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SMALL SCALE FARMING AND AGRICULTURAL RISKS IN THE SEMI-ARID AREAS OF JORDAN

by

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ABSTRACT

This thesis attempts to fill a long outstanding gap in research concerning the decision-making process under risk of small subsistence farmers in the semi-arid zones of Jordan. It focuses on farm income variability, cultivation practices and policy measures to mitigate yield and price risks. Contributions include: assessment of yield and price risks and their effects on the variability of farm income; comparison of labour-intensive and capital-intensive agricultural practices in terms of risk-income trade-offs, crop mix and resource allocation. The thesis proposes hypothetical actuarially-fair revenue insurance and yield/price insurance and analyses their potential impact in mitigating risk, stabilizing farm income and improving resource allocation. It also attempts to determine the role that traditional weedy fallow plays as a risk management strategy in subsistence labour-intensive dryland farming. Risk analysis is carried out using a linear risk programming technique known as Minimization of Total Absolute Deviation (MOTAD).

AVANT-PROPOS

Cette thèse tente de combler une lacune dans les activites de recherche concernant le processus de prise de decision des petits agriculteurs de subsistance des zones semi-arides de la Jordanie. Elle est centrée sur la fluctuation des revenus agricoles, les pratiques culturales et les mesures politiques visant à reduire les risques au niveau des récoltes et des prix. Elle comprend notamment l'évaluation des aléas dans la récolte et les prix, ainsi que leurs effets sur les fluctuations des revenus agricoles; un examen comparé des pratiques culturales à fort coefficient de main-d'oeuvre et des pratiques capitalistiques en termes de la variable risque, des cultures mixtes et de l'allocation des ressources. La thèse analyse egalement des regimes d'assurance actuariellement satisfaisants pour les revenus agricoles, ainsi que les prix des récoltes, afin de determiner dans quelle mesure ils pourraient réduire le risque en stabilisant le revenu agricole et en améliorant l'allocation des ressources. Cette these vise essentiellement à déterminer le rôle de la pratique de la jachere comme strategie de gestion des risques dans la culture traditionnelle des terres arides. L'analyse de l'élément risque des revenus a éte faite par la technique de programmation linéaire de la "Minimisation de l'Ecart Absolu Total" (Total Absolute Deviation - MOTAD).

CHAPTER I: INTRODUCTION

Unlike other types of business, the business of farming, is carried out in the face of continuous uncertainty of natural elements -- drought, frost, wind, flood, insects and other pests, and various crop diseases. These adverse natural elements, most of which are uncontrollable, affect crop production and are greatly responsible for instability of farm income from year to year. It has repeatedly been shown that farmers all over the world experienced uncertainties emanating from natural perils and calamities, such as serious drought and recurrent pest invasions. The consequences of such disasters are much more severe for Less Developed Countries (LDCs) than for developed ones. A serious crop failure means loss of income and farm investment for the farmers, the immediate consequences being inability to pay taxes and rents, as well as to repay credit installments. Their impoverishment also leads to the loss of purchasing power and an increase in their debt/equity ratio.

Uncertainties of crop production in LDCs can be lessened by introducing, on the one hand, such measures as irrigation, better drainage, extensive land reclamation and effective measures against desertification, and by administrative reforms, social and institutional improvements, and efficient credit delivery systems on the other. Investment in the agricultural sector often involves the adoption of advanced agricultural techniques and practices. One reason small farmers in most developing countries continue to use traditional and often below-optimal techniques is that more advanced techniques have not been developed for small farmers as the primary users. In addition, and perhaps more plausibly, farmers who produce for subsistence tend to be more risk-averse than farmers engaged in commercial agricultural production (Binswanger, 1980), and thus unwilling to adopt anything new. This is especially true in countries like Jordan where agricultural production is carried out under very harsh climatic conditions.

More than 92 percent of agricultural production in Jordan is carried out under the harsh conditions of its arid and semi-arid climate. Over 80 percent of cereal crops are grown under rainfed conditions. Rainfall is extremely variable from year to year and within each year. Year-to-year variations in wheat and barley yield and production were substantial during the period 1959 to 1984.

Farmers in the arid and semi-arid areas of Jordan are among the poorest in the country, relying on cereal production and to a certain extent on the raising of small ruminants for their survival. As in the past, today they face a number of problems in growing and marketing their crops. Inflation has caused the cost of fertilizers, seeds, herbicides, and machinery services to increase drastically in recent years.

Crop yields in Jordan are among the lowest in the Near East and North African region (Weinbaum, 1980 and FAO, 1982; see Table 1 in Appendix). Both Jordan's population growth (at about 3 percent per year) and its considerable increase in GNP over 1975-1985 have triggered a substantial growth rate in cereal consumption, not only by low-income groups for whom cereals are the staple food, but also for middle- and upper-income groups. The latter group has increased expenditures on food items, of which cereals are the intermediate goods, notably red meats, poultry and dairy products. Consequently, the cereal deficit has more than doubled, and the gap between wheat production and consumption has steadily increased.

Wheat and barley yields (the most commonly grown cereals in the arid areas of Jordan) are extremely unstable. In good years, yields can be three to five times the yields of bad years, ranging from 26 kgs per dunum to 126 kgs per dunum. In dryland farming it is not uncommon to have a crop failure three years in a row resulting in instability in farm income and recurrent food deficits at the farm level.

Prior to 1973, prevailing cereal prices were basically determined by international prices, with most of the cereal trade in Jordan, both local and imported in the hands of Jordanian merchants. After the creation of the Ministry of Supply (MOS) in 1973, the Government began a policy of intervention (through MOS) by controlling the price of cereals, flour, and other food items. While the border price of wheat in 1973-1974 was above US$ 300 per ton, the Government fixed the domestic wheat price at about US$ 100/ton. Although the Government paid wheat producers slightly higher prices in 1973-1975 (US$ 120-150), they were still far below international prices. In fact, international wheat prices in the same period reached a record high (over US$ 300/ton FOB). A significant increase in Jordanian producers' prices was initiated only after 1979/1980.

In spite of the support price instituted by the Jordanian Government to encourage cereal production, time-series data on prices received by farmers for the last eleven years for wheat and barley show that price uncertainty has not been entirely eliminated. Among the reasons advanced for this uncertainty are marketing bottlenecks, poor storage facilities and the poor timing of announcement of support prices (Gotsch, 1980). This suggests that until recently farmers in rainfed areas in Jordan have had to cope with production and price risks simultaneously.

The Government of Jordan has, over the past twenty years, initiated a number of projects and programs in the rainfed areas to increase yields and production of cereals. These programs aim to introduce capital-intensive agricultural practices comprising appropriate tillage, combine harvesting, fertilizers, herbicides, and clean fallow to replace traditional weedy fallow. In spite of their potential to increase cereal yields and thus improve farm income, there is abundant evidence that small farmers' adoption of these practices has been very limited, particularly clean fallow, application of fertilizers and chemical weed control (El Hurani, 1975; Gotsch, 1980; IFAD, 1983; IFAD, 1986).

For the last twenty years, dryland research and farm demonstrations in Jordan have concentrated on the package approach, which requires that a number of new practices be adopted simultaneously. This approach is predicated on the belief that the positive interactions among separate components of the package are so great that, even though the innovations are not very productive when adopted singly, they generate very large output increases when adopted as a package (Mazur, 1979).

A number of explanations have been offered as to why farmers in dryland areas have not adopted these practices. Gotsch (1980) attributed it to unfavorable input/output prices, while El Hurani (1980) pointed to the gap between results of experimental demonstrations of the technologies and farmers' perception of achievable gains from their use. This gap was attributed to a number of factors, including institutional rigidity, lack of basic rural infrastructure, poor extension services, land fragmentation, high illiteracy rates and the unavailability of credit (Mazur, 1979 and IFAD, 1983).

Among the causes for failure to adopt the capital-intensive practices listed above, two fundamental ones seem to have been overlooked. The first is the inherent conflict in any new production system between expected profitability and risk. The second is the fact that not all small farmers are risk-neutral (Binswanger and Barah, 1980; Hazell, 1984; Dillon, 1985; Lipton and Longhurst, 1985; Tisdell, 1968).

If small farmers are indeed risk-averse, the chances of adoption of new practices would be greater if:

- yields are increased substantially so that yield variability becomes less than when using traditional methods; and
- yields are increased moderately, while their variability is reduced substantially below that of traditional methods.

Objectives of the Study

The objectives of this study are to examine the decision-making process of small subsistence farmers under price and yield uncertainty; to assess the role of uncertainty in determining the adoption of improved agricultural practices; and, to examine the potential impact of agricultural insurance as a policy instrument in mitigating risk and stabilizing farm income.

The specific objectives of this study include:

a) Examining and evaluating trade-offs between expected net income and income variability under labor-intensive traditional agricultural practices.

b) Assessing the separate and combined effects of price and yield variability on farm income under traditional labor-intensive agricultural practices.

c) Examining and comparing traditional labor-intensive and the capital-intensive agricultural practices in situations with and without insurance.

d) Designing a number of hypothetical agricultural insurance options and analyzing their potential effect on resource allocation and farm income. This will be carried out for the two situations mentioned in (c) above.

The analysis employs a linear risk-programming technique called Minimization of Total Absolute Deviation (MOTAD). This technique is similar to and requires the same data as quadratic programming. The difference between the two techniques is that MOTAD is fairly robust, easy to use and involves less computational operations.

Observed behaviour of small farmers shows that farmers grow cereal crops in two- and three-year rotations involving traditional fallow, consume a considerable portion of their production, rely heavily on family labor and have little liquidity. Thus, to achieve objective (a), a linear-risk programming model reflecting the farmers' behaviour was formulated and analyzed.

To achieve objective (b), certain assumptions concerning yields and prices were made and income variability was broken down into its main components, that is, price and yield variability and the variability caused by their interaction.

To achieve objective (c), a linear-risk programming model reflecting the capital-intensive model was formulated and then solved. The results were then compared to those obtained in objective (a).

To achieve objective (d), a number of steps were followed. Previous work on agricultural insurance was used as the background for formulating the various insurance options. Specific attention was given to the design of alternatives which could be implemented to mitigate the risk inherent in cereal production in Jordan.

The analysis involves actuarially fair insurance schemes, specifically, price/yield insurance and revenue insurance. Other actuarially unfair insurance options were also considered. The impact of agricultural insurance on farm income, and on resource allocation in the context of a typical small holding in the study area were highlighted using the linear-risk programming technique. Agricultural insurance options were investigated for both labor-intensive and capital-intensive practices.

The Region Studied

The analysis was carried out for two crops -- wheat and barley -- grown on a typical small holding in Irbid Governorate. Out of 5,000,000 dunums (10 dunums = 1 hectare) of arable land in Jordan, 10-14 percent are under irrigation (500,000-770,000 dunums). Agricultural production in

Jordan is restricted almost exclusively to two areas: the Jordan Valley and its side wadis, where 80 percent of the irrigated land is located; and the western edge of the high plateau in the east of Jordan. This triangular shaped region, covering the Governorates of Irbid and Amman, extends from the Syrian border in the north to the city of Madaba in the south (see Map in Appendix). It has adequate precipitation for cropping activity and contains the bulk of the population. Official government estimates indicate that out of the 3,420,000 dryland dunums in Jordan (all agro-climactic zones), about 2,000,000 dunums are in this region and about two-thirds are in the Governorate of Irbid. The average small-scale landholding is about 76 dunums. According to a recently published report on Jordanian agriculture by the United Nations' Economic and Social Commission of Western Asia (1985), over 80 percent of the highland small farmers are in the lower-income strata.

The Irbid Governorate was selected for four reasons:

a) It is the area with the greatest potential for expanding production of wheat and barley, and has the highest incidence of rural poverty in Jordan (IFAD, 1988).

b) Experimental results of previous research, as well as data, are more available for the Irbid Governorate.

c) The area is fairly homogeneous in terms of soil and precipitation.

d) As an agro-climactic zone it shares many characteristics (soil, precipitation, agricultural practices, etc.) with other countries in the region, namely, Syria, Algeria, Iraq, Morocco and Tunisia.

This study mainly concerns farm income stabilization. Its findings will contribute to a better understanding of small farmers' attitudes, practices and needs. It will also shed some light on the adequacy of agricultural insurance as a potential policy instrument in stabilizing farm income, reducing rural poverty and improving food security in the dryland areas of the Near East and North Africa. This study may also stimulate further research in Jordan and in other countries of the region.

Organization of the Study

The study is organized into eight chapters:

- Chapter 1 provides introductory material including the purpose of and justification for the study.

- Chapter 2 provides a detailed account of the agricultural economy of Jordan with particular emphasis on cereal production -- its constraints and potential. This chapter also summarizes the findings of available research pertaining to crop losses and farmers' perception of risk -- its sources and mitigating strategies. Experimental research on farmers' attitudes toward adoption of technological packages is also discussed.

- Chapter 3 reviews the relevant literature pertaining to decision-making under uncertainty.

- Chapter 4 reviews relevant literature on experiences with crop insurance in both developing and developed countries. Elements of a theory of crop insurance, factors affecting the demand for it and its welfare implications are also explored. Finally, the role of crop insurance in mitigating agricultural risk in developing countries is discussed.

- Chapter 5 describes the methodology pursued, presents the MOTAD model and establishes its assumptions and advantages. Sources of data and problems with the data analysis or collection are described. Steps for carrying the empirical analysis are elaborated.

- Chapter 6 deals with the empirical results; various scenarios without crop insurance are analyzed. This includes analysis of basic farm plans both under labor- and capital-intensive agricultural practices, and an assessment of the separate and combined effects of price and yield variability on farm income.

- Chapter 7 provides optimal farm plans using the hypothetical agricultural insurance schemes, namely, yield/price insurance and revenue insurance for labor- and capital-intensive practices. The impact of crop insurance on stabilization of farm income is analyzed.

- Chapter 8 provides a summary, conclusion, policy implications and recommendations for further research.

CHAPTER II: COUNTRY BACKGROUND

A. Introduction

This chapter aims to provide background material related to the subject of this study. It is divided into six sections: the first summarizes the salient features of the agricultural sector in Jordan and highlights the role it plays in the economy as a whole; the next two sections discuss the characteristics of rainfed cereal production; the fourth section explores the cultivation practices which include both labor- and capital-intensive methods; the fifth section is devoted to a discussion of the results of the research and the campaign made so far in relation to the adoption of capital-intensive agricultural methods as compared to labor-intensive techniques; and finally, in section six, the extent, nature and incidence of crop damage in Jordan is described.

Population

The population of Jordan's East Bank is estimated at 2.153 million people (1985), of whom about 854,000 live in rural areas. Over 50 percent of the population is less than 14 years of age, 46.6 percent between 15 and 64, and the rest above 65. The male population is 1.125 million and the female population 1.028 million. In 1979 the estimated labor force was about 397,000 and, according to Zahlan (1985) the labor force grows by about one percent per year.

The total number of Jordanians working abroad is about 240,000 (Seccombe, 1981). Between 1975 and 1982, remittances to Jordan averaged

JD 248.9 million, or about JD 1,000/year per worker. In 1976 remittances represented 23.1 percent of GDP, declining to 13.8 percent in 1985.

As a result of high Jordanian emigration to the Gulf countries (40 percent of the labor force in 1980) and increased government spending during the 1975-1977 period, Jordan experienced an acute labor shortage and consequent surge in wage rates. These factors led to an influx of foreign workers from Egypt, Sudan and Southeast Asia. The total number of foreign workers in Jordan increased from 18,785 in 1978 to 93,402 in 1981, with about 30 percent working in irrigated agriculture in the Jordan Valley.

Role of Agriculture in the Economy

Agricultural GDP was JD 26 million in 1963 and reached JD 99 million in 1983 (in current JD). However, this quadrupling of the agricultural GDP corresponds to a relative decline in agriculture's share of total GDP. From 1973 to 1975 agriculture's share of GDP stood at 12 percent, in 1976-1980 it was 9 percent, and in 1981-1982 it declined further to 7 percent (see Table 2.1). Agricultural GDP recorded a real annual growth rate between 1973 and 1983 of about 11 percent. This increase is mainly due to irrigated agriculture in the Jordan Valley where citrus fruit and a wide range of vegetables are grown. During this period, drip irrigation and greenhouses were introduced throughout the East Jordan Valley. At the same time, however, output from dryland farming has been not only low (as compared to other countries in the region), but extremely unstable.

During both the 1960s and 1970s, the role of agriculture in Jordan in generating employment was below the average of middle-income countries.

The agricultural sector employed about 33.5 percent of the total active labor force in the country in 1961, but by 1979 this figure had declined to about 10.3 percent. In the ten-year period 1960-1970 agriculture, was responsible for 13.3 percent of Jordan's real total GDP growth. During the period 1970-1980, however, it recorded a remarkable decline, contributing only about 0.2 percent annual growth in real terms.

