3.0	1.2		1.5				1.5	
22	2	12.5	2.0	0.9	3.9	36	18.2	18.2	66	220	0	1000	3.9	3.9	3.9	0.9		1.2		1.5		1.2	
23	2	25.0	2.0	1.8	3.0	32	28.0	45.3	70	559	200	200	0.0	3.0	0.0		1.8					3.0	
24	4	12.5+	1.5	0.9	5.4	192	26.0	26.0	195	483	0	1000	5.4	5.4	5.4		0.9	0.6		2.1		2.7	
25	4	25.0	2.0	0.9	6.0	60	26.0	45.0	152	0	0	500	6.0	6.0	6.0	0.9		1.5		1.5		3.0	
26	4	12.5	2.0	0.5	5.4	12	36.4	54.6	178	91	0	800	3.6	5.4	5.4	0.5					1.8	3.6	
27	4	12.5	1.5+	1.8	5.4	236	42.0	36.0	95	259	0	200	4.2	5.4	3.3		1.8	1.5			1.2	2.7	
28	2		1.5	0.25	6.25	10	20.0	36.0	126	145	500	0	7.25	7.25	7.25		1.35	2.5		1.75		3.0	
29	5	25.0	1.5	1.8	6.6	208	44.0	57.0	180	487	0	1000	6.6	6.6	6.6	1.8		2.55			0.75	3.3	
30	1	12.5	1.5	3.0	7.8	0	21.0	21.0	241	0	300	1500	7.8	7.8	7.8		3.0*	3.3*		2.4*		2.1*	
31	2	12.5	1.5+	1.8	9.6	22	31.0	40.0	406	0	0	2000	9.6	9.6	6.0		1.8*	4.8*		2.4*		2.4*	
32	5	12.5	1.5+	3.0	9.6	376	52.0	78.0	265	0	0	2000	5.4	9.6	9.6	3.0		2.7			3.3	3.6	
33	6	12.5	1.5	2.4	21.0	132	46.0	55.0	361	0	0	3000	21.0	21.0	21.0	2.4		7.2		2.4		11.4	

+Imputed values, as data not available. Farmers not hiring-in labor had a wage-rate imputed and farmers who did not borrow from a moneylender but stated they could borrow from this source had an interest-rate imputed.

*Actual acreage in 1972/73, as these farmers had not made up their minds about cropping pattern prior to the season.