Table 2.1: Jordan's Agricultural GDP Compared to Middle-Income Countries

	Jordan		Middle-Income Countries	
	1960-70	1970-81	1960-70	1970-81
Agriculture as a % of Total GDP	16.0	8.5	24.0	14.0
Average Annual Growth Rate[a]				
- GDP	6.6	9.3	6.0	5.4
- Agriculture	5.0	0.2	3.5	3.0
Percent of Agricultural Growth in GDP Growth[b]	13.3	0.2	14.0	7.7

[a]Calculated from various World Bank World Development Reports.
[b]Computed as: (Agricultural growth rate) x (% of GDP contributed by agriculture)/Growth of GDP.

Non-agricultural growth (increased per capita income and population), however, stimulated the demand for agricultural produce. This demand for food has been effectively transmitted to the farmers through the marketplace, partly through more responsive marketing enterprises and price increases. Farmers have responded to the increased demand with greater output (Table 2.2).

Agriculture and the Balance of Trade

In spite of the dramatic increase in exports over the last 20 years, imports have also increased by the same proportion. For example,

Table 2.2 <u>Commodity Composition of Domestic Consumption and Production (1973 - 1981)</u>
(Thousands Metric Tons)

	1973		1977		1981	
	Consumption	Production	Consumption	Production	Consumption	Production
Wheat	122	50	201	62	290	51
Barley	12	5.9	80	12	29	19
Lentils	0.1	4.8	6	6	4.3	7.9
Vegetables	157	177	99	205	195	115
Fruits	136	104	142	104	164	156
Sugar	19	--	45	--	90	--
Meat (Red & White)	32	29	40	34	90	65
Dairy Products	78	45	104	40	137	42
Fish	2.4	0.1	3.4	0.1	6.8	0.1
Eggs	109	36	250	214	288	350
Tea & Coffee	6	--	6	--	7	--

Source: "The Demand for Agricultural Products," by Adeeb Haddad in Zahlan 1985 while agricultural exports grew at about 29 percent over the period 1970-1980, agricultural imports stayed about the same. The export market constitutes mostly fruit and vegetables. Vegetable production from the Jordan Valley satisfies total local demand.[1]

Food imports have been on the rise over the last ten years, particularly cereals. Jordan is a net importer of cereals, dairy products, tubers, meat and fish, and fats and oils. Over the period 1973-1982, agriculture's share of total imports reached 19 percent. (The average of total imports over the period 1973-1982 was JD 514 million of which an average of JD 98 million was for all agricultural imports.) Imports of cereals during the same period averaged about JD 12 million or 12 percent of total imports. The value of these imports stood at JD 3.8 million in 1973-1975, and reached JD 22 million in 1981-1982 (see Table 2.3 and Figure 2.1).

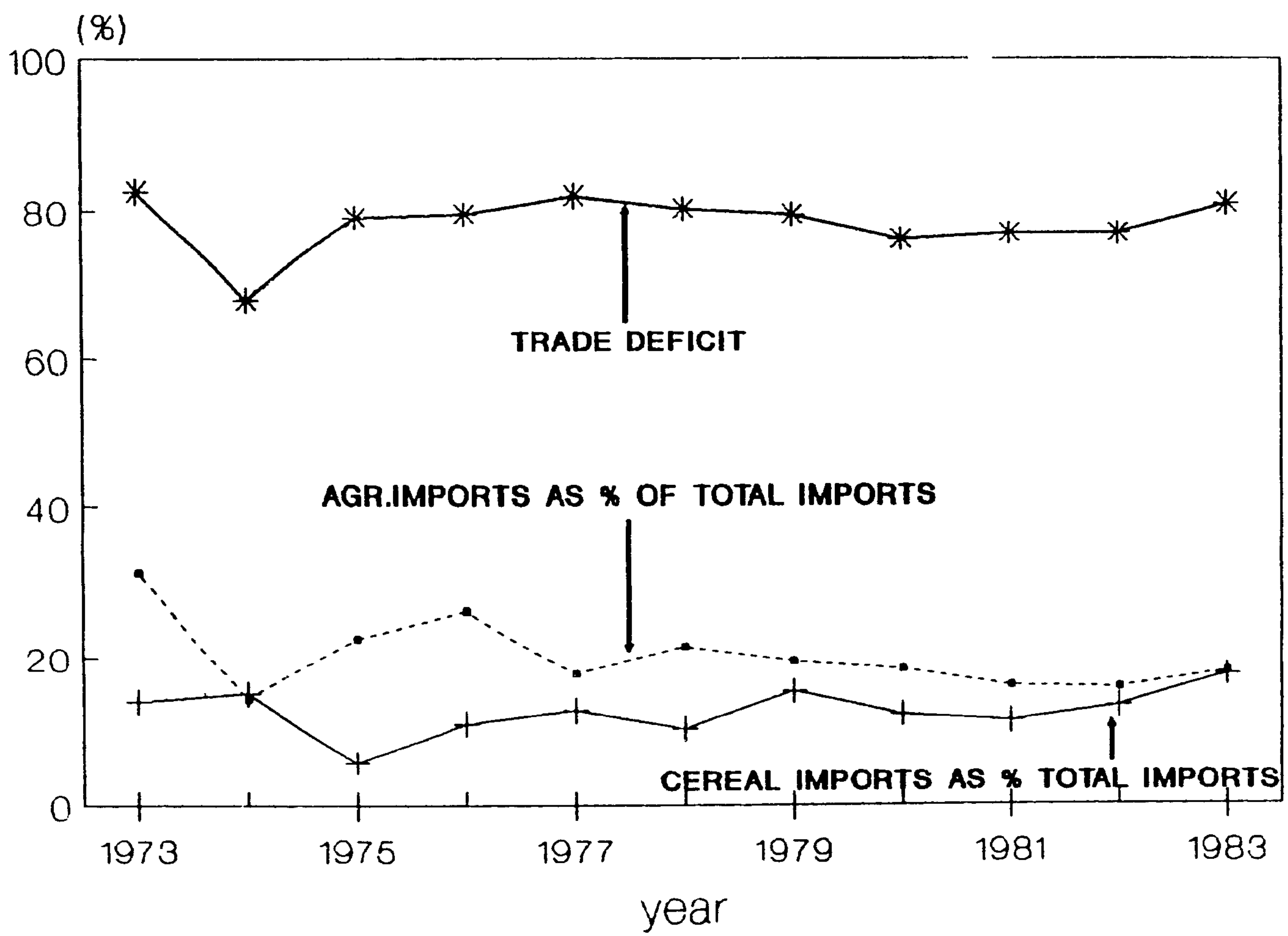
Table 2.3: Value of Agricultural and Non-agricultural Imports to Jordan, including Cereals - 1973-1983
(JD million, current prices)

Year	All Imports	Agricultural Imports	Agriculture as % of All Imports	Cereals	Cereals as % of All Imports
1973	108.2	33.5	31	4.7	14
1974	156.5	42.6	27	3.4	15
1975	234.0	52.9	21	3.2	6
1976	339.5	88.5	27	10.0	11
1977	454.5	80.8	17	10.5	12
1978	458.5	98.9	22	10.7	11
1979	589.7	114.1	19	16.2	15
1980	715.9	131.7	18	16.2	12
1981	1047.5	167.9	16	19.4	12
1982	1042.5	180.0	17	24.0	13

Source: Annual Statistics Reports (various issues). Department of Statistics, Amman, Jordan.

importance of agricultural imports
in total imports JORDAN(1973-1983)

fig:2.1



all expressed in percentage

Public Investments in Agriculture

Since Jordan's agricultural potential is limited and the country is unable to achieve food self-sufficiency, the government's investment strategy is to reduce the agricultural trade gap by increasing high-value fruit and vegetable exports. During the past decade, this agricultural sector has benefitted from sizeable public investment (see Table 2.4).

Table 2.4: Public Investment by Sector
(JD million)

Sector	1973-1975		1976-1980		1981-1985	
	amount	%	amount	%	amount	%
Irrigation and Agriculture	33	14	78	6	756	23
Industry and Energy	45	19	416	32	922	28
Tourism	6	1	24	2	66	2
Transport	57	24	352	27	546	17
Communications	7	3	23	2	109	3
Housing	50	21	258	20	308	9
Services	41	17	160	12	597	18
TOTAL	239	100	1,311	100	3,304	100

Source: Ministry of Planning, National Development Plans (various years)

Jordan's major short-term production potential lies in areas where water is or can be made available. In the past, the government's investment strategy has therefore concentrated on establishing and expanding an advanced, irrigated farming sector. During the 1976-80 planning period, 76 percent of the planned public investment in agriculture was directed to the irrigated sector, while only 16 percent was budgeted for the rainfed areas; the remaining 8 percent went to agricultural support services. While priority for the irrigation sector was justified as long as an unexploited potential existed, the decreasing rate of return of costly irrigation schemes shows that the cost per dunum of irrigated land development is increasing.

Agricultural Income

Past development strategies and investment programs have had a direct bearing on income level and on the equity of income distribution. In Jordan there are indications (UNESCWA, 1985) of considerable inequities and wide disparities between urban and rural incomes. According to preliminary results of the 1983 Agricultural Census, the average urban income was estimated at JD 572, which was 60 percent higher than the average rural income. The top 10 percent of the urban population, as compared to the top 27 percent of the rural population, appropriated more than 35 percent of the total income of the respective urban and rural sub-sectors. In 1978, 50 percent of the urban population and 72 percent of the rural population had per capita incomes of less than JD 400. Significant disparities were evident between those engaged in and dependent on agriculture and those who were not.

B. Physical Characteristics of the Rainfed Sector in Jordan

Rainfall

Time-series data on rainfall for the last four decades, available show that rainfall in Jordan is highly variable, less so in the western and northern parts of the country than in the southern and eastern parts. Rainfall variability in the occupied West Bank does not exceed 40 percent; in some areas of the West Bank it is less than 25 percent. Variability of rainfall throughout the East Bank, however, is no less than 40 percent.

The East Bank of Jordan can be classified into three homogeneous rainfall areas: the first consists of the Governorates of Balqa and Irbid, the second of Amman and Karak and the third of Ma'an. The analysis of variance for these three regions demonstrates that there is a significant statistical difference between their average rainfall precipitation, thus confirming the climactic zoning. The average rainfall (1960-1984) in the five governorates, together with the coefficient of variation, is shown in Table 2.5.

Table 2.5: Average Rainfall, Standard Deviation and Coefficient of Variation (1960-1984)

Governorate	Average Rainfall (mm/year)	Standard Deviation	Coefficient of Variation
Balqa	569	181	32
Irbid	450	128	28
Amman	373	139	37
Karak	339	147	43
Ma'an	65	41	63

Source: Raw data from Meteorological Department in Amman. Calculation made by author on basis of data collected from (1960-1984).

The overall average precipitation countrywide during the period 1960-1984 is stationary. Rainfall variation in certain governorates, such as Karak and Ma'an, makes rainfed culture extremely risky. The coefficients of variation are 43 percent and 63 percent, respectively. Wheat and barley yields and total rainfall in the months November to April are shown in Figures 2.2 and 2.3.

The bulk of Jordan's agricultural land resources are arid, that is, receive less than 200 mm annual precipitation. Only 8.6 percent of the total land, about 8 million dunums, receives more than 200 mm of annual rainfall and only half of that land is suitable for cultivation. Only 350,000 dunums of Jordan's agricultural land is irrigated or partially irrigated, the balance relies on rainfall. Table 2.6 shows the broad agro-climatic zones in Jordan.

Table 2.6: Agro-climactic Zones of Jordan

Region	Precipitation Average (mm/year)	Area (du 000)	Percent
Arid desert	200	8 456	91.4
Marginal	200-300	530	5.7
Semi-arid	300-500	170	1.8
Semi-humid	500	99	1.0

Source: IFAD. Cooperative Development of Rainfed Agriculture Appraisal Report, 1981.

Incidence of Frost in Jordan

Data on incidence of frost in the northern part of the Jordan Valley were compiled and analyzed. For the period 1960-1984 there were, on average four days per year where the grass temperature at 5 mm above ground was 0°C, with variations ranging from zero to ten days (see Table 2.7). No time-series data were available on damage caused by frost. Analysis of the records available and the data collected from farmer interviews show that frost is an important natural calamity and a source of serious crop damage in the Jordan Valley, particularly for vegetable crops and bananas (IFAD, 1986).

fig:2.2 wheat & barley yields in IRBID
(1963–1983)

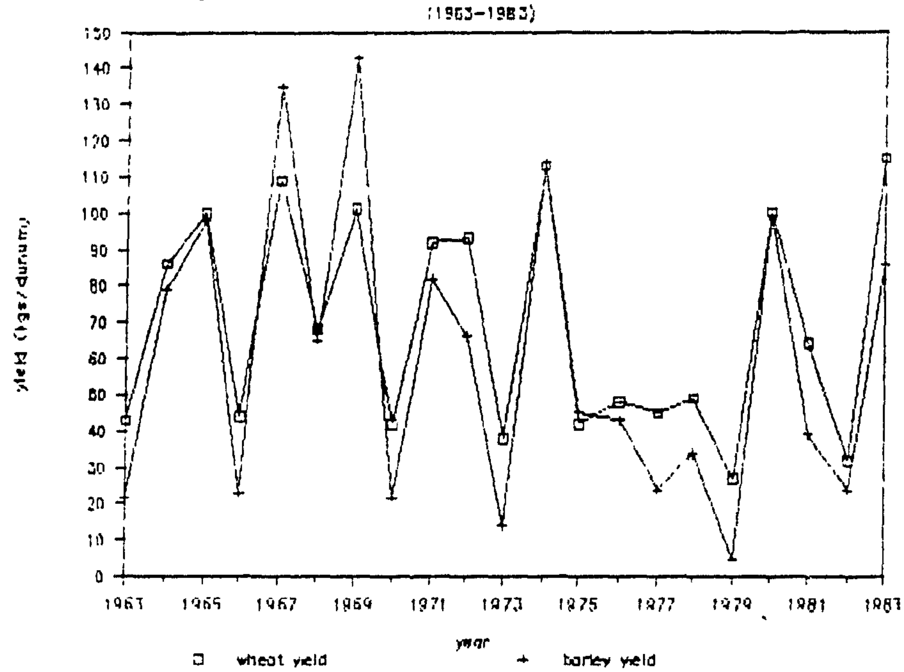


fig:2.3 annual rainfall in IRBID
(1963–1983)

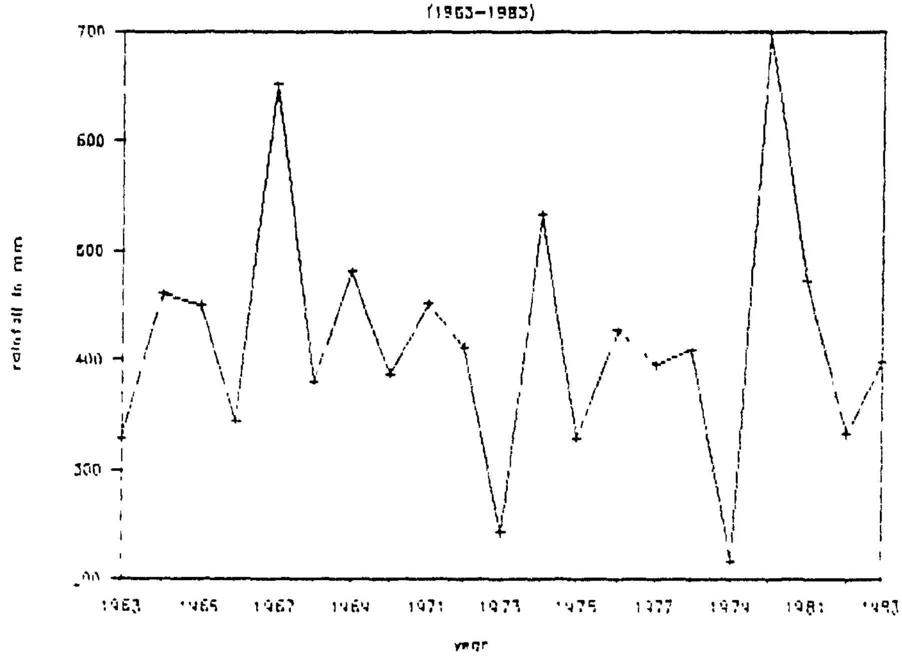


Table 2.7: Number of Days where the Grass Temperatures at 5 mm above Ground in January was 0 C, 1960 - 1984

Year	No. Days	Year	No. Days	Year	No. Days	Year	No. Days
1960	0	1967	2	1974	5	1981	1
1961	9	1968	10	1975	3	1982	7
1962	1	1969	0	1976	6	1983	6
1963	2	1970	3	1977	8	1984	4
1964	1	1971	10	1978	1	Average	3.94
1965	0	1972	9	1979	0	SD	3.40
1966	0	1973	5	1980	5	CV	86.35%

Source: Raw data from Meteorological Department. Calculations by author.