Table 20. The Linear Programming Matrix for Unirrigated Farms

	Rice for home consumption			Rice for sale		Jowar for home consumption		Jowar for sale		Groundnuts (with jowar)		Groundnuts (with cotton)		Cotton (with jowar)		Cotton (with groundnuts)				
	Low fertilizer	High fertilizer	Low fertilizer	High fertilizer	No rotation	With cotton or groundnuts	No rotation	With cotton or groundnuts	Low labor	High labor	Low labor	High labor	Low fertilizer	High fertilizer	Low fertilizer	High fertilizer	Savings	Co-operative	Moneylender
Objective function																			
Rice land	1	1	1	1															
Land other					1	1	1	1	1	1	1	1	1	1	1	1			
Transplanting labor	21	21	21	21															
Family labor for transplanting	- 2	- 2	- 2	- 2															
Weeding labor	35	35	35	35	18	18	18	18	15	40	15	40	21	21	21	21			
Harvesting labor rice	25	30	25	30															
Family labor harvesting rice	- 2	- 2	- 2	- 2															
Harvesting labor groundnuts									27	40	27	40							
Family labor harvesting groundnuts									- 4	- 5	- 4	- 5							
Harvesting labor jowar[2]					5	5	5	5											
Family labor harvesting jowar					- 1	- 1	- 1	- 1											
Harvesting labor cotton													9	12	9	12			
Family labor harvesting cotton													- 2	- 2	- 2	- 2			
Capital requirement	28	70	28	70	10	10	10	10	35	35	35	35	9	33	9	33	- 1	- 1	- 1
Savings																	1		
Borrow co-operative																		1	
Borrow moneylender																			1
Home consumption rice	20.6	25.65			3.74	3.74													
Home consumption jowar					11.7	11.7													
Dry fodder value	49.6	61.9	49.6	61.9	21.2	21.2	21.2	21.2	25.8	30.8	25.8	30.8							
Rotation 1						1		1	- 1	- 1			- 1	- 1					
Rotation 2											- 1	- 1			1	1			
Maximum groundnut (acres)									1	1	1	1							
Maximum jowar (acres)					1	1	1	1											
Maximum cotton (acres)													1	1	1	1			
Deviation 1966			-166.2	-197.6			-124.3	-124.3	-121.3	-121.3	-121.3	-121.3	-152.7	-278.3	-152.7	-278.3			
Deviation 1967			-52.2	-64.2			70.0	70.0	-11.2	-11.2	-11.2	-11.2	-11.9	-60.6	-11.9	-60.6			
Deviation 1968			6.2	-26.6			52.6	52.6	36.9	36.9	36.9	36.9	95.4	111.3	95.4	111.3			
Deviation 1969			108.4	136.8			95.8	95.8	240.8	240.8	240.8	240.8	40.5	247.6	40.5	247.6			
Deviation 1970			55.2	104.1			-40.6	-40.6	-38.5	-38.5	-38.5	-38.5	50.3	48.1	50.3	48.1			
Deviation 1971			48.6	47.5			-53.5	-53.5	-106.7	106.7	-106.7	-106.7	-21.6	-68.1	-21.6	-68.1			
Real income	321.4	400.4	321.4	400.4	273.2	273.2	273.2	273.2	340.2	422.1	340.2	422.1	286.4	414.9	286.4	414.9	- 1.0	- 1.09	- 1.25*
Cash income			271.8	338.5			252.0	252.0	314.4	391.3	314.4	391.3	286.4	414.9	286.4	414.9	- 1.0	- 1.09	- 1.25*

*Starred coefficients change from farmer to farmer, reflecting different numbers of family members, different interest rates for moneylender credit, or different constraint levels.

[1]All labor coefficients are measured in man days, land in acres, capital and deviations in Rs., and home consumption in maunds (= 20 kg. in Gujarat).

[2]Jowar is an inferior cereal.

Table 20. Continued

	Buy rice	Buy jowar	Buy fodder	Sell fodder	Hire labor weeding	Hire labor planting and harvesting rice	Hire labor harvesting other crops	Family labor planting rice	Family labor harvesting rice	Family labor harvesting groundnuts	Family labor harvesting jowar	Family labor harvesting cotton	Real income	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Constraints
Objective function													- 0.33	- 0.33	- 0.33	- 0.33	- 0.33	- 0.33		MAX
Rice land																				EO .9*
Land other																				E 6.0*
Transplanting labor						- 1		- 3*												L 0
Family labor for transplanting								1												L 0
Weeding labor					- 1															L 60*
Harvesting labor rice						- 1			- 3*											L 0
Family labor harvesting rice									1											L 0
Harvesting labor groundnuts							- 1			- 3*										L 0
Family labor harvesting groundnuts										1										L 0
Harvesting labor jowar[2]							- 1				- 3*									L 0
Family labor harvesting jowar											1									L 0
Harvesting labor cotton							- 1					- 3*								L 0
Family labor harvesting cotton												1								L 0
Capital requirement					1.5	2.0														L 0
Savings																				L 0*
Borrow co-operative																				L 0*
Borrow money lender																				L 500*
Home consumption rice	1																			E 26*
Home consumption jowar		1																		E 45*
Dry fodder value			1	- 1																G 152*
Rotation 1																				E 0
Rotation 2																				E 0
Maximum groundnut (acres)																				L 6.0*
Maximum jowar (acres)																				L 6.0*
Maximum cotton (acres)																				L 6.0*
Deviation 1966	- 1.47	1.78												1						G 0
Deviation 1967	0.62	- 0.25													1					G 0
Deviation 1968	- 1.71	1.88														1				G 0
Deviation 1969	0.88	- 4.27															1			G 0
Deviation 1970	1.00	1.26																1		G 0
Deviation 1971	0.68	- 0.4																	1	G 0
Real income							- 2.0						- 1							= 0
Cash income	-13.20	-17.33	- 1.0	1.0			- 2.0													= λ

*Starred coefficients change from farmer to farmer, reflecting different numbers of family members, different interest rates for moneylender credit, or different constraint levels.