Incidence of Hail in Jordan

Data on occurrence of hail were analyzed for the governorates of Amman, Karak, Madaba and Irbid. The incidence can be classified as light to moderate, however, the variation of hail incidence is very high, from 66 percent in Madaba/Amman to 168 percent in Karak (see Table 2.8). The probability of occurrence according to intensity is shown in Table 2 of the Appendix. Interviews with farmers and a review of the Ministry of Agriculture files show that hail has caused no crop losses (see Part C).

Table 2.8: Frequency of Hail in the Governorates of Jordan

Governorate	Hail Intensity[a]	Average Number of Days/Year[b]	Standard Deviation	Coefficient of Variation
Amman	Moderate	2.47	2.47	100
Karak	Light	0.72	1.21	168
Irbid	Moderate	2.08	1.85	89
Madaba	Light	1.60	1.05	66

[a]According to USFCI, intensity is ranked as: less than two days = light; 2-3 days = moderate; and 3-9 days = heavy.
[b]1923-1985 for Karak and Madaba. Irbid data are for 1961-1985 only.

Source: Raw data from Meteorological Department. Calculations by author.

Landholdings

The average landholding in the rainfed areas is about 76 dunums. Eighty percent of the landholdings are less than 100 dunums, however, 20 percent of the holdings occupy 80 percent of the total land. Rentals constitute 16 percent in terms of number of holdings and 12 percent of total agricultural land (see Table 2.9). The landholdings distribution pattern in the Jordan Valley is completely different, due to the recent land reform laws that have been applied since 1975.' The majority of farmers (about 87 percent) own landholdings not exceeding 40 dunums.

Table 2.9: Land Tenure of Agricultural Landholdings in Jordan (1985)

Size of Holding (dunums)	Number of Holdings Total Number	Owned	Rented	% of Holdings Rented	Holdings in Dunums Total Area	Area Owned	Area Rented	% of Area Rented
Less than 5	8,522	7,922	530	6.2	16,039	14,534	1,505	9.4
5-10	3,825	3,136	689	18.0	25,679	21,064	4,615	18.0
10-20	6,926	5,253	1,673	24.2	92,233	70,257	21,976	23.8
20-30	5,337	4,068	1,269	23.8	121,891	93,336	28,555	23.4
30-40	4,666	3,561	1,105	23.7	150,825	116,097	34,728	23.0
40-50	2,968	2,468	500	16.8	125,914	105,053	20,861	16.6
50-100	8,634	7,355	1,279	14.8	570,793	489,440	81,353	14.8
100-200	5,479	4,799	680	12.4	701,829	617,119	84,710	21.1
200-500	3,359	2,891	468	13.9	999,770	873,164	126,606	12.7
500-1,000	719	655	64	8.9	452,125	411,580	40,545	9.0
1,000-2,000	253	238	15	5.9	299,726	281,156	18,570	6.3
2,000-5,000	84	81	3	3.4	220,488	214,238	6,250	2.8
5,000-10,000	10	9	1	10.0	58,920	53,920	5,000	8.5
10,000 plus	9	9	-	-	133,800	133,800	-	-
Total	50,791	42,515	8,276	16.3	3,970,037	3,494,758	475 274	12.0

Source: Department of Statistics, Amman

Historic Land Use Patterns

Land use patterns in Jordan over the last ten years show that 1.97 million dunums were cultivated with field crops, 3.6 million dunums with vegetables and 3.6 million dunums with fruit trees. About 96 percent of field crops, 35 percent of vegetables and 93 percent of fruit trees are grown in the rainfed areas. National rainfed land use patterns during 1980-1984 are provided in Table 2.10.

Table 2.10: Land Use Pattern of Rainfed Agricultural Holdings (000 du)

Land Use	1980	1981	1982	1983	1984
Field crops	1981	1650	1692	1662	1306
Vegetables	133	158	154	139	106
Fruit trees	316	327	339	395	343
TOTAL	2430	2135	2185	2196	1755
Fallow	532	808	791	707	1137
Unused	369	518	501	277	331
Uncultivable	301	177	160	113	73
TOTAL	3632	3638	3637	3293	3296

Source: Jordan. Department of Statistics.

C. Rainfed Cereal Economics in Jordan

Wheat Production in Jordan

The average area (1960-1984) cultivated with wheat each year is estimated at 1.64 million dunums (see Table 2.11), with a maximum of 2.3 million dunums and a minimum of 500,000 dunums (degree of variability of about 30 percent). Over the past two decades, the average area cultivated shows a negative and significant trend countrywide and by province, except perhaps for Ma'an (ACSAD, 1985). In fact, the trend shows that the area cultivated with wheat over the last 20 years has declined by about 5,000 dunums per year. At the governorate level, wheat cultivation areas have declined more rapidly in Irbid and Amman than in the other governorates.

Table 2.11: Wheat and Barley: Variability of Production and Area Cultivated in Jordan (1960 - 1984)

Crop	Production Average (tons)	Production C.V.	Area Cultivated Average (du)	Area Cultivated C.V.
Wheat	87,000	66%	1,640,000	31%
Barley	15,000	82%	298,840	25%

Source: raw data from Department of Statistics. Calculations by author.

Average wheat production duirng the same period registered about 87,000 tons, with a high coefficient of variability (about 66 percent). The maximum wheat production recorded was in 1965, a total of about 225,000 tons, and the lowest level was 16,401 tons, in 1979. In spite of this negative trend, wheat production could be described as stagnant (fig. 2.2 and Table 4, Appendix). The average wheat yield over the same period was about 53 kg/du, with a coefficient of variation of 47 percent. Yield data show no sign of trend, either positive or negative, at the national or provincial level.

Wheat production can be classified into three different regions. The first region includes Balqa and Irbid, where the highest average wheat yield for 1960-1984 was recorded: 73 kg/du in the Governorate of Balqa and 60 kg/du in Irbid Governorate. The second region consists of Amman, with average yields of 58 kg/du. The third region consists of Karak and

Ma'an with an average yield of about 47 kg/du. Coefficient of variation shows that Ma'an and Karak have the highest wheat yield variations, which are statistically significant.

Barley Production in Jordan

Barley is the second most important cereal grown in Jordan. During the period 1960-1984 (see Table 2.11), the average area cultivated was about 300,000 dunums (the highest average of about 320,000 dunums was recorded in 1962 and the lowest average 220,080 dunums in 1984). During the past 20 years, the barley cultivated areas have been less variable than the wheat cultivated areas. Irbid and Amman have traditionally been the main barley producing areas, averaging about 200,000 and 160,000 dunums, respectively, over the last 20 years, followed by Karak with about 110,000 dunums, and by Ma'an and Balqa with about 30,000 to 40,000 dunums each. The 20-year average is about 15,000 tons with a high degree of variation (coefficient of variation = 82%). The maximum production was recorded in 1969, about 188,000 tons, and the lowest in 1982, about 6,700 tons. However, there is a significant downward trend, showing that barley cultivation in the country as a whole has been decreasing by a yearly average of about 10,000 dunums. This negative trend has also been recorded at the governorate level, particularly in Irbid, Amman and Karak. In Balqa, the negative trend is not statistically significant.

Barley yields in Jordan are among the lowest in the region; the average for the years 1960-1984 was about 700 kg/ha. Despite the decline in the area cultivated during that same period, there was no significant trend in barley yield. The stagnant yields have been experienced in all governorates, without exception. No governorate showed any trend in barley improvement or deterioration over the last 20 years.

Balqa and Ma'an have the highest average yields, about 75 kg/ha and 57.5 kg/ha, respectively, followed by Irbid and Amman, with yields slightly above average, and Karak, with the lowest yields. Analysis of variance supports the hypothesis that there are significant differences between the average barley yields among the three regions. Within the second group, Irbid and Amman, the difference in barley yields was not significant.

Factors Affecting Cereal Production in Jordan

The most important factor affecting wheat production is rainfall -- in terms of absolute amount, timeliness and overall distribution during critical wheat growing periods. El Sherbini (1979) showed that when wheat yield was regressed on the average annual rainfall, the regression equation explained only 22 percent of the variation in the yield. The standard error of the estimated parameter was relatively high indicating the imprecision of the parameters estimated.

To further explore the yield/rainfall relationship, a regression analysis is used whereby the dependent variables are wheat and barley, respectively. The concommitant variables or regressors are the monthly average rainfall (that is, the monthly rainfall from November to April). Time-series data for wheat and barley yields and for the monthly rainfalls for 1962-1984 in the study area are used.

Regression equations which best explain wheat and barley yield variability were selected using Mallows (1973) C_p statistics.' The results show that the best fit is obtained when yields for both wheat and barley are regressed on all six months' average rainfall.

Rainfall in December, January and February seem to be the most important in explaining wheat/yield variability. Table 2.12 shows that the monthly rainfalls of November, March and April do not contribute much to explaining yield variability. The same regression analysis shows that in the best regressions, December, January and February average rainfall are the most important in explaining barley/yield variability (see Table 2.13).

Table 2.12: Regression Analysis for Wheat vs. Monthly Rainfall Best Regression Equations

Number of Regressors[a]	Monthly Rainfall	Theoretical C_p	Calculated C_p	R^2	F	D.W.
4	Dec., Jan. Feb.	4	3.71	0.559	7.181	1.537
5	Nov., Dec. Jan., Feb.	5	5.19	0.573	5.358	1.647
6	Dec., Jan. Feb., Mar., Apr.	6	5.91	0.607	4.626	1.460
7	All	7	7	0.631	3.981	1.614

[a]Including intercept. R^2 in all regressions did not show any significant change.
[b]All six months average rainfall (November - April).

The analysis shows that rainfall variations during November/December and March/April could best explain yield variations. The absolute effect on wheat yields of the November/December rainfall was, however, less than that of the March/April rainfall.

Poor rainfall intensity in the early part of the agricultural year is often used as an indicator of whether or not to sow. Early sowing is considered important to increase average wheat yields. Results of a study by Duwayri (1979), in a number of experiments conducted over the 1974-1979 period at different locations in Jordan, show that early sowing was more often associated with higher wheat yields than late sowing. These results apply to all seed varieties.

Table 2.13: Regression Analysis for Barley Yield vs. Montnly Rainfall Best Regression Equations

Number of Regressors[1]	Monthly Rainfall	Theoretical C_p	Calculated C_p	R^2	F	D.W.
4	Dec., Jan., Apr.	4	4.41	0.595	8.334	1.759
5	Dec., Jan. Feb., Mar.	5	4.62	0.637	7.012	1.820
6	Nov., Dec., Jan. Feb. Apr.	6	5.53	0.662	5.878	1.829
7	All[2]	7	7	0.674	4.836	1.801

[1]Including intercept. R^2 in all regressions did not show any significant change.
[2]All six months average rainfall (November - April).

The factors affecting barley production are generally the same as those affecting wheat. An important factor adversely affecting barley production is the pricing policy, which favors other cereals and legumes. Based on data collected in the 1985/1986 survey (IFAD, 1986), most farmers felt that the price of barley was not sufficient to cover all production factors. Farmers found it more remunerative to cultivate wheat in barley areas in spite of mediocre wheat yields.

D. Agricultural Practices

Labor-Intensive Practices

Tillage. Jordanian small farmers normally in dryland farming carry out as few tillage operations as possible for cereal production. No tilling operation takes place prior to sowing, and after sowing only one shallow tillage is performed, mostly using disc ploughs after sowing to cover the seeds on the soil surface. Seedbed preparation is rare; Duwayri (1985) found that 99 percent of farmers in the study area do not till their land prior to seeding.

A number of surveys have been carried out on tillage. Snobar (1984) and IFAD (1986) show that between 90 and 98 percent of farmers in the study area use mechanical power to till the land with either disc ploughs or mold-board ploughs. Wooden ploughs and draught animals are used in stony and/or steep fields (El Hurani, 1975).

Seeds. Basically farmers use two local varieties of durum wheat, Horani Nawawi and F8. High-yielding varieties are not used by farmers in dryland areas. Although seed cleaning and chemical treatment of the local variety is widespread, in fact, more than 65 percent of farmers clean their seeds at home. The widespread adoption of seed-cleaning practices is due to the belief that a cereal crop clean of weed seeds brings a price as much as 20 percent higher than the price of wheat sold with impurities (El Hurani, 1975).

seeding is carried out by the farmers themselves. Small farmers in Jordan still use the traditional method of broadcasting seed, covered with soil by shallow tilling. In the study area, 98.5 percent of small farmers still practice seed broadcasting (Snobar, 1984).

Chemical Fertilizers. It is estimated that less than 5 percent of the total wheat acreage in dryland areas is chemically fertilized (AOAD, 1978). Out of 48,563 dunums (belonging to 212 farmers surveyed) in the study area, fertilizers were used on less than 48 percent. The average expenditure per dunum is about 0.400 JD, which represents less than 30 percent of the recommended dose (IFAD, 1986).

El Hurani (1975) showed that there was a correlation between precipitation and chemical fertilizer use. He also found that 20 percent of farmers use organic fertilizer, stemming from the belief that organic fertilizer maintains soil fertility for a longer period (from 5 to 8 years).

Chemical Weed Control. In spite of the general awareness among farmers in the study area of the harmful effects of weeds, use of chemical weed control is rarely used by small farmers. Most farmers conduct one tilling after the rain falls, so as to seed and kill weeds at the same time. About 83 percent of these farmers have never used any type of chemical weed control. Hand weeding is carried out by family labor and some of the weeds are given to domestic animals as fodder (Mazur, 1979; Duwayri, 1985).

Traditional (Weedy) Fallow. Continuous wheat cropping in Jordan dryland areas is almost nonexistent because small farmers have learned from experience that this practice may lead to disease build-up and to yield deterioration. A rest phase, known as bour or fallow, has been introduced into the crop sequence. Three crops are grown in rotation with fallow in the study area: wheat, lentils and barley. The crop rotations primarily include wheat/fallow, wheat/lentil/fallow, barley/fallow and barley/lentils/fallow. The land that is fallow may be left to grow volunteer weeds. The period of fallow is about 18 months. According to official statistics, the national average of fallow (1980-1985) as a percentage of area cropped with field crops is about 32 percent, fluctuating between a low of 24 percent and a high of 42 percent. The crop rotations practiced by farmers in the study area are summarized in Table 2.14.

Table 2.14: Common Crop Rotations in the Study Area

Rotation	% of Farmers
Wheat/lentils	26
Wheat/fallow/lentils	7
Wheat/fallow	30
Wheat/fallow/barley	20
Barley/fallow	9
Wheat/lentils/barley	8

Source: Zahlan (1985) and El Hurani (1975)

Traditional fallow is synonomous with volunteer weedy fallow, as opposed to clean summer fallow or improved weedy fallow, which involves medics. Most research in Jordan concerning fallow has concentrated on "clean fallow," which as opposed to traditional fallow, involves proper tilling with better mechanized weed control during the fallow year. through the use of clean fallow, it is hoped that 30-50 percent of the rainfall during the idle season will be conserved and thus available for the next season's crop. If moisture is lost through faulty fallow practices or weed growth the benefit of clean summer fallow is lost.

El Hurani (1980) speculated that the primary reason for traditional fallow is that most small farmers do not have the financial capacity to cultivate the entire land holding.

The research carried out in Jordan under the USAID-sponsored Wheat Research Project (1976) demonstrates that farmers would likely fail to recover clean fallow technology adoption costs. In Amman and Karak farmers would incur losses in one out of every four years, while in the study area the incidence of loss appears to be one of every two years. Results suggest that clean fallow may have contributed to an increase in yield of between 40 and 60 percent. However, the shortcomings of the economic analysis of labor-intensive versus capital intensive practices (involving clean fallow) are the following:

- experimental plots under clean fallow were managed by experienced and well qualified staff, while the control plot (the adjacent farmer yield) was operated by individual farmers. Thus the increased yields could not be attributed to the package alone, but also to better management which suggests that the gains in yields due to clean fallowing are likely to be overestimated.

- size of the experimental farm was larger than the average size in the study area. If small holdings were used instead, the production cost per dunum of adopting the technology is likely to be higher. Furthermore, family labor, which plays an essential part in small-scale farming, was completely ignored;
- value of weeds in the traditional weedy fallow crop rotation was assumed to be equal to zero; and
- farmers' attitude towards risk was not considered, or more accurately, farmers in the study area were ipso facto assumed to be risk neutral.

Economic Value of Traditional Fallow. No research has been carried out to date in Jordan to estimate the opportunity cost, if any, of "fallowing." Weeds compete with crops for moisture and soil nutrients, but at the same time provide green pasture for livestock during the most critical period of the year. Clean fallow involves tillage and opportunity costs, the latter involves alternative grazing grounds, purchase of feed or reduction in the number of animals.

Mann's (1980) research results in Turkey show that the crude protein content of volunteer weeds grown during fallow was equivalent to about 60 percent of barley protein content. He also found that the expected increase in yield resulting from clean fallow does not provide sufficient incentive for farmers to forgo the grazing value of weeds in order to adopt clean fallow. This suggests, in the context of Turkey, that unimproved traditional weedy fallow is economically more viable than clean summer fallow.

Capital-Intensive Practices and Production Cost

The capital-intensive agricultural practices recommended to small farmers by the government owned agricultural machinery station in the study area involve a number of operations, applying both to wheat and barley (Table 2.15).

Table 2.15: Operations and Cost/Dunum of Capital-Intensive Agricultural Practices

Operation	Cost JD/du
2 shallow tillings	0.80
Seed cleaning and chemical treatment	0.25
Fertilizers (10 kgs per dunum mecaphos)	1.05
Seed drilling	0.50
Weed control (herbicides)	0.50
Combine harvesting	1.50
Bags, sewing & transport	0.96
Seeds 10 kg/dunum	1.10
Total cost of production	6.66

Source: Zahlan, 1985.

Evidence (Snobar, 1984; IFAD, 1986; AOAD, 1978) suggests that small subsistence farmers in the study area still rely on family labor for crop production. Because of limited access to credit and lack of job opportunities elsewhere (Seccombe, 1981), in addition to uncertainties associated with the capital-intensive practices (see next section), small farmers resort to cost minimizing techniques which imply full utilization of family labor and no use of fertilizers or chemical weed control and minimum tillage. For example, the total variable cost of production per dunum for wheat under traditional labor-intensive practices is estimated at JD 2.86. The amount of family labor for each dunum of wheat is about 2.05 man days (Ministry of Agriculture, 1975). The additional per-dunum cost associated with fertilizer application is JD 1.05; for chemical weed control it is JD 0.50; and for combine harvesting it is JD 1.50. (See Appendix for detailed crop budgets.)

Capital-intensive practices are of particular importance to large-scale farmers because family labor is insufficient to handle large farming operations, and supervision of the farming activities and labor costs can be extremely high. The extent of land fragmentation on large farms is also less acute as compared to small holdings (Shafii, 1985) (see Table 2.16). Finally, most large farmers have better access to institutional or commercial credit (NENARACA, 1985).

Table 2.16: Land Fragmentation in the Rainfed Areas

Land Holding	Average Holding Area (du)	Degree of Absolute Fragmentation
Less than 5	2.2	1.12[1]
5 - 10	4.8	1.56
10 - 20	8.8	1.70
20 - 30	12.6	1.98
30 - 40	16.2	2.16
40 - 50	17.8	2.53
50 - 60	26.1	2.87
100 - 200	45.2	3.32
200 - 500	84.7	4.13
500 - 1,000	127.6	5.88
1,000 - 2,111	363.0	4.13
2,111 - 5,000	992.0	3.53
5,000 - 10,000	1546.0	4.85
Greater than 10,000	5521.0	3.17

Source: Shafii, 1985.

[1] number of parcels per holding.

Input-Output Relationships

In this section we will examine the relationships between input and output for both labor- and capital-intensive practices, with the assumption that yields are increased by 30 to 70 percent under the latter.

Table 2.17 shows that the benefit/cost ratio is sensitive to the probability of occurrence of a bad year. In fact, if the capital-intensive practices guarantee an increase in yield equivalent to 30 percent of the observed yield and if the probability of occurrence (of a bad year) is greater than 0.3, adoption of capital-intensive practices by farmers is doubtful. However, if the probability of occurrence of a bad year is less than 0.3, farmers may adopt those practices.

Table 2.17: Benefit/Cost Ratio for Capital-Intensive vs. Labor-Intensive Agricultural Practices for Wheat

	Poor Year 1984	Good Year 1983	Average Year 1975 - 1985
Labor-Intensive Practices			
Yield (kg/du)	45.76	121.51	74.59
Price (JD/ton)	115.00	146.94	110.30
Total Variable Cost (JD/du)	3.91	3.91	3.91
Value of Weedy Fallow (JD/du)[a]	1.00	1.00	1.00
Gross margin (JD/du)	2.35	14.94	5.32
Capital-Intensive Practices			
Yield (30%)[b]	59.49	157.96	96.97
Yield (70%)[c]	77.79	206.57	126.80
Price	115.00	146.94	146.94
Total Variable Cost	6.66	6.66	6.66
Gross margin (30%)	0.18	16.55	7.59
Gross margin (70%)	2.29	23.69	11.97
Benefit/cost (30%)	0.08	1.11	1.43
Benefit/cost (70%)	0.97	1.59	2.25

[a] This is set arbitrarily equal to JD 1.00/dunum
[b] Assumed to provide an additional 30% over the yields obtained under labor-intensive practices.
[c] Assumed to provide an additional 70% over the yields obtained under labor-intensive practices.

E. Yield Response to Capital-Intensive Practices

A considerable number of wheat demonstrations were carried out by the Ministry of Agriculture experimental station during 1968-1973. The objective of these demonstrations was to investigate yield response to capital-intensive agricultural practices. The increase in wheat yields achieved over this period, in different parts of the country, ranged from 29 percent to 77 percent. The capital-intensive practices did considerably better in areas with higher rainfall. In Balqa, for example, yield response increased by an average of 77 percent. In the poor rainfall areas, such as Ma'an, the increase in yield did not exceed 29 percent. In the study area, the yield increased by about 50 percent. The results nationwide are presented in Table 2.18.

Table 2.18: Average Yield Achieved in Demonstration Plots Using Capital-Intensive Practices Including Clean Summer Fallow vs. Labor-Intensive Practice for All Rainfall Areas (250-400): Wheat

	Capital-Intensive Practices (kg/du)	Labor-Intensive Practices (kg/du)	Difference
1969	186	107	73%
1970	164	85	92%
1971	101	57	77%
1972	141	97	31%
1973	62	37	67%
1974	153	119	28%
Average	134	84	
S.D.	42	28	
C.V.	31	34	

Note: While average yield increased by 54 percent, the coefficient of variation in yield, with and without the capital-intensive practices, more or less remained the same, 31% vs 34% respectively.

Source: Ministry of Agriculture Research Department. Annual Report. (various issues)

The most important externally financed project which has been completed to date and that lasted a considerable period of time (1968-1974) was the joint USAID/Jordanian Government project. The goal of the project was to double wheat production by 1980. The major activities of the project were to conduct annual cropping and summer fallow demonstrations. These demonstrations took place on privately owned farms in order to attract farmers' attention and demonstrate the benefits of capital-intensive practices for increasing wheat yields.

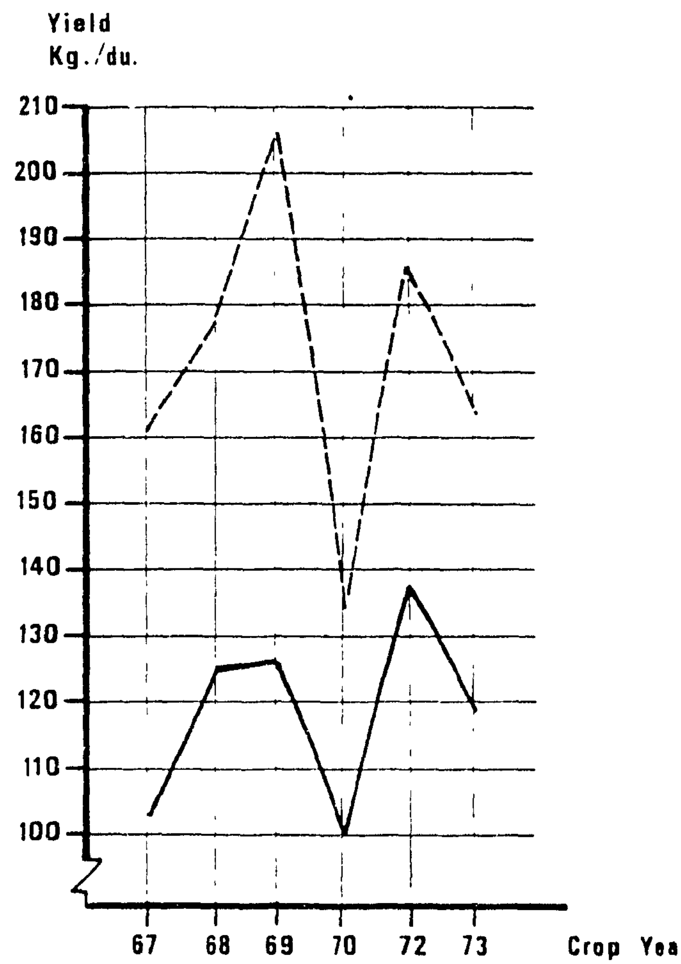
The technical package involved proper tillage, grain drills, chemical weed control and use of fertilizer. The average increase in wheat yield in the study area, as a result of adopting the technology discussed above, was about 50 percent, with a standard deviation of 22.5 kg, or 71% higher than the standard deviation of the yield resulting from the use of labor-intensive practices.

The capital-intensive techniques increased overall average yield as well as yield variability in all governorates (see Figures 2.4, 2.5 and 2.6). The coefficient of variation was on the same order of magnitude as that for official statistics on yields obtained in the study area.

Jordan's Potential in Wheat and Barley

Under an IFAD-sponsored program, the Arab Center for the Studies of Arid and Drylands (ACSAD) developed high-yielding, drought-resistant wheat and barley varieties for use in the rainfed areas of Jordan. During the period 1981-1984, ACSAD conducted a number of experiments in three governorates of Jordan (Irbid, Karak and Amman) using these varieties instead of the local wheat and barley varieties. These

FIGURE 2.4: WHEAT YIELD VARIABILITY, ANNUAL DEMONSTRATIONS IRBID GOVERNORATE, 1967 - 1973

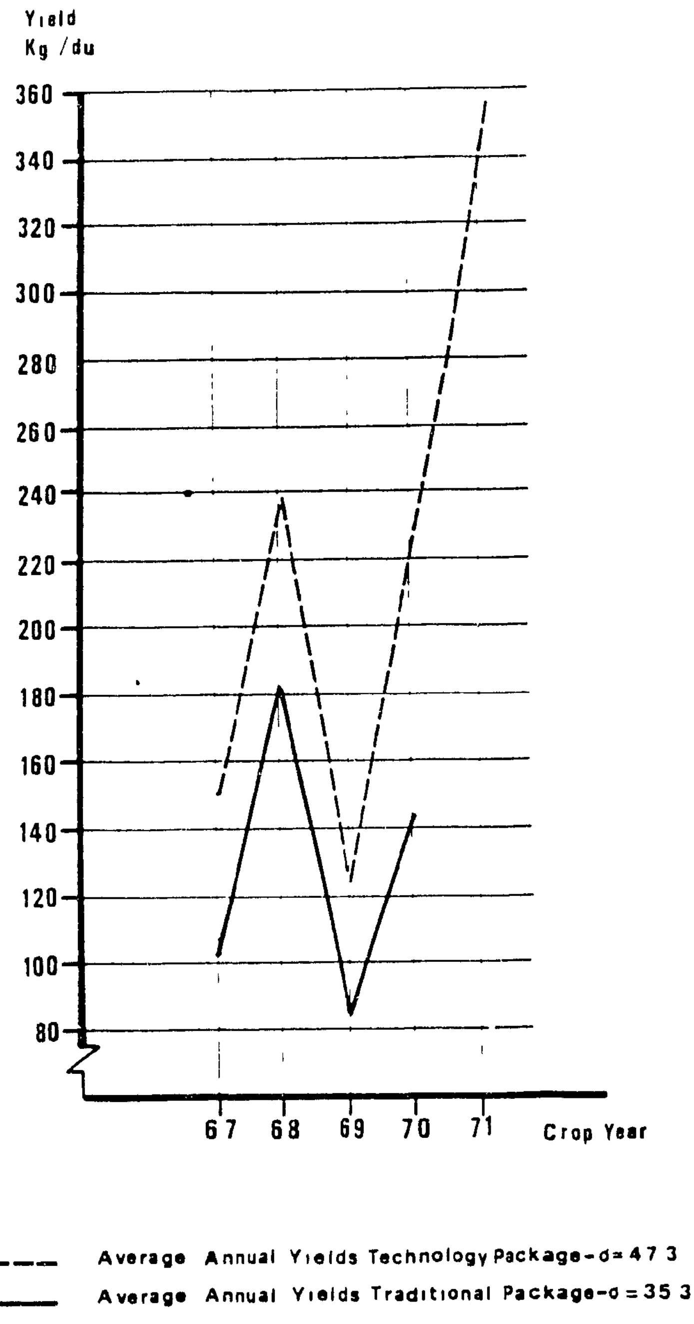


- - - - - - Average Annual Yields Technology Package – σ = 22.5

——— Average Annual Yields Traditional Package – σ = 13.1

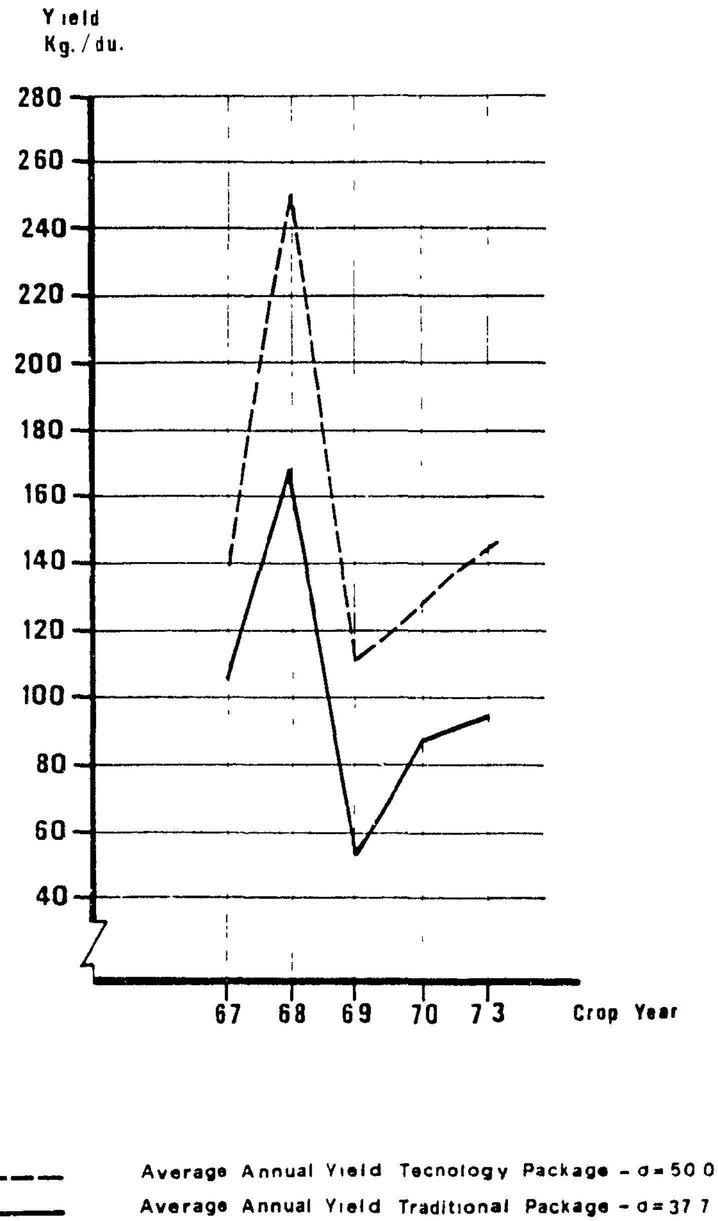
SOURCE JORDON Wheat Research Production Programme USAID Washington Dc 1976 Page 115

FIGURE 2.5: WHEAT YIELD VARIABILITY, ANNUAL DEMONSTRATIONS AMMAN GOVERNORATE, 1967 - 1973



SOURCE JORDAN Wheat Research Production Programme USAID Washington Dc 1976 Page

FIGURE 2.6: WHEAT YIELD VARIABILITY, ANNUAL DEMONSTRATIONS
KARAK GOVERNORATE, 1967 - 1973



SOURCE JORDAN Wheat Research Production Programme USAID Washington Dc 1976 Page experiments took into consideration all possible combinations of seeding rates, degrees of fertilization, number of rain days, etc.

The ACSAD wheat and barley varieties outperformed the local varieties. Using proper seedbed preparation techniques, adequate fertilizing at appropriate seeding rates, as well modern technology, the early results show the potential for increase of both wheat and barley production to be substantial.[1] A University of Jordan study conducted during the 1970s by Duwayri and others reached similar conclusions.

F. Incidence of Crop Losses in Jordan

There are few studies concerning crop losses in Jordan, most of which focus on post-harvest losses. Duwayri (1984) found that the most important source of post-harvest losses for wheat was harvesting procedures: mechanical harvesting accounted for about 25 percent of loss, while 15 percent was attributed to manual harvesting. Storage is the second most important source, with losses ranging from 4.5 percent in modern storage houses to 14 percent in ordinary storage houses. Transportation contributes about 0.5 percent to the total post-harvest losses.

Haddad (1981) found that for many vegetable crops harvesting practices, packing and transportation were responsible for 2 percent, 12 percent and 6 percent of losses, respectively. The conclusions of this study are shown below.