[1]All labor coefficients are measured in man days, land in acres, capital and deviations in Rs., and home consumption in maunds (= 20 kg. in Gujarat).

Table 21. Time Series Yield Data for Major Unirrigated Crops, Surat District, 1966/67-1971/72

Crop and Source/Year	Yield per Acre (in 20 kg units)					
	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72
Rice (Low Fert.)[1]						
Farm Management data	7.19 (24)*	17.45 (31)	16.09 (27)			
Baroda University data			23.91 (13)	33.25 (2)	35.11 (4)	
Schluter data				30.06 (6)	23.47 (10)	25.59 (12)
Values in matrix	7.19 (24)	17.45 (31)	18.63 (40)	30.86 (8)	26.80 (14)	25.59 (12)
Rice (High Fert.)[1]						
Farm Management data	9.60 (9)	53.26 (4)	24.71 (9)			
Baroda University data			15.99 (7)	27.01 (1)	43.79 (9)	
Schluter data				22.00 (3)	32.31 (17)	30.83 (19)
Values in matrix	9.60 (9)	21.81[2]	20.90 (16)	38.58[2]	36.28 (26)	30.83 (19)
Cotton (Low Fert.)[1]						
Farm Management data	2.18 (57)	7.40 (33)	8.79 (32)			
Baroda University data			9.51 (65)	6.50 (58)	4.92 (44)	
Schluter data					4.27 (27)	4.85 (27)
Values in matrix	2.18 (57)	7.40 (33)	9.27 (97)	6.50 (58)	4.67 (71)	4.85 (27)
Office Dir. Ag.	2.40	2.50	2.0	3.50	2.40	2.0
Cotton (High Fert.)[1]						
Farm Management data	2.10 (7)	9.48 (15)	11.74 (11)			
Baroda University data			13.45 (16)	13.37 (19)	6.84 (26)	
Schluter data					5.06 (8)	6.31 (16)
Values in matrix	2.10 (7)	9.48 (15)	12.75 (27)	13.37 (19)	6.42 (34)	6.31 (16)

Table 21. Continued

Crop and Source/Year	Yield per Acre (in 20 kg units)					
	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72
Groundnuts						
Farm Management data	NA	23.04	19.60			
		(33)	(32)			
Baroda University data			17.39	20.64	10.27	
			(46)	(50)	(51)	
Schluter data					13.43	9.80
					(26)	(34)
Values in matrix	12.00	23.04	18.30	20.64	11.34	9.80
Office Dir. Ag.	12.00	14.60	18.90	18.10	21.50	NA
Jowar						
Farm Management data	4.93	15.41	16.05			
	(36)	(30)	(16)			
Baroda University data			16.48	13.74	8.85	
			(89)	(76)	(46)	
Schluter data					11.06	8.32
					(48)	(44)
Values in matrix	4.93	15.41	16.41	13.74	9.98	8.32
	(36)	(30)	(105)	(76)	(94)	(44)
Office Dir. Ag.	25.60	35.50	26.10	13.90	13.90	NA

*Numbers in parentheses indicate the number of observations (farmers) on which the average is based.

Source: Directorate of Economics and Statistics, "Studies into the Economics of Farm Management in Surat District, 1966-1968" Ministry of Food and Agriculture, Government of India, (unpublished); M.B. Desai, "Changing Farm Production and Organization in Developing Agriculture, 1968-70," Department of Agricultural Economics, Baroda University, Baroda, Gujarat, 1972; Data supplied by Office of the Director of Agriculture, Government of Gujarat, Ahmedabad; Data supplied by State Income Unit, Bureau of Economics and Statistics, Government of Gujarat, Ahmedabad; Data collected by Michael G.G. Schluter for doctoral dissertation.

Footnotes to Tables 21-24

[1]Low is defined as less than 5 Rs. expenditure per acre on chemical fertilizers and high as 5 Rs. and above.

[2]This is assumed to be 25 percent greater than the unfertilized figure, which is the average percentage increase in other years, because the number of sample farmer observations is too small for a reliable estimate of yield.

[3]Estimated as the same percentage above the 1967/68 figure as in State Income Unit data.

[4]The improved variety of rice is Kollam, and of wheat, NP 824 and NP 718.

[5]Baroda University data include some farmers growing high-yielding varieties (HYV), whereas Schluter data do not. Yields for HYV (irrigated) from the Schluter data are 57.21 (8) in 1969/70, 64.83 (32) in 1970/71 and 65.07 (40) in 1971/72. For 1966-68 in the LP model, we assume yields are 28 percent above those of the improved variety.

[6]Baroda University data include some farmers growing high-yielding varieties whereas Schluter data do not. Yields for HYV from the Schluter data are 38.33 in 1970/71 and 34.00 in 1971/72 (for Sonalika and two cases of Sonakhlyan), so we assume for 1966/67-1969/70 yields of HYV wheat were 33 percent above those of improved varieties.

[7]Refers to *all* wheat varieties (desi, improved, and HYV).

[8]For HYV rice, the price in 1969/70 was Rs. 15.00 per maund, in 1970/71 was 14.00 and in 1971/72 was 14.96 (Schluter data). Thus, we assume from 1966/67-1068/69, HYV price was 15 percent below the Improved Variety price.

[9]For HYV wheat, the price in 1971/72 was 17.38 (Schluter data). So for 1966/67-1970/71, we assume the price was 2.5 percent below the improved wheat price.

Table 22. Prices of Major Unirrigated Crops, Surat District, 1966/67-1971/72

Crop and Source/Year	*Prices in Rupees per 20 kg*					
	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72
Rice (Kada)						
Farm Management data	14.68	12.58	14.92			
	(33)*	(35)	(34)			
Schluter data				12.32	12.20	12.52
				(15)	(40)	(44)
Values in matrix	14.68	12.58	14.92	12.32	12.20	12.52
Cotton						
Farm Management data	53.86	34.90	38.93			
	(64)	(48)	(43)			
Baroda University data			39.70	47.80		
			(81)	(77)		
Schluter data					68.46	51.24
					(41)	(46)
Co-op Gin, Bardoli						
Values in matrix	53.86	34.90	39.43	47.80	68.46	51.24
Groundnuts						
Farm Management data	NA	13.16	18.24			
		(33)	(32)			
Baroda University data			19.90	26.90	NA	
			(46)	(50)		
Schluter data					24.33	24.12
					(26)	(34)
State Income Unit	23.72	19.40	19.88	23.46	26.38	NA
Values in matrix	16.09[3]	13.16	19.22	26.90	24.33	24.12
Jowar						
Farm Management data	15.55	17.58	15.49			
	(36)	(30)	(16)			
Baroda University data			15.40	21.60		
			(89)	(76)		
Schluter data					16.07	17.73
					(14)	(44)
Values in matrix	15.55	17.58	15.45	21.60	16.07	17.73

*Numbers in parentheses indicate the number of observations (farmers) on which the average is based.
Source: Same as for Appendix Table 21.

Footnotes to Tables 21-24 (Con't.)

[10]Average village prices; individual farmer data were not available.

[11]We use Bardoli Factory prices in the linear programming matrix.

[12]Annual average price.

[13]Assumed to be the same percentage below (or above) the 1968-69 yield as in data from the Office of the Director of Agriculture, Gujarat State.

Table 23. Time Series Yield Data for Major Irrigated Crops, Surat District, 1966/67-1971/72

Crop and Source/Year	Yield per acre (in 20 kg units)					
	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72
Rice (Improved)[4]						
Farm Management data	13.35 (35)*	48.27 (37)	47.26 (35)			
Baroda University data[5]			41.38 (92)	46.67 (110)	55.18 (100)	
Schluter data					54.55 (38)	44.78 (52)
Values in matrix	13.35	48.27	43.00	46.67	55.01	44.78
Wheat (Improved)						
Farm Management data	NA	NA	28.49 (8)			
Baroda University data[6]			27.19 (53)	22.81 (72)	29.61 (72)	
Schluter data					28.60 (31)	25.21 (39)
Office Dir. Ag.[7]	15.7	17.4	19.1	24.3	24.9	NA
Values in matrix	22.49[13]	24.92[13]	27.36	22.81	29.31	25.21
Val						
Farm Management data	NA	NA	7.90 (35)			
Baroda University data			9.77 (67)	4.53 (71)	6.26 (63)	
Schluter data					9.03 (59)	7.51 (61)
Office Dir. Ag.	13.7	14.5	13.7	NA	NA	NA
Sugarcane						
Baroda University data			33.10 (10)	32.10 (24)	28.7 (19)	
Schluter data				32.01 (13)	36.44 (20)	33.36 (36)
Office Dir. Ag.	24.78	24.78	22.55	26.47	23.72	NA
Values in matrix	36.37[13]	36.37[13]	33.10	32.08	32.50	33.36