In a survey conducted by the author on behalf of IFAD involving small farmers in the study area, it was found that 80 percent of the farmers suffered from crop damages. The major cause of crop damage is drought; in fact, out of 165 respondents, 159 ranked drought as the main cause of crop loss. The remaining six farmers named frost, low prices, pests and floods as major causes of crop damage. In addition, the most frequent problems facing rainfed agriculture in the study area are lack of and/or inadequate distribution of rain during the growing season.

Table 2.19: Percentage of Crop Loss due to Harvesting and Threshing

	Wheat	Barley	Lentils
Harvested by hand & machine threshed	5.5	-	-
Combine harvesting	9.2-10.4	-	-
Traditional threshing	3.3	14	-
Traditional harvesting & threshing	-	28.5	18.6
Traditional harvesting	4.4	10	-
Mechanical harvesting	0.7-4.6	-	-
Traditional sowing & machine harvesting	12.5-16.5	-	-

Note: Crop loss is calculated as a percentage of yields in plots which were grain drilled and harvested with adjusted combine harvesters.

Source: N. Haddad (1981).

Wheat and Barley Losses

In the 1986 survey, farmers were asked to state damage as a percentage of the total variable cost of production. The following table summarizes the farmers' responses for the years 1984/85 and 1983/84.

Table 2.20: Percentage of Farmers Reporting Crop Damage

Damages as Percent of Total Variable Cost	Wheat 1984/85	Wheat 1983/84	Barley 1984/85	Barley 1983/84
No Loss	43	35	36	30
10%	6	7	2	4
20%	7	5	7	4
25%	7	4	4	4
30%	10	6	10	4
50%	13	17	17	9
100%	15	26	24	44

Source: IFAD Baseline Survey: Small Farmers Agricultural Credit Project, 1986

Farmers' Attitudes to Crop Insurance

The results of the survey (IFAD, 1986) conducted in the rainfed areas of Amman, Irbid and Karak show that of the farmers interviewed, 79 percent are in favor of a crop insurance scheme that would guarantee at least total variable production costs. Seventeen percent of the farmers were against any form of crop insurance, basically for religious reasons, and four percent expressed no opinion. Of the farmers who were in favor of crop insurance, 57 percent expressed interest in insurance against drought, while 42 percent preferred all-risk insurance including drought, pests and diseases, and hot winds (see Table 2.21).

Table 2.21: Farmers' Response to Crop Insurance Scheme

Region	No. Farmers	%	Favor No. Farmers	Favor %	Oppose No. Farmers	Oppose %	Undecided No. Farmers	Undecided %
Amman	75	36	69	92	3	4	3	4
Irbid	92	44	63	68	25	27	4	4
Karak	40	19	31	78	7	18	2	5
Total	207	100	163	79	35	17	9	4

Source: IFAD Baseline Survey: Small Farmers Agricultural Credit Project, 1986

Summary

This chapter reviews the agricultural sector in Jordan and the characteristics of dryland farming and cereal production as practiced by small farmers. Results of past agriculture research experiences were critically analyzed, specifically with relation to the agricultural practices and their effect on crop yields, farm income, and their variability. From this review while it appears that capital-intensive techniques have a potential to increase yields of crops studied, their variability remained the same or higher than that of traditional practices. Fallow as a crop seems to play an important role in explaining why small farmers have shown little interest in switching from traditional practices to capital-intensive practices.

In the next chapter, relevant literature pertaining to risk and uncertainty in agriculture will be critically reviewed.

Notes

[1] With the exception of the four main crops where Jordan is a net importer (potatoes, onions, cantaloupes, and apples). Total imports of these commodities average about 2,300, 1,300, 6,000, and 25,000 tons per year, respectively. Vegetable exports comprise about 60 percent of Jordan's total exports.

[2] Jordan Valley Authority statistics show that the average development cost per irrigated hectare for the latest Southern Ghors project is about US$ 12,000/hectare.

[3] According to the Land Reform Law of 1975, irrigated land in the Jordan Valley is distributed according to the following schedule.

Size of Holding (dunum)	Percent Distribution
26-40	87
41-70	11
71-100	2

[4] The number of regressions performed in each case is equal to $\sum_{i}^{7} \binom{7}{i}$ where $\binom{7}{i}$ represents (7!)/{i!(7-i)!}, and where 7 refers to number of regressors, including the intercept.

[5] "C_p defined as

$$C_p = \frac{(SSE)_p}{\hat{\sigma}^2} + (2p - n)$$

(SSE) is equal to the sum of the square of the residuals, p is the number of regressors, n the number of observations, and σ^2 is the variance of the error term. Where $\hat{\sigma}^2$ is an estimate of σ^2, and is usually obtained from the linear model with the full set of q variables. It can be shown that the expected value of C_p is p, when there is no bias in the fitted equation using p variables. Consequently, the deviation of C_p from p can be used as a measure of bias. The C_p statistic, therefore, measures the performance of the variables in terms of the standardized mean square error of prediction. It takes into account both the bias as well as the variance. Subsets of variables that produce values of C_p that are close to p are the desirable subsets. The selection of "good" subsets is done graphically. For the various subsets a graph of C_p is plotted against p. The line C_p=p is also drawn on the graph. Sets of variables corresponding to points close to the line C_p=p are the good or desirable subsets of variables to form an equation." (Daniel and Wood, 1971)

[6] ACSAD 59, ACSAD 65, ACSAD 67, AND ACSAD 71 for wheat, and ACSAD 60, ACSAD 68, AND ACSAD 76 for barley.

[7] Wheat varieties such as Hourani, F8, Deiralla, and barley varieties such as Deiralla 102 and Deiralla 106.

[8] If the farmers' adoption rate is assumed to be about 50 percent and if the effect of rain is eliminated, i.e., by choosing those years with similar rainfall intensity and distribution as 1981-1984, the potential yield increase is about 40 percent.

CHAPTER III: REVIEW OF THE LITERATURE: RISK AND UNCERTAINTY

A. Introduction

The beginning of the formal study of risk can be traced to Bernoulli (1954), who was puzzled by why people were not willing to put large amounts of money into a game with infinite mathematical expectation. This phenomenon is known to economists and statisticians as the St. Petersburg Paradox. According to Bernouli, a plausible solution to this apparent paradox is to suppose that people maximize expected utility and not expected monetary value. The importance of risk in economic decision-making was recognized by Marshall (1920), Walras (1926) and Knight (1957). Objective probability and subjective probability, in Knight's view, designate risk and uncertainty, respectively.[1]

Economic decision theory as a formal area in economic analysis owes a great deal to Morgenstern and Von Neumann's (1967) work on game theory and to Savage's (1962) contribution to decision theory. Von Neumann and Morgenstern (1947) demonstrated that maximization of expected utility as a rational decision-making criterion can be proved from simple postulates about choice, and that the utility function can be cardinally measurable up to a linear transformation. The utility function is assumed to be a function of random variables, whose expected value can be maximized subject to well-specified constraints. The decision-maker is classified according to the shape of his utility function -- as risk averse, risk prone or risk neutral; his behaviour can be explained by converting the risky decision problem into an optimization problem. An important extension of Von Neumann and Morgenstern's approach is the Baysian decision theory and its applications (Marschak, 1963; Zellner, 1971). In this approach the decision-maker's prior beliefs are combined with other relevant information to obtain posterior probabilities. The prior probabilities can be modified sequentially on the basis of new information.

Several other approaches of subjective or behavioural natures were developed and applied. Behavioural decision-making models are based on the concept of "bounded rationality," characterized by a continuous search for a satisfactory choice or alternative (Simon, 1973). The rules are often ad hoc, and risk is identified as the probability that the objective (which is considered a stochastic variable) does not fall below pre-set critical levels. There are several rules which are offshoots of the "bounded rationality" concept. These include the "safety-first" principle and its family members, the "strict safety first" and "safety fixed" principles (Charnes & Cooper, 1959; Roy, 1952).

The safety-first concept argues that the decision-makers' dependence on their external environment for survival dictates their relative preference for security over high average profits per se. In strict-safety first (or chance-constrained programming) profit is maximized subject to an exogenously predetermined disaster level and probability limit. In the safety-fixed or minimax rule, the minimum returns are maximized subject to fixed confidence levels.

In both the normative and subjective models of decision-making the risk concept of probability is used explicitly. Day (1965) introduced the principle of "cautious optimizing," which allows the decision-maker to optimize provided that his choices are limited to alternatives that are "in the neighbourhood" of the safety zone. The probability of a disaster is replaced by a "safety metric," on which the solution in the neighbourhood of the safety zone is based. Cautious optimizing is also a variety of Simon's bounded rationality concept.

Another concept, closely related to cautious optimizing, is the "focus loss" concept introduced by Shackle (1949). It involves the modification of a feasible region facing the enterprise to account for risk, a form of which was developed by Boussard and Petit (1967). This concept assumes that farmer's focus on a maximum permitted loss level. No single undertaking is allowed to contribute more than a certain proportion to the total permitted loss. Each undertaking adds to the allowed loss by increasing the total expected income.

B. Expected Utility and Risk Aversion

Utility analysis provides a system whereby consistent choices between risky alternatives are evaluated. The process involves choosing between a number of alternatives, the consequences of which are associated with probability distribution.

Utility analysis is based on Bernoulli's principle that the optimal behaviour of the decision-maker is the maximization of expected utility. Utility in this context is assumed as cardinally measurable. Von Neumann and Morgenstern (1947) showed that if a certain number of simple postulates (NM postulates) are satisfied, the utility is measurable up to a positive linear transformation. These postulates are: (a) complete ordering and transitivity; (b) continuity; and (c) independence. If these postulates are adopted by the decision-maker, a utility function exists, reflecting his preferred outcomes and personal judgement of the choices confronting him.

Bernoullian decision theory requires decision-makers to be utility maximizers. Assuming that the decision-maker's choices are consistent with the MV postulates, then for every alternative there exists a utility function associated with it. The value of this utility function designates the rank of the alternative choices.

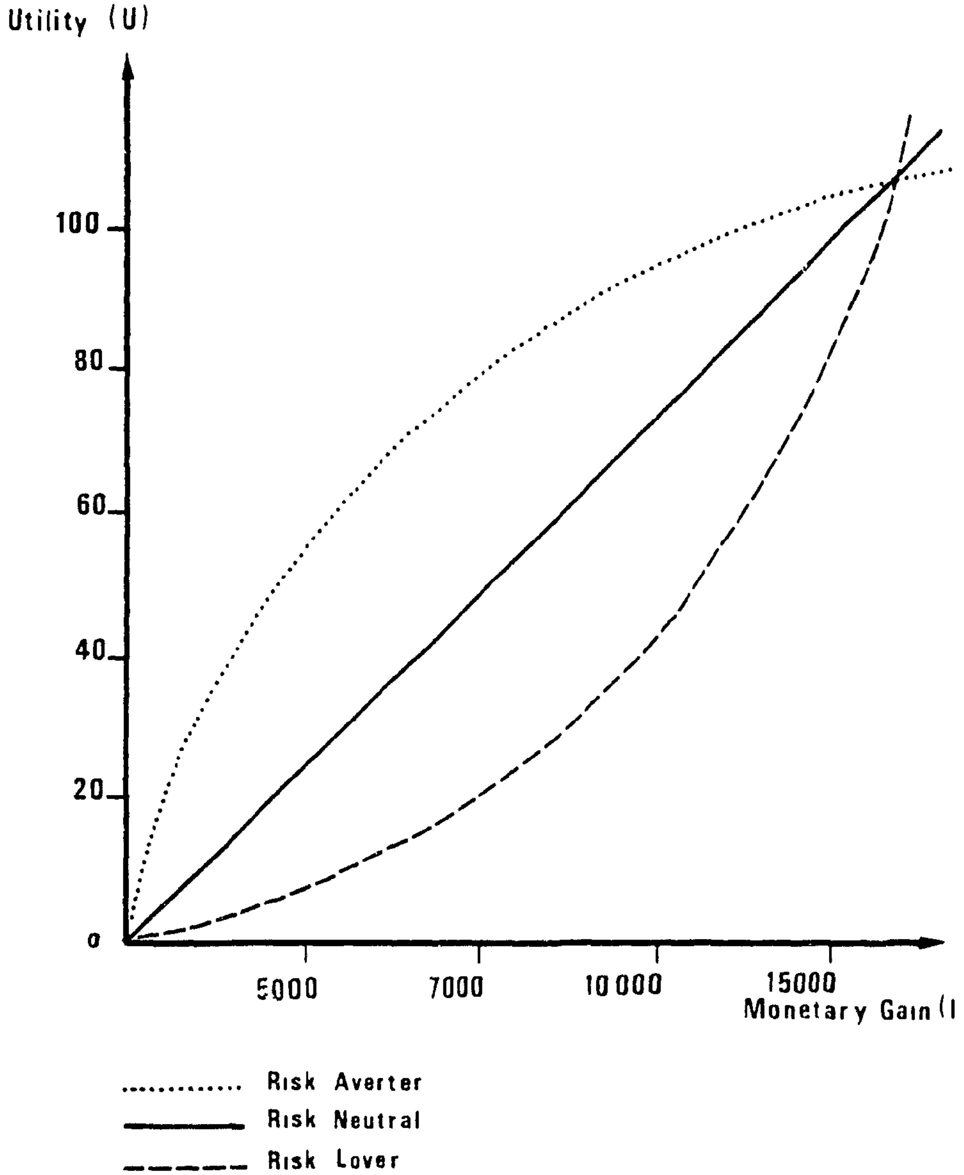
In cases where the utility function is monotonically increasing, i.e., the larger the monetary gains, the greater the utility. The marginal utility depends on the attitude of the decision-maker toward risk. Marginal utility decreases, remains constant, or increases if the decision-maker is risk-averse, risk-neutral or risk-prone, respectively (see Figure 3.1).

The expected utility model, commonly used as a decision-making tool, is based on mean-variance analysis. The mean-variance analysis implies a quadratic utility function in income. The quadratic utility function exhibits increasing absolute risk aversion and has a maximum value beyond which the marginal utility of income declines. Pratt (1964) has rejected the mean-variance hypothesis as "untenable."

Although decreasing marginal utility is sufficient to define risk-averse behaviour, the magnitude of $\partial U/\partial W$ (with W equal to wealth) is insufficient to assess the degree of risk aversion (Arrow,

fig:3.1

choice involving risk



1971; Pratt, 1964). A satisfactory measure of risk aversion, according to Arrow/Pratt, should be unaffected by positive linear transformation of utility function. This led Arrow/Pratt to suggest the absolute risk-aversion (ARA) measure which is a non-increasing function of wealth. Arrow also proposed an index to measure relative risk aversion (RRA), a non-decreasing function of wealth.

An alternative to increasing absolute risk aversion. proposed by Freund (1956), is a utility function with constant absolute risk aversion. This function was rejected as untenable by Arrow (1964), and Friedman and Savage (1948). Turvey et al. (1986), however, argues that constant risk aversion is tenable in farming businesses since:

> most farmers will make decisions as to their farm plan in the spring. Without temporal interference, and assuming that decisions made between periods are independent of one another, the farmer's attitude toward risk will be characterized by a single value which remains constant at least until the next year.

Expected Utility Model with Yield and Price Uncertainties

The application of expected utility with yield and price uncertainties involves three groups of variables. The first group, assumed to be under the control of the farmer at the time of his decision, include the use of fertilizer, machinery, labor, land, herbicides, insecticides and crop varieties. The second group involves pre-determined variables which, although not controllable are known to the farmers, such as soil fertility, moisture, elevation, slope, etc. The third group of variables are neither controllable nor known to the farmer at the time of his decision, and include output, prices, rainfall, temperature, wind, etc.

It is assumed that a yield-response function expressed as a function of a set of variables is:

$$Y = f\ (X,\ Z,\ S) \tag{3.1}$$

where Y is the crop yield; X is a vector of controlled inputs; Z is a vector of uncontrolled but predetermined variables; and S is a vector of uncontrolled and unknown variables.

Output and input prices vary over time as, in general, farmers are price takers, however, we can assume that only output prices change, due to the time lag between planting and harvesting seasons. The prices of inputs are assumed to be known with certainty. Risk associated with output prices is, therefore, related to supply/price correlation, as the demand for many crops is highly price inelastic. Thus, when substantial shifts in supply occur combined with inelastic demand, price fluctuations are likely to be very great.

If $\bar{P}$ is the price of the output Y, and P_i is the price of the input X_i, the gross-revenue equation is as follows:

$$R = \bar{P} \cdot Y - \sum_{i=1}^{n} x_i P_i \tag{3.2}$$

Let us assume that the probability distribution of R is g(R), which can be expressed as follows:

$$g(R) = g\ \{\bar{P} \cdot f\ (X,\ Z,\ S)\ -\ \Sigma(PX)\} \tag{3.3}$$

As PX is given for any X, the distribution of g(R) will have the same shape as $g(\bar{P} \cdot Y)$. The expected utility relation is:

$$E(U) = h\ \{E(R),\ V(R)\} \tag{3.4}$$

It follows that

$$d(U)/dx_1 = \delta E(U)/\delta E(R) \; . \; dE(R)/dx_i + \delta E(U)/\delta V(R) \; . \; dV(R)/dx_1 \quad (3.5)$$

By equating to zero the first-order condition gives:

$$\{dE(R)/dx_1\}/\{dV(R)/dx_1\} = - \{\delta E(U)/\delta V(R)\}/\{dE(U)/dE(R)\} \quad (3.6)$$

or

$$dE(R)/dV(R) = - \{\delta E(U)/\delta V(R)\}/\{\delta E(U)/\delta E(R)\} \quad (3.7)$$

The expression on RHS of equation (4.7) is the slope of the iso-utility curve in the E-V plane, and the expression of LHS is the rate of substitution betwen E(R) and V(R).