*Numbers in parentheses indicate the number of observations (farmers) on which the average is based.
Source: Same as for Appendix Table 21.

Table 24. Time Series Price Data for Major Irrigated Crops, Surat District, 1966/67-1971/72

Crop and Source/Year	Prices in Rupees per 20 kg					
	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72
Rice (Improved)[8]						
Farm Management data	14.83 (35)*	14.34 (37)	19.90 (35)			
Baroda University data			19.50 (92)	18.20 (110)	NA	
Schluter data					16.23 (38)	17.81 (52)
Values in matrix	14.83	14.34	19.61	18.20	16.23	17.81
Wheat (Improved)[9]						
Baroda University data			18.30 (53)	19.00 (73)	NA	
Schluter data					16.00 (31)	17.82 (39)
State Income Unit	22.43	19.47	18.73	19.44	17.38	NA
Values in matrix	22.03[8]	19.02[8]	18.30	19.00	16.00	17.82
Val						
Farm Management data	19.40[10]	21.10[10]	14.49 (35)			
Schluter data					14.33 (59)	16.38 (61)
State Income Unit	NA	NA	NA	17.74	14.10	NA
Sugarcane						
Bardoli Factory[11]	87.0	113.0	100.0	95.0	100.0	114.0
Madhi Factory	NA	NA	95.0	77.25	89.0	114.80
Banana[12]						
Banana Federation (Bardoli)	5.40	6.90	6.00	4.90	5.75	NA

*Numbers in parentheses indicate the number of observations on which the average is based.
Source: Same as for Appendix Table 21.

Table 25. Average Monthly Prices for Brinjals in Surat Market, 1966/67-1970/71

Year/Month	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1966-67	54.25	32.80	48.55	32.20	30.60	26.00	34.60	47.45	58.35	34.30	66.95	96.85
1967-68	75.75	37.10	19.70	34.40	27.30	11.85	36.40	38.05	66.30	32.60	27.25	91.55
1968-69	101.50	44.85	20.80	22.35	11.25	14.70	36.90	46.30	81.15	60.95	87.30	119.55
1969-70	114.60	55.90	50.90	38.35	21.60	29.05	21.55	80.05	67.30	24.70	81.00	143.25
1970-71	115.00	53.25	53.25	20.25	14.85	14.75	11.75	45.50	67.75	33.50	84.00	78.25

Source: Cooperative Marketing, Surat.

Table 26. Coefficients Used in the Matrix for the Representative Irrigated Farm[1]

	Rice		*Wheat*		
Constant/Crop	Improved	HYV	Improved	HYV	Sugarcane
Kharif land	1	1			
Rabi land	– 1	– 1	1	1	1
Planting labor for rice[2]	21	21			
FM Labor available for planting	– 2	– 2			
Weeding labor requirement (K)	31	39			
Harvesting labor for rice	29	28			
FM labor available for harvesting rice	– 2	– 2			
Planting labor for sugarcane					21
FM labor available for planting sugarcane					– 2
Harvesting labor for wheat			19	18	
FM labor available for harvesting wheat			– 2	– 2	
Capital requirement (K)	105	154			
Capital requirement (R)[3]			130	126	583
Fodder supply	52	35			
Home consumption rice	41.85	54.54			
Home consumption wheat[4]			25.36		
1966	–514.1	–570.1	25.1	32.9	– 70.8
1967	– 20.0	18.9	3.9	5.2	166.7
1968	131.0	148.4	30.4	39.4	34.4
1969	137.2	155.1	– 37.0	– 47.6	–100.0
1970	180.6	131.0	– 1.4	– 11.6	– 49.4
1971	85.3	155.3	– 21.1	– 18.6	88.9
Cash income	712.2	790.6	470.3	609.5	1486.0

K = Kharif, R = Rabi (seasons), FM = Family members.

[1]The form of the matrix is the same as for the unirrigated farm (see Appendix Table 25).

[2]The wage rates assumed now are those of the irrigated zone – Rs. 2.5 for kharif weeding, Rs. 3 for planting rice and harvesting all crops and Rs. 1.5 for rabi weeding.

[3]The farmer is now assumed to have access to unlimited cooperative credit at 9 percent interest, but can no longer borrow form a moneylender. These assumptions make clear how the capital requirement changes along the EV frontier to its maximum point.

[4]The farmer is assumed to have switched from home consumption of jowar to home comsumption of wheat, with no change in the quantity consumed.

APPENDIX B

MARKETING HANDICAPS OF THE SMALL FARMER

A recently published study of the problems of small farmers in U.P. suggests the over-riding difficulty of small farmers centers in marketing handicaps, and prices received in the vicinity of 15 percent less per quintal than larger farmers.[1] Lele, in contrast, argues that rural foodgrain markets do operate efficiently,[2] which suggests large farmers do not have an unfair advantage. In this note we examine briefly for this sample whether:

1. Small farmers tend to sell a shorter period after the harvest than large farmers, and therefore receive lower prices.
2. Small farmers tend to sell to moneylenders or traders rather than to cooperatives, and therefore receive lower prices.

Date of Crop Sales by Size of Farm Group

Small farmers tend to sell their crops earlier than large farmers, as shown in Table 1. For both varieties of rice and wheat, farmers in the 5-10 acre group sell their crop relatively late; very large and small farms sell earlier. But for groundnuts, grown mainly in the tribal zone, it is farmers in the over-10 acre group who delay sales. The rice sales tend to occur a longer period after harvest than the wheat sales, despite the greater cash requirements at the kharif harvest.

The average prices received for each crop in each month after harvest are shown in Table 2. Prices for all crops listed in Table 2 increase substantially after harvest. For rice and wheat the increase occurs only in the second period, and the price does not show a steady increase after that. For groundnuts, the increase continues into the third period, but losses from storage in farmers' homes are also high.[3] When asked why they did not delay rice sales longer, many farmers gave price uncertainty as the reason, and the above analysis supports their contention. Under these circumstances, credit to small farmers to increase storage capacity or reduce storage losses, so they can obtain better market prices, may not be a desirable policy.

There is no evidence to suggest large profits by moneylenders or merchants in wholesale markets, except in the case of cotton, as shown in Table 3. For groundnuts, the moneylender's price is higher than the other merchants, perhaps because he owns an oil mill. But for cotton, the moneylender's price is substantially lower than that of the cooperative. In 1971-72 prior to the assembly of the harvest, the crop was expected to be considerably greater than it turned out to be; merchants, therefore, were offering very low prices initially, when sample farmers sold their crops, and only raised their prices when it became clear that the hybrid cotton was not going to raise aggregate production as much as anticipated. The cooperatives, in contrast, paid a flat sum (about 75 percent of the estimated value) at time of harvest, and distributed the remaining part of the price after calculation of the gin's profit, and thus what the gin could afford to pay. For rice, cooperative prices are higher than prices offered by merchants after the harvest period.

Small farmers tend to sell a relatively large part of their cotton and groundnuts to moneylenders, whereas there is little difference between farm size groups in the buyers of rice and wheat as shown in Table 4.

As indicated in Table 3, there is an advantage for groundnut, but a big disadvantage for cotton, in selling to moneylenders or merchants. In the case of rice, there are almost no sales to moneylenders. The relatively low proportion of sales to cooperatives among farmers of 0-2 acres probably reflects their lack of participation in the cooperatives, owing to a lack of assets against which to secure loans.