Figure 3.2 shows two levels of the expected-utility curves: U_1 expresses a higher level of utility for all combinations of E(R) and V(R) which lie on their curve as compared to U_2, that is, an equal level of E(R) on both curves is associated with lower risk for U_1 than for U_2. Similarly, an equal level for V(R) for both curves is associated with higher E(R) for U_1 than for U_2.

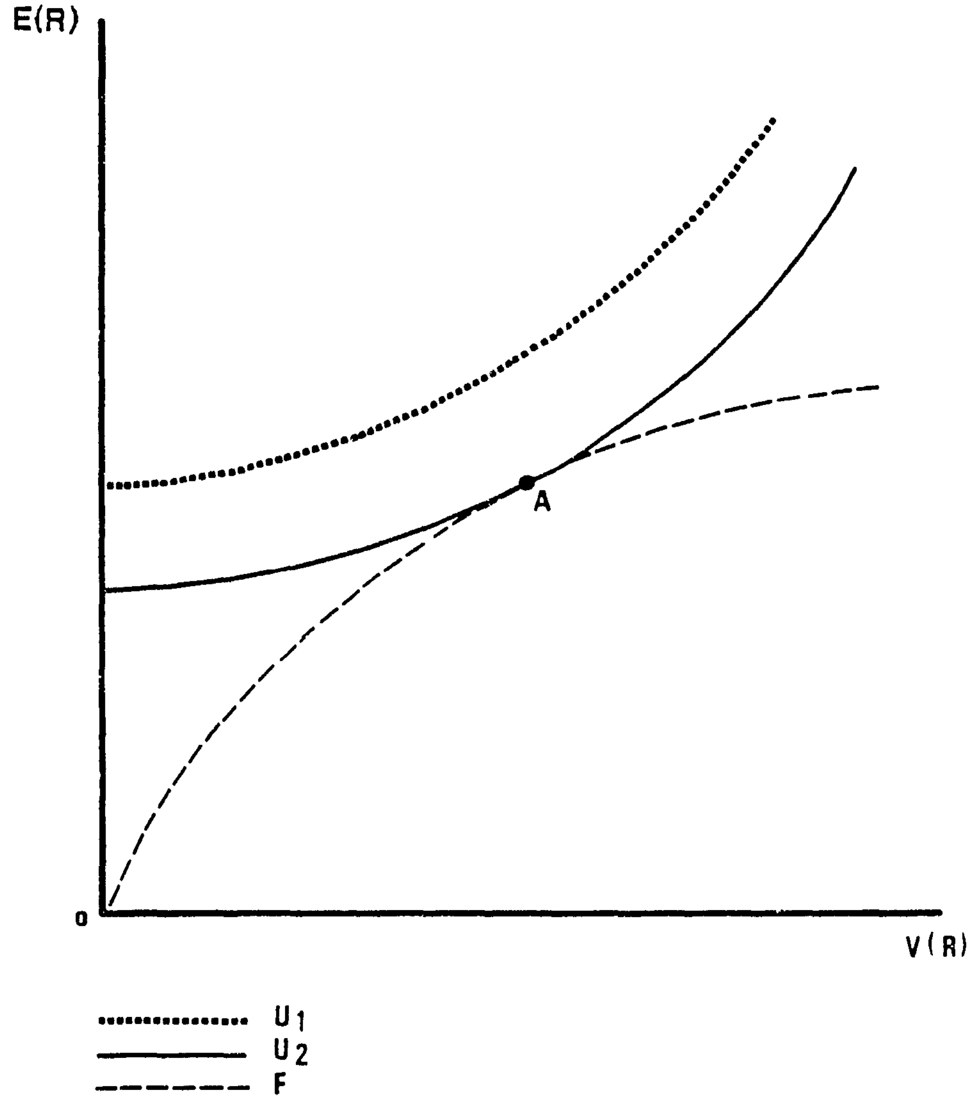
F is the mean-variance frontier of yield-response possibilities of each point on the curve, and reflects an efficient alternative combination of decision variables. Each combination portrays a certain level of risk associated with a particular expected level of monetary gain (R). The maximum utility is obtained at point A.

The relationship between marginal revenue and marginal cost can be derived as follows (Anderson, 1977):

$$E(R) = E(P)E(Y) - \Sigma P_1 x_1 \quad (3.8)$$

$$V(R) = \{E(P)\}^2 V(Y) + \{E(Y)\}^2 V(Y) + V(P)V(Y) \quad (3.9)$$

fig:3.2
choice involving risk
solution to equation (7)



Differentiating E(R) and V(R) with respect to x_i results in

$$\frac{dE(R)}{dx_i} = \frac{E(\bar{P})dE(Y)}{dx_i} \tag{3.10}$$

$$\frac{dV(R)}{dx_i} = \{(E(\bar{P}))^2+V(\bar{P}))\}.\left[\frac{dV(Y)}{dx_i}\right] + wV(\bar{P})E(Y) .\left[\frac{(dE(Y)}{dx_i}\right] \tag{3.11}$$

Substituting $dE(R)/dx_i$ of equation (10) into equation (7) yields

$$E(\bar{P})\cdot(dE(Y)/dx_i) = P_i + RSUEV\ (dV(R)/dx_i) \tag{3.12}$$

The LHS of equation (12) represents the expected value of the marginal product per unit of x_i (marginal revenue). The RHS consists of the marginal cost per unit of x_i, P_i at equilibrium, plus the marginal cost of risk per unit of x_i as a result of the variance of R. Equation (12) can be expressed, alternatively, as (Magnusson, 1969, and Anderson et al., 1977):

$$E(MVP_i) = MFC_i + R_a I_r \qquad i = 1, 2, \ldots n \tag{3.13}$$

where $E(MVP_i)$ is the expected marginal value product of input x_i, MFC_i is a non-stostastic margin factor cost of input x_i, and $R_a I_r$ is a "risk adjustment factor." R_a is the farmer's risk-aversion coefficient and I_r is the marginal contribution to risk of additional input use. If $R_a = 0$ the farmer is risk-neutral, if $R_a < 0$, the farmer is a risk-taker. If I_r is assumed positive, then with $R_a > 0$ and $E(MVP_i) > MFC_i$ the risk-averse farmer will tend to use fewer inputs, x_i.

Risk Aversion and Resource Allocation

In the previous section the discussion focussed on the effects of uncertainty on the level of input demand. In this section the effects of uncertainty on the cost structure are discussed for a single output case. For a discussion of the multi-input models see Nelson (1987).

It is assumed at the outset that uncertainty affects the output price only and that the decision maker exhibits constant absolute risk aversion. In addition, the decision maker is assumed to be a price taker, in that he maximizes expected utility of profit, and the marginal cost is a monotonic increasing function of output. The expected utility[3] of income takes the form:

$$E\{U(I)\} = E(I) - \frac{1}{2} \cdot R_a \, VR(I) \qquad (3.14)$$

where E(I) = expected profit; VR(I) = profit variance; and R_a = a measure of absolute risk aversion parameter, $R_a \geq 0$.

The expression for profit can be written as follows:

$$I = (e + P)Y - C(Y) - FC \qquad (3.15)$$

where Y is the output (non-stochastic), C(Y) is the total variable cost of production, FC denotes the fixed costs, and e is a random variable with mean zero and a variance of VR(e).

From equation (3.15) it follows that:

$$VR(I) = Y^2 \, . \, VR(e) \qquad (3.16)$$

$$E(I) = PY - C(Y) \qquad (3.17)$$

Substituting equations (3.16) and (3.17) in equation (3.14) and differentiating with respect to Y, the first-order condition for maximizing expected utility gives:

$$P = \text{marginal cost} + (R_a/2) \cdot Y \cdot VR(e) \qquad (3.18)$$

The expression of RHS in equation (3.18) is also known as certainty equivalent. The term $(R_a/2) \cdot Y \cdot VR(e)$ is the risk premium. The relationship between Y and R is such that as R increases Y increases.

C. Measurement of Risk-Aversion Parameter

Various methods for estimating the risk-aversion parameter (RAP) have been proposed in the literature. Young et al. (1979) distinguishes three main procedures:

a) Direct elicitation of utility function is based on interviews with farmers. These interviews are designed to determine points of indifference between "certain" outcomes and risky alternatives involving hypothetical gains and losses. The data gathered from these interviews are analyzed and a utility curve is fitted to them.

b) Observed behaviour techniques concentrate on collecting information related to the economic behaviour of the decision-maker with respect to input demand and output supply. The results are then compared to behaviour predicted by theoretical models of profit maximization under uncertainty.

c) Experimental technique draws upon psychological research for measuring risk preferences of farmers by using actual financial compensation at different levels over a series of several visits to the farmers. The farmer is expected to select certain alternatives from a number of suggested gambles, with the outcome determined by a flip of a coin.

One variant of the observed-behaviour method relies on the generalized power-production function (Moscardi and Janvry, 1977). The first-order condition with respect to input demand is derived from a safety-first model to arrive at:

$$MVP_i = P_i/(1-aR_a) \qquad (3.19)$$

where MVP_i is the marginal value product for input x_i and P_i is the price for input x_i; a is the coefficient of variation of yield, and R_a is the risk-aversion parameter (RAP). Another variant relies on varying the risk-aversion coefficient parametrically, and the value that minimizes the difference between observed and predicted behaviour is selected as representing the farmer's preferences.

Empirical Evidence

Empirical studies based on normative and behavioural models were mostly carried out in developing countries, and provide empirical evidence about the attitude of agricultural producers vis-à-vis risk. In these empirical studies the three techniques discussed above are used. Table 3.1 summarizes some of the empirical studies. It appears that, with the exception of those in Roumasset's work, most farmers in developing countries are risk-averse.

Table 3.1: Summary of Empirical Studies

Author	Year	Country	Model/Technique	Major Conclusion
Scandizzo & Dillon	1978	Brazil	EU/UE	Majority of farmers are risk averse.
Binswanger	1980/ 1983	India	EU/ET & EU	More than 80% of sample sample are risk averse.
Roumasset	1976	Philippines	LSF/OB	Inconclusive
Moscardi	1979	Mexico	SF/OB	100% risk averse

EU: Expected-utility models
ET: Experimental technique
OB: Observed behaviour
UE: Utility-elicitation technique
LSF: Lexicographic safety first
SF: Safety first

Whole-Farm Planning Models

Several mathematical programming models have been utilized to elaborate whole-farm planning as an aid for farmers in decision- making. These whole-farm planning tools include linear programming, quadratic programming and linear-risk programming. A brief summary of these models follows.

Linear Programming. Linear programming (LP) has been the most widely used technique for farm planning. The LP maximization model could be expressed as follows:

$$
\begin{array}{ll}
\text{Maximize:} & Z = CX \\
\text{Subject to:} & AX \leq B \\
\text{and: } x_j \geq 0: & (i = 1,2,\ldots m,\ j = 1,2,\ldots,n)
\end{array}
$$

where Z is net farm income, C is a row vector of the per-unit net return of the n enterprises, and X is a column vector of the n enterprises. A is a (m x n) matrix of the amount of resources required for a unit of jth enterprises and B is a column vector whose elements are the resources available.

LP as a farm-planning tool has been subject to certain criticisms. It assumes that all parameters in A, B and C are known with certainty, however, risk could also be incorporated in the element of A matrix following Wicks and Guise (1968). The optimal plan resulting from LP may have a rather large variance of net farm income. LP operates with the tacit assumption of profit maximization in which $EU(I) = U(E(I))$, i.e. the farmer is risk-neutral. If the farmer is risk-averse, the farm plan derived using LP may not be optimal.

To allow for the risk-averse decision-maker, the LP farm planning model would need to be extended to include income variance or risk. The inclusion of income variance and co-variance in a basic LP model is expressed as a constraint or an objective function. It is not a linear expression but a quadratic one, and so this problem must be solved alternatively.

Quadratic-Risk Programming. Quadratic-risk programming (QRP) is a technique used to accommodate non-linear (quadratic) constraints or objective functions in the optimization process to arrive at efficient farm plans. Risk is considered only with regard to the net returns. The resource constraints or the technical co-efficients are all assumed with certainty. The typical formulation of a standard QRP is as follows:

Minimize: $V = XMX$

Subject to: $Fx = \lambda \; (0 < \lambda < \lambda_{max})$

$Ax <=> B$

and, $x_{ij} > 0 \; (i = 1,2, \ldots m;\; j = 1,2, \ldots n)$

X, A and B are as specified for LP, while M is the variance-covariance (n x n) square matrix. The diagonal elements are respective variances of each of the n enterprises, and the off-diagonal element m_{ij} is the covariance of gross margin between ith and jth enterprises. F is a row vector whose elements are the gross margins of n enterprises, and λ is a parameter which varies between 0 and any pre-specified value, usually the expected maximum total gross margin.

The objective of QRP is to derive a risk-efficient farm plan that either minimizes V for a given expected gross margin or maximizes the expected gross margin for a given level of risk. The parametric approach used through different values of λ will produce a set of efficient farm plans which outline the E-V frontier F (Figure 3.2).

QRP was initially used in portfolio analysis to allocate resources efficiently across a number of risky alternatives to maximize the decision-maker's utility. Markowitz (1970) was the first to suggest that portfolio choice problems could be formulated as a QRP problem. Freund (1956) and Heady (1952) applied QRP to farm planning. Heady and Candler (1958) pointed out that risk aversion may lead to selection of a farm plan with lower risk and more stable income.

QRP has found several practical applications in farm planning. It has been used to determine risk by Stovall (1966), How et al. (1968), Chen and Baker (1974), Wiens (1976), and many others.

It should be noted that QRP offers optimal choices without the need to estimate farmers' utility functions directly. Although it is intuitively appealing, certain difficulties associated with its applications often arise, mainly large-scale computations and lack of efficient algorithms. There are also problems with "local optima bound by global optima" (Schurle, 1977). Post-optimality and marginal and sensitivity analysis are not straightforward and may cause certain difficulties (Hazell, 1971).

Linear Risk Programming. In order to solve some of these problems, Hazell (1971) suggested a linear-risk-programming alternative to QRP for farm planning under risk. This technique is known as Minimization of Total Absolute Deviation (MOTAD). Although MOTAD requires the same data as QRP, it does not have many of the inherent computational problems because it can be solved with standard linear programming methods. MOTAD will be discussed in detail in Chapter V.

There are several other linear-programming techniques which have been developed as an alternative to QRP in deriving E-V frontiers. These include separable programming developed by Thomas et al. (1972), marginal risk constraint LP (Chen and Backer, 1974), focus/loss technique (Boussard and Petit, 1967), and chance constraint programming (Kennedy and Francisco, 1974).

Summary

In this chapter, literature pertaining to decision making under risk was reviewed, including expected utility model with yield and price undertainties, risk aversion, and resource allocation under risk. Other theoretical and empirical evidence relating to the measurement of risk-aversion parameter was also discussed. The whole-farm planning models approach to decision making under risk, such as quadratic programming and other linear-risk programming alternatives were also discussed.

The second part of the literature review, which deals with agricultural insurance, is found in the next chapter.

Notes

The difference between the two lies in the degree of homogeneity of events such as tossing an unloaded coin or the chances of a particular catastrophe at a given time.

Objectives to be optimized are assumed to be normally distributed, which means that the implied expected-utility function is quadratic, and also implies increasing absolute risk aversion.

The normal distribution of the action outcome assumes that the decision-maker is not concerned with higher moments (kurtosis, skewness, etc.) as a measure of risk and that variance is sufficient. Variance as a risk measure assumes that the utility function considers only one attribute to be optimized. If decisions are to be based on multiple objectives, variance is not sufficient.

However, according to MacCrimmon (1968), consistency holds only if risky events are perceived as equivalent to uncertain events. If this distinction cannot be made, the Baysian approach may be more suitable because it "represents a true formalization of Knight's concept of uncertainty as opposed to risk."

Roumasset (1970) illustrates that the explicit assumption that an indirect utility function based on one-period gambles, ignores all other periods violates the MV independence postulates.

Absolute and relative risk aversion coefficients are defined as:

$R_A(W) = -U''(W)/U'(W)$

$R_R(W) = -WR_A(W)$

where W is wealth, and U' and U" are first and second derivatives of U with respect to W.

The Arrow-Pratt argument can be summarized as follows:

a) A farmer possesses greater absolute risk aversion than another farmer at all levels of wealth, if and only if the risk premium for the first farmer is always higher than the risk premium for the second farmer at all levels of wealth. If this condition applies, the first farmer will always be willing to pay a higher insurance premium than the second farmer.

b) Risk aversion is a decreasing function of wealth if and only if for any risk level the certainty equivalent is higher with higher assets, i.e. the amount of risk premium is smaller

c) A utility function exhibiting a decreasing absolute risk aversion can be used to describe the behaviour of an individual who is willing to pay a risk premium against risk decreases as his level of wealth increases (Pratt, 1964, p. 123).

"In order to explain the relationship between absolute risk aversion and relative risk aversion Arrow-Pratt first define two other concepts: the risk premium and certainty-equivalent income. Risk premium is the sum of money such that the farmer is indifferent to between a risky income (I) and the expected value of the risky income (E(I)) minus the risk premium (R(W_0,I)), where $W = W_0 + I$ and W_0 is initial wealth in Arrow's notation.

$$U([illegible] + E(I) - R([illegible], I)) = EU([illegible] + I)$$

where [illegible] is the initial wealth. $R(W_0, I)$ is the risk premium, which is a non-stochastic variable. $[E(I) - R(W_0, I)]$ is certainty-equivalent income.

Where $E(U(I)) = \int_{-\infty}^{+\infty} U(I)\, dFU(I)$ with $U(I)$ being the Freund-type utility function which exhibits constant absolute risk aversion. $U(I) = 1 - \exp(-R_a \cdot I)$, where R_a is the risk-aversion parameter and I is income.

CHAPTER IV: REVIEW OF THE LITERATURE: CROP INSURANCE

A. Introduction

Early studies on crop insurance suggest that when crop insurance is not available, farmers tend to protect themselves by hoarding or diversifying crops. Hoarding results in the withdrawal of savings from investment activities, which may have a negative effect on production. Crop diversification often results in a shift from intensive, specialized cash crops to more diversified subsistence production. The farmer's rationale for diversification is that growing different crops in various climactic and ecological zones reduces the probability of a total loss in the case of an unforeseen natural calamity. This risk-management measure is based to a large extent on the risk-aversion attitude, and not on market signals or stimuli. Because of the absence of alternative risk-management decisions, crop specialization often involves an excessive risk for the producers (Shipley, 1967).

An increase in the amount of funds borrowed by the farmer will increase the overall riskiness of his income, that is, by keeping the total assets fixed, the degree of risk in the income stream increases as the debt/equity ratio increases (Hogan, 1982). If the farmer is risk-neutral (profit maximizer), he will tend to choose higher levels of debt provided that the expected rate of return on his total investment is higher than the funds he would have to borrow. Small and marginal farmers with limited net-asset holdings are, in general, not easily covered under agricultural-credit projects or programs (IFAD, 1983), because of their risk-averse situation and their fear that such programs would change their level of investment, increase their debt/equity ratio and thus place them at greater risk.

Small farmers have, however, engaged in a range of informal risk-sharing arrangements. These include sharecropping, borrowing from informal credit sources or family members, selling parts of main assets and resorting to seasonal migration. As these arrangements spread risks only over one region, and often over one village, they are not efficient as in pooling risks as might, in principle, be achieved with a nationwide crop-insurance scheme. This, however, is still subject to further study (Halcrow, 1948; Pfeffer, 1956; RAy, 1981; Ahsan, 1981; and Hazell et al., 1986).

The effectiveness of these and other traditional risk management strategies by various types of farmers is an empirical issue. What is of concern to this study is the cost-effectiveness of these risk-management measures, which could be very expensive for subsistence farmers. The obvious alternative risk prevention techniques include crop diversification, inter-cropping and flexible input use. There is also strong evidence that tenancy has been used actively in rural areas of India to spread production risks both within and between cropping years. (Johda et al., 1985) The employment of strategies such as storage, institutional credit and off-farm employment could help reduce the effects of serious crop losses arising from natural catastrophes.

Policy makers have been concerned with the incidence of risks for the following reasons:

a) Fluctuation of farm income has welfare implications for the rural poor; crop failure could result in episodes of misery and malnutrition. Farmers may be forced to sell farm assets such as livestock, homestead or agricultural lands, or even to abandon agriculture completely which could affect whole rural communities, including traders and consumers. This is particularly evident in the dryland farming in the Near East and North Africa region, including Jordan, where rural exodus is growing at an alarming rate (El Sherbini, 1979).

b) As farmers in LDCs are typically risk-averse, the returns are reduced by avoidance of risk through the use of traditional measures. This behaviour leads to reduction in farm incomes and lower supply of "riskier" agricultural commodities. Lower supplies can directly affect consumers' welfare, and reduce foreign exchange and national income. (Hazell _et al._, 1986)

c) Severe risk exposure may increase the likelihood of default on bank loans, especially in years of crop failures. Poor loan recovery by financial credit institutions would have several consequences: reversion to credit rationing and application of rigid collateral requirements which exclude poor and assetless farmers access to credit. (Hogan, 1980)

There are certain risk-sharing mechanisms that can reduce the farmers' burden of risk. One is to distribute risk geographically, between crops or among other sectors of the economy. Another is to transfer risks to other members of society or to specialized institutions that can either bear the risk or are less risk-averse. There are not many risk-sharing institutions in developing countries, such as efficient credit institutions, agricultural insurance companies or traders in futures markets. Efficient risk spreading reduces the total risk burden to society and may be beneficial to farmers.

In order for risk-averse farmers to adopt new technologies, as well as to receive the necessary training and other technical needs, the risk associated with the introduction of such new practices should be mitigated. The mitigation of risks is, as shall be seen later, necessary but not sufficient for farmers to adopt new technologies.

Many risks are uncontrollable and can only be dealt with by compensating farmers in bad years. If price fluctuations are the primary reason for income instability, price-support or price-stabilization schemes may be the best alternative. Efficient credit institutions can also help tide farmers over in poor years. Crop insurance is another policy option; it works best when the source of income fluctuation is yield failure as a result of climatic conditions (Dillon, 1985).

The remainder of this chapter provides a brief review of the principles of agricultural insurance. The impact of risk on crop insurance is explored, and the various agricultural insurance schemes offered are examined in Part B. The impact of agricultural insurance on risk aversion and resource allocation is reviewed in Part C. Parts D and E discuss the factors affecting the supply and demand of agricultural insurance, respectively. The final section outlines selected countries' experiences with agricultural insurance schemes which were implemented in various countries.

B. Principles of Crop Insurance

Two categories of crop insurance, namely yield and revenue insurance will be discussed in this section. Yield insurance covers crop loss not exceeding some historical average value. The price of the crop(s) in question are specified in advance, and indemnities are be paid to the farmers if yields fall below some specified percentage of the historical average (expected value).

For a yield-insurance policy, the insurance premium could be specified as (Hogan, 1982):

$$PR = E(C_h)(1 + S + a)$$

PR is the premium to be paid in every state of nature, h (h = 1, 2 ... n), over which $E(C_h)$ is determined; C_h is the compensation payment in the state of nature h; S is the safety loading; and a equals the administrative loading. The safety loading S allows for a reserve fund to cover losses of the insuring institution during bad states of nature. In ideal situations, premiums and indemnities should sum to zero across the states of nature.

Because risk of crop damage among policy holders in the same region does not satisfy the standard actuarial assumption of independence (e.g., drought, flood, or pest infestation are likely to affect many farmers), a reserve allowance is provided to maintain financial viability of the insurance. The administrative loading reflects the administrative costs. It is assumed that the insurance is actuarially fair, meaning that administrative costs plus indemnities are, on average, equal to the total premiums. It is also assumed that if administrative costs are subsidized, the social benefits of these subsidies off-set the costs.

If under unfavourable states of nature compensation payments are further reduced by a deductible amount and by co-insurance, the formula for the premium is adjusted as follows:

$$PR = E(P_h)\ K \cdot \max\ (\beta\ E(Y) - Y_h, \emptyset)(1 + S + a)$$

where $E(P_h)$ is the expected price of the output at the state of nature h, and K is the co-insurance factor, β is the deductible factor where $K > 0$ and $0 < \beta < 1$, and Y_h is the yield in the state of nature (Hogan, 1982).

Crop Insurance and Risk

Following Ehrlich and Becker's (1972) model of crop insurance and risk, the standard economic model of decision-making under risk is depicted in Figure 4.1, where the horizontal scale represents income and the vertical scale represents utility. Let $U_a(I)$ and $U_n(I)$ represent risk-averse and risk-neutral utility functions, respectively. I_h and I_s are levels of income associated with the states of nature h and s, and p and (1-p) are the associated probabilities. P is the probability that the state h occurs and (1-p) is the probability that the state s occurs. The expected income under this situation is $E(I) = p(I_h) + (1-p)I_s$. If the state of nature h occurs, the utility level is $U(I_h)$; similarly, the utility enjoyed for the state of nature s, if it occurs, is $U(I_s)$. The expected utility for risk-averse farmers is: $E(U(I)) = pU(I_h) + (1-p)U(I_s)$. Risk-aversion is represented by the function $U(E(I)) > E(U(I))$ and risk-neutrality by $E(U(I)) = U(E(I))$.

In Figure 4.2 the maximum amount of insurance a risk-averse decision maker would be willing to purchase against a probable risk is $E(I) - I_c$ where I_c is certainty equivalent. If an insurance scheme

fig:4.1
decision involving risk
risk averse vs risk neutral

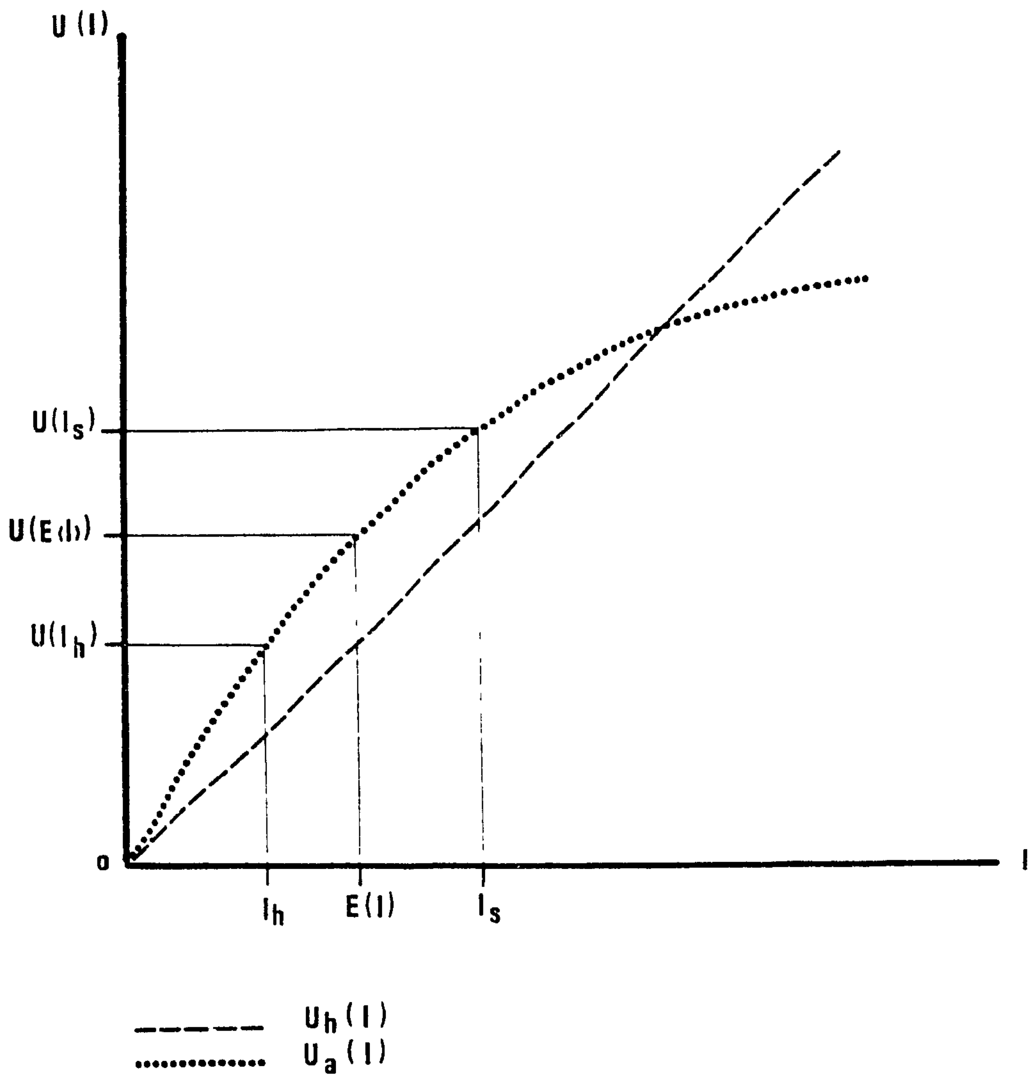
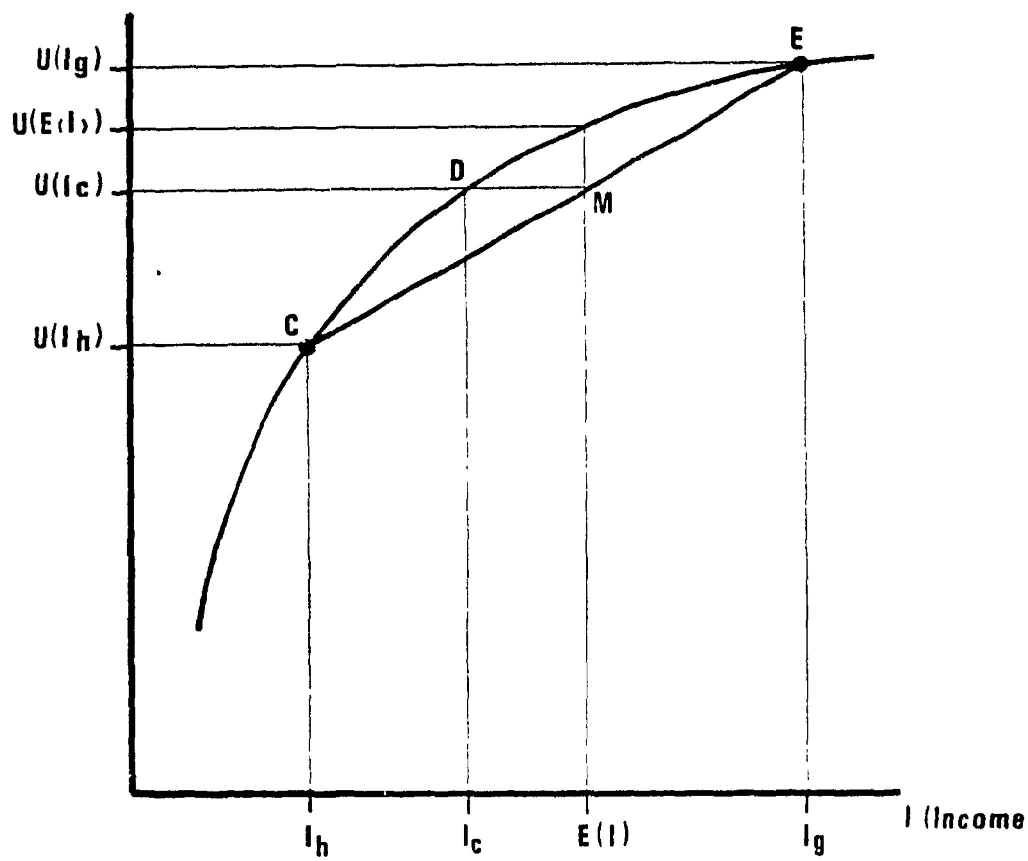


fig:4.2
decision involving risk
risk averse farmer



guarantees a certain income level I_k, and if $I_c < I_k < E(I)$, the premium level $E(I) - I_k$ is acceptable because it is smaller than the maximum $E(I) - I_c$ that the decision-maker is willing to pay. If, on the other hand, $I_k < E(I)$, but $I_g < I_c$ than the premium $E(I) - I_k$ would be too high because $E(I) - I_g > E(I)-I_c$. The decision-maker is unlikely to participate in this insurance scheme. (Djogo, 1983).

Analysis of the efficiency (E-V) frontier (whole-farm planning method) facing the decision-maker in a situation without insurance is shown in Figure 4.3). If it is assumed that by purchasing insurance the decision maker's risk would be reduced by moving to the left of A but lower than C (because of the premium payment), his efficiency frontier would shift from F_0 to a higher efficiency frontier but lower than F_1, that is, to a higher utility level than I_0 but lower than I_1, and he may opt for crop insurance.