Table 1. Average Number of Months After Harvest When Crop is Sold, by Farm Size Group for Major Crops, for Sample Farmers, Surat District, 1971-72

	Farm Size (net. cult. acreage)			
Crop	0-2	2-5	5-10	Over 10
Improved rice	2.00	1.89	2.58	1.80
HYV rice	1.50	1.71	1.89	1.45
Improved wheat	–	1.00	2.50	1.43
HYV wheat	–	1.00	1.25	1.00
Groundnuts	1.30	1.38	1.33	1.66

Notes:

a) 1.00 in the table would indicate the crop is sold within thirty days after harvest, 2.00 would indicate 30-60 days after harvest, etc.

b) Cotton and sugarcane are both sold at harvest, so they are not included in the table.

[1] "Problems and Prospects of Small Farmers in Two Regions of Uttar Pradesh in 1969-70," Uttar Pradesh Agricultural University, Pantnagar, December 1971.

[2] Lele, *Foodgrain Marketing in India, op. cit.*

[3] As one farmer commented, "there are more rates in my house than groundnuts."

Table 2. Prices Received by Farmers by Time Period of Sale After Harvest for Major Crops for Sample Farmers, Surat District, 1971-72 (prices for 20 kg)

Crop	*Number of Months After Harvest*			
	0-1	1-2	2-3	3 or more
Improved rice	17.75 (11)*	18.50 (13)	18.44 (7)	18.58 (4)
HYV rice	15.00 (18)	15.30 (15)	14.00 (3)	13.00 (1)
Improved wheat	17.53 (4)	19.81 (4)	18.00 (1)	–
HYV wheat	17.25 (9)	18.00 (1)	–	–
Groundnuts	24.93 (24)	26.11 (9)	26.60 (2)	–

*Numbers in parentheses show number of farmers on which average is based.

Table 3. Average Prices Paid to Sample Farmers by Cooperatives, Merchants and Moneylenders for Major Crops by Month After Harvest, Surat District, 1971-72 (prices for 20 kg)

Crop and month	*Cooperatives*		*Merchants*		*Moneylenders*[1]	
	Number Farmers	Average Price	Number Farmers	Average Price	Number Farmers	Average Price
Improved Rice (Kollam Variety)						
1	2	17.50	9	17.81	–	–
2	8	18.67	5	18.24	1	19.00
3	–	–	7	18.44	–	–
4	2	20.35	2	16.80	–	–
HYV Rice (Masuri Variety)						
1	5	15.12	13	14.96	–	–
2	10	15.38	5	15.15	–	–
3	1	15.30	2	13.35	–	–
4	–	–	1	13.00	–	–
Unirrigated Rice (Kada Variety)						
1	–	–	4	12.52	–	–
2	–	–	2	11.80	1	13.00
Groundnuts						
1	–	–	11	24.14	13	25.00
2	–	–	5	25.40	4	27.00
3	–	–	2	26.60	–	–

Table 3. Continued

Crop and month	Cooperatives		Merchants		Moneylenders[1]	
	Number Farmers	Average Price	Number Farmers	Average Price	Number Farmers	Average Price
Cotton						
1	31	55.60	–	–	13	42.73
Improved Wheat (NP 824 Variety)						
1	–	–	4	17.53[2]	–	–
2	–	–	4	19.81[3]	–	–
3	–	–	1	18.00	–	–
HYV Wheat (Sonalika Variety)						
1	1	16.00	4	17.00	3	18.03

[1]Moneylender is defined here as a merchant who lends money to a farmer for input purchase and consumption needs, and later may buy the crop.
[2]In one case, the crop was sold to village school for 17.50.
[3]In these four cases, the crop was sold to other farmers in the village.

Table 4. Percent of Sales to Different Marketing Agencies by Crop for Each Farm Size Group, Surat District, 1971-72[1]

Farm Size	Groundnuts			Cotton[2]			Paddy[3]		
	Coop.	Mer.	Money.	Coop.	Mer.	Money.	Coop.	Mer.	Money.
0-2	–	30	70	–	–	–	33	67	0
2-5	–	37.5	62.5	0	–	100	46	50	4
5-10	–	100	0	50	–	50	29	71	0
Over 10	–	100	0	60	–	40	36	59	5

[1]All farmers sold wheat to merchants or other farmers in the village.
[2]Applies only to unirrigated zone, since all farmers in the irrigated zone, irrespective of farm size, sold cotton to the cooperative.
[3]Refers to sales of the three main varieties of rice.

Conclusions

A complex interaction of factors determined prices received in different farm size groups for different crops. For all crops, small farmers (0-5 acres) tended to sell earlier, resulting in lower prices. The relatively high proportion sold to moneylenders in the case of groundnuts offsets the low prices, whereas for cotton the low price is compounded. For rice, small farmers sell a relatively high proportion to cooperatives; for those few who sell after the first month after harvest, this gives a price advantage. Conversely, the larger farmers have an advantage in selling late, but a price disadvantage in selling relatively more to merchants. Overall, small farmers receive slightly lower prices because they sell at harvest, but suffer no other major price disadvantages, except in cases where they sell cotton to moneylenders.

APPENDIX C

CROP CALENDAR FOR SURAT DISTRICT

June — *First and Second Weeks.* Ploughing for cotton, jowar, groundnuts, tur. Sow cotton before rain. Broadcast paddy for seedlings. Apply farmyard manure.
Third and Fourth Weeks. Two or 3 days after rains, sow jowar, arrad, tur and groundnuts.

July — Ploughing for paddy. Intercultivating and weeding other crops 15 or 20 days after rain. Application of chemical fertilizers above the ground. Resowing cotton, jowar, tur, arrad if rains poor and insufficient seed germination.
20th to 25th July. Transplant paddy. Sow late Kauchi and Jowar.

Aug. — Weeding and intercultivating all crops. Application of second dose of chemical fertilizer when sufficient water. Weed paddy about 1 month after planting.

Sept. — Weeding and intercultivating all crops.
Third and Fourth Weeks. Harvest Padma paddy variety.

Oct. — *First and Second Weeks.* Harvest Kauchi and Kada paddy.

Nov. — *Mid-October to Beginning November.* Harvest Kollam paddy, arrad and cut grass. Ploughing for rabi crops.
November 1 and 2. Harvest Arti paddy. Harvest groundnuts.
November 10th to 20th. Harvest Masuri paddy. Begin to sow rabi crops.
Third and Fourth Weeks. Harrow paddy. Sow wheat, val, gram, mehti, lucerne, vegetables, sugarcane.

Dec. — Weeding and giving fertilizer to rabi crops. *End of December.* Watching jowar.

Jan. — Watching jowar for *first 15 days.*
Second and Third Weeks. Harvesting and threshing jowar, tur, mug.
Some weeding of rabi crops. Harrow jowar.

Feb. — Harvest cotton after first week.

March — Harvest cotton up to end of March.
Harvest val in third and fourth week.

April — *End of March, beginning of April.* Harvest and thresh wheat, gram, garlic. Harvest lucerne in March, April, May and June up to rains, cutting every 15-20 days.

May — Harvest vegetables at the end of April and through May, picking every 3 or 4 days. Ploughing for cotton, jowar, tur.

Timing of Operations

1. To plant paddy, must have 2 or 3 inches of water in field. Extremely time-bound.
2. Weeding, some flexibility. Can delay 10 or 15 days depending on labor availability.
3. To delay harvesting of paddy is risky owing to possibility of late rains.

APPENDIX D

A. Items Included in Expenditure per Acre for Tables 8, 9, 12

1. Studies including only *cash* costs of cultivation, Nos. 7, 8, 13, 29.

2. Studies including variable inputs—seed, fertilizers, organic manure, pesticides, casual labor charges, irrigation (whether payment in cash or kind), Nos. 16, 17, 26 (4 and 34 also include imputed value of family labor).

3. Studies using definition in 2, but including land revenue and rent paid to landlord, Nos. 15, 28, 37.

4. Studies using cost A_1, as defined in the Farm Management Studies (i.e. all costs except interest payments and imputed value of family labor), Nos. 2, 3, 12, 16, 20, 38.

5. Studies using cost A_2, as defined in the Farm Management Studies (include all costs except imputed value of family labor), Nos. 5, 11, 39.

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A.E.R.C. = Agro-Economic Research Centre
H.Y.V.P. = High-Yielding Varieties Programme

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