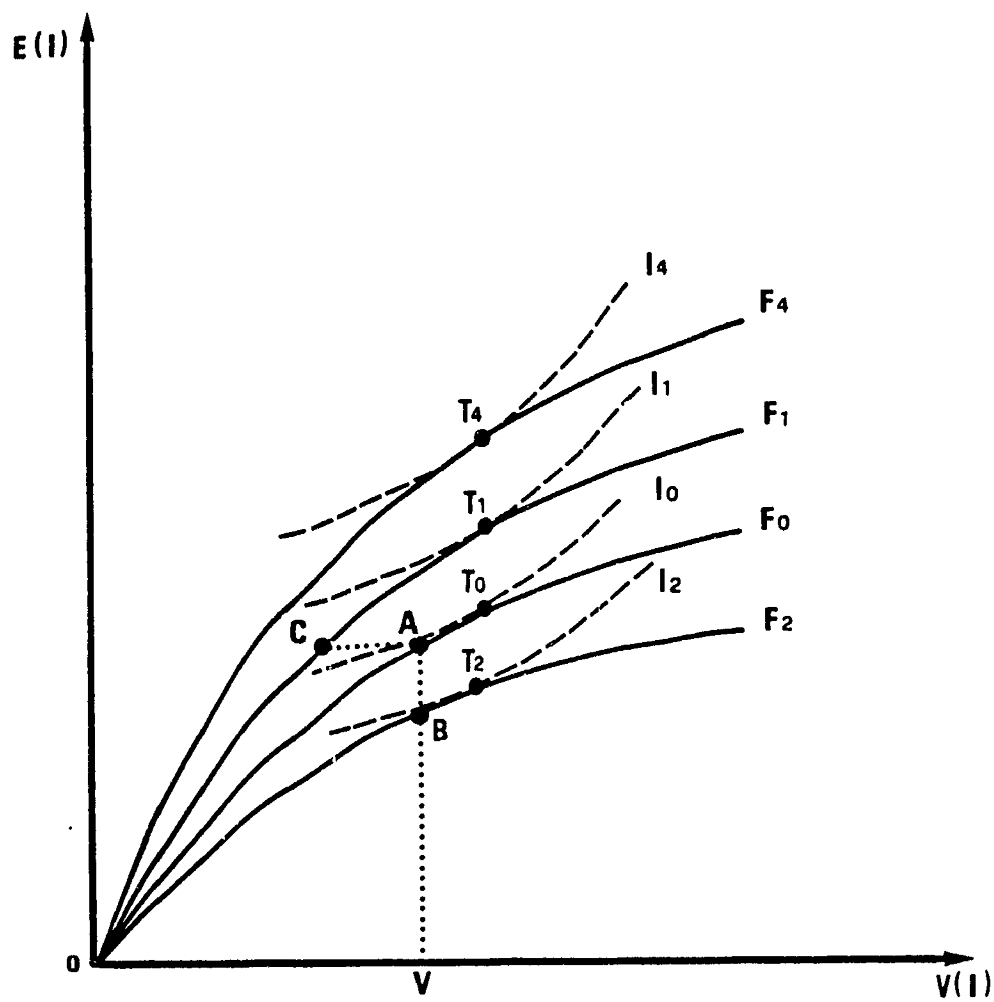
If the insurance premium is too high, by opting for crop insurance his efficiency (E-V) frontier would shift from F_0 to a lower frontier but higher than F_2 and would move to the left of B. The decision-maker would be on a lower utility level as compared to doing without insurance and he may choose not to purchase insurance (Djogo, 1983).

Revenue Insurance

After World War II, many governments were concerned with the problems of price and yield uncertainties facing agricultural production and fluctuations in farm income. Many existing agricultural insurance schemes are concerned primarily with yield rather than price instability.

fig: 4.3

least efficiency frontiers under alternative farm plans



In the United States, the Federal Crop Insurance Agency (FCIA) offers producers two options: All Risk Crop Insurance which pays an indemnity to the insured for any yield decline arising from any unavoidable factor such as weather, pests, floods, hail, frost, disease, etc.; and under the second option, the producer is allowed to choose from among three levels of yield protection 30, 60 or 75 percent of their historical yield. At the same time, the insured is offered three levels of price protection. Under this option, no indemnities are paid if yields are above the covered level and the price below the selected price. When indemnity is called for, it is carried out on the basis of the yield and price levels as selected by the policy-holder.

An alternative to yield insurance is the relatively new idea of revenue insurance, initially discussed by Johnson (1947), Swerling (1959), Lloyd (1977) and Dandekar (1977). The most comprehensive discussion available on this subject is the report on rural income fluctuations prepared in 1978 by the Australian Industries Assistance Commission (AIAC) and published by the Australian Government. AIAC provides a detailed discussion of the farm income stabilization plan as originally proposed by Lloyd (1977). This plan is based on a voluntary, regionally-based income insurance plan. As an illustration of this voluntary insurance scheme,

> assume that the regional income per hectare from a product was X percent higher or lower than normal in a particular year. All insured farmers in the region would then receive pay-outs of X percent of the region's normal per hectare income from that product on each hectare they had insured (Lloyd and Mauldon in Hazell, 1985).

A major advantage of the revenue insurance scheme is its potential for substantially reducing the risk of moral hazard and adverse selection (to be discussed later in this chapter), particularly when the premiums and indemnities are determined by movement in regional yields and prices. In such cases, they are not dependent on events under the control of the individual farmer or on risk characteristics of the individual farm. The other advantage of revenue insurance is that it relates the benefits to the income of the individual farmers and protects but does not support income at relatively high levels.

Similar to the study undertaken in Australia, the U.S. Congress appointed a Farm Income Protection Task Force (FIPTF) to investigate the concept of revenue insurance. The FIPTF report of June 1985, entitled Farm Income Protection Insurance, concluded that basic data to evaluate the usefulness of this type of program is not available and precluded its initiation at that time. It did, however, recommend implementation of a pilot revenue scheme in order to collect the data necessary to determine the usefulness of such a scheme nationwide. In a 1983 study, the Congressional Budget Office recommended initiation of a pilot revenue insurance scheme.

Unlike classical yield insurance, revenue insurance is designed to deal with price and yield uncertainties. The present agricultural policies in Jordan are geared towards dealing with price uncertainties through price support for wheat and barley. This support was initiated in 1979/1980 and involves payment of specified prices at harvesting. Support prices are announced early in the season. Revenue insurance integrates price and yield policies by directly addressing the issue of income fluctuations arising from yield and price variability, as well as the variability caused by their joint effect.

Revenue insurance is potentially useful in situations where price and yield variability exists; as in Jordan where local production of major cereals is negligible as compared to total imports, thus producers price is affected by the variability of the international prices. The variability of yield, as shall be seen later, is an important factor which largely contributes to farm income fluctuation. Furthermore, most of the subsidies provided by the government to the agricultural sector in terms of cheap credit seem to favor large farmers (World Bank, 1983). Among the recommendations made in a report published by an inter-governmental committee, Analytic Study of Possibilities of Increasing Cereal Production in Jordan, were gradual elimination of wheat subsidies to consumers (which cost the Jordanian Government a yearly average of about JD 6.98 million or the equivalent of US$ 20 million) and increasing the Government's support to cereal producers from its present level of about the equivalent of US$ 3 million. The committee also recommended researching the feasibility of agricultural insurance.

C. Insurance, Risk Aversion and Resource Allocation

This section will illustrate the effect of insurance on a risk-averse farmer in terms of resource allocation and risk sharing. This section is based, with slight amendments, on the work of Ahsan *et al.* (1982), Kouadio (1982) and (Nelson 1987). The analysis is concerned with a single output. It is assumed that the farmer is competitive and growing one crop, with the yield as a random variable and the price predetermined.

There are two states of nature: i) bad state occurring with probability a, and ii) good state occurring with probability (1-a). If the farmer pays a premium in all states of nature and receives an indemnity during the bad state of nature, the profit in both states is expressed as (with probability a and (1-a), respectively):

$$I_b = PY_b + P(sY-Y_b)L-RL-VL \quad (4.1)$$

$$I_g = PY_gL + RL-VL \quad (4.2)$$

where P = the known price; Y_b = the yield associated with the bad state of nature; Y_g = the yield associated with the good state of nature; V = the marginal cost measured in acreage;[1] R = the insurance premium; s = the insurance coverage rate as a percent of average yield; Y = the average yield; and L = the land allocated to the crop.

The relationship between insurance indemnity and premium can be expressed by:

$$R = t \cdot P(sY-Y_b) \quad (4.3)$$

where t is the cost per amount of coverage.

Equations (5.1) and (5.3) can be rewritten where:

$$I_b = PY_bL + (1-t)P(sY-Y_b)L-VL \quad (4.4)$$

$$I_g = PY_gL + tP(sY-Y_b)L-VL \quad (4.5)$$

The expected utility of the profit can thus be expressed:

$$E\{U(I)\} = aU(I_b) + (1-a)\ U(I_g) \quad (4.6)$$

The first-order condition is arrived at by differentiating equation (4.6) with respect to L after substituting the values of: I_b and I_g for their values from equations (4.4) and (4.5).

$$dE\{U(I)\}/dL = aU'(I_b)\{PY_b + (1-t)P(sY-Y_b)\}-V + (1-a)U'(I_g)\{PY_g-tP(sY-Y_b)-V\} = 0 \qquad (4.7)$$

$U'(\cdot)$ denotes to the first derivative.

The second-order condition is as follows:

$$f = d^2E\{U(I)\}/dL^2 = aU''(I_b)\{PY_b+(1-t)P(sY-Y_b)-V\}^2 + (1-a)U''(I_g)\{PY_g-sP(sY-Y_g)-V\}^2 < 0 \qquad (4.8)$$

This is satisfied for a farmer exhibiting a risk-aversion level, i.e., $U''(I) < 0$.

The relationship between the cost of insurance and acreage can be explored by total differentiation of equation (5.6) and using the results of the second-order condition. The expression proposed by Pratt (1964) and Arrow (1971) for the absolute risk-aversion coefficient is defined as:

$$R_a(I) = -U''(I)/U'(I) \qquad (4.9)$$

by assuming $R_a(I)$ constant in all states of nature, specifically:

$$f=\{L/(P(sY-Y_b))\}\ dL/dt = aU''(I_b)\{PY_b + (1-t)P(sY-Y_b)-V\}L + (1-a)\ U''(I_g)\{PY_g-P(sY-Y_b)-V\}L+aU'(I_b)+(1-a)U'(I_g) \qquad (4.10)$$

By substituting $R_a(I)$ above for a constant value R_a, L_1 becomes

$$f = (1-R_a)\{aU'(I_b) + (1-a)U'(I_g)\} \qquad (4.11)$$

Under positive marginal utility of profit, the impact of reducing the premium on planned acreage depends on the sign of $(1-R_a)$ and on whether the utility function exhibits positive and diminishing marginal utility. If so, the premium reduction could bring about an increase in output of $(R_a<1)$.

Ahasan, Ali, and Kurian (1982) have provided an analytical framework for analyzing crop insurance as a public good. They assumed that the producer maximizes the expected utility, that the insurance scheme is actuarially fair, and that in equilibrium the insurer earns zero profit. The producer-choice variable is the amount of input which could be devoted to risky and riskless production activities, the input is risk-increasing and the producer is risk-averse. Under these assumptions a number of conclusions can be drawn with respect to the producer's behaviour.

a) Producers will opt for full insurance coverage if premiums are actuarially fair.

b) Producers devote inputs to risky production activities until expected return on the margin of that input is equal to the rate of return on riskless activities.

c) Input into risky production activities is greater with insurance than without insurance.

Ahsan <u>et al</u>. extend the analysis to more than one producer and conclude that information externalities will inhibit equilibrium under competitive insurance markets and that public subsidization of insurance is desirable as a second-best solution.

Nelson <u>et al</u>. (1987) extended the work of Ahsan <u>et al</u>. by considering a general production model with multiple inputs and outputs. Nelson <u>et al</u>. show that in the multiple input/output model it is not generally true that risk-averse farmers would use less inputs than risk-neutral farmers because of the interaction of inputs. For example, two outputs could be produced with a single input. If this input is risk-increasing for output one and risk-reducing for output two, the risk-averse producer will produce less of output one and more of output two than the risk-neutral producer. This is because the marginal risk premium is positive if the input is marginally risk-increasing and negative if the input is marginally risk-reducing.

In the same article Nelson et al. showed, using the economic theory of contracts, that under information externalities a second-best solution is possible with commercially designed insurance.

Insurance and Welfare

Pareto optimality of the effects of insurance in risk sharing has been demonstrated by Borch (1962) and reiterated in Stiglitz et al. (1979). However, for Pareto optimality to be obtained a certain number of assumptions must be made. The most important is that competitive insurance firms have perfect knowledge of the risk attitudes of farmers, which implies that problems such as moral hazard and adverse selection are ruled out. Furthermore, Pareto optimality requires actuarially fair premiums. Under these assumptions such insurance will alter the input/output decisions of the risk-averse farmer, causing him to behave as if he were risk-neutral.

There are two approaches to assessing the social-welfare impact of any public insurance scheme. The first approach is the concept of net return to society, or the Hicks-Harrod version of Pareto optimality (Just, 1978). The procedure involves approximating the supply and demand curves for a given input under the assumption of constant absolute risk aversion and constant factor prices. Changes in social welfare are associated with areas below the aggregate demand curve and above the aggregate supply curve.

The second approach relies on the work of Arrow and Lind (1970) and treats public insurance as any public investment (i.e., "public good"). According to Arrow and Lind, uncertainties associated with public investments are borne by society as a whole, since the cost of risk to the society as a whole is negligible. Therefore, in evaluating the desirability of a public project (such as public insurance) the government should act as if it were risk-neutral. This implies that "Positive social benefits of insurance occur, therefore, when the availability of insurance moves private-resources allocation in the direction of risk-neutral optimum" (Roumasset, 1976, p. 223).[1]

Moral Hazard

In insurance literature (Ahsan, 1985; Hazell, 1986; Ray, 1981; Nelson, 1987), moral hazard occurs when the insured farmers take actions that alter the probability-loss function without this being detected by the insurer. The consequences of moral hazard are that the insured individual's rational choices differ from the Pareto optimality device. In other words, "Inputs which reduce the probability of low yield could be used less intensively than is socially optimal" (Nelson, 1987).

In the absence of strict control by the insurance agency, it is likely that Jordanian farmers would act intentially to increase the probability that yields would fall below the covered level. These actions could include lower fertilizer and herbicide use, improper use of combine harvesters and minimum tillage. They many not make adequate efforts to obtain the maximum price for their crops or may not report the true value of their crops by selling portions without reporting the sales. The average report yields, wou'd thus fall below the insured level, making that farmer eligible for indemnity, when in fact he may not legitimately qualify. A number of remedies have been suggested to discourage moral hazard, including:

a) offer insurance contracts to cover less than 100% of the historical yield or income;

b) provide clear legislation specifying the illegality of intentional alteration of yield and revenue;

c) include a deductible clause by which participating farmers share part of the crop damage or loss in revenue with the insurer;

d) require participating farmers to provide satisfactory proof regarding their agricultural practices;

e) base indemnities on measurable parameters which characterize the state of nature (such as rainfall, type of soil, wind, termperature, pest population, etc.)

These parameters are in turn applied, using econometric models, to estimate the output. The estimated output is then used to determine whether indemntity is warranted or not. In Jordan, it is unlikely that (d) or (e) above could be implemented because they require rigourous monitoring, highly qualified staff and considerable budgetary allocations which at present may not be available.

Adverse Selection

Adverse selection occurs if the insurer cannot distinguish the "inherent riskiness" of different farmers. Insurance companies may have access to information about aggregate riskiness of a group of farmers, for example, those in a certain region. Premiums are set by treating each farmer's expected loss as if it were equal to the area's aggregate expected loss. This premium may be higher or lower than the actual expected loss for a particular farmer. Those with expected loss above the average would opt for insurance while those with expected loss below the average would opt out. Adverse selection will cause departure from Pareto optimality.

Adverse selection is a potential problem in the context of Jordan. There is significant difference in climatic conditions between and within the governorates of the country, particularly soil quality and rainfall. Although area approaches could be used to address this issue, separate zoning would be required for its implementation.

The most difficult question, which needs careful analysis, is how to cope with the yield variances among farmers in any single zone. There is sufficient evidence that significant differences in average wheat and barley yields as well as their variance exist between farmers in the same governorates (see Chapter II). The major reasons, in addition to climatic and agronomical reasons, are that farmers practice different agricultural practices -- varying from labor-intensive semi-traditional to capital-intensive improved practices. The size of the holdings as well as management of the farm largely contribute to this variablity of yields. A uniform insurance premium is unlikely to be attractive to farmers who have historic yields above the historic governorate yields and most certainly they would not participate in such a scheme on a voluntary basis.

Participation would thus be attractive under such conditions only to high risk farmers.

A number of remedies have been suggested which could be applied in Jordan: drop-outs from the program would be discouraged by charging re-entry fees; or multi-period contracts could be introduced which on the basis of the individual loss ratio, a flexible premium rate would be adopated (i.e., increased or decreased over the contract period). These measures could work well in countries where some experience with crop insurance already exists, proper legislation is institutionalized and where proper monitoring by the insurance agency is operational. In the context of Jordan, where no experience with crop insurance exists, it may be useful to start on a pilot level with a compulsory area-oriented scheme.

Public vs. Competitive Insurance Schemes

Individual full-coverage, actuarially fair insurance contracts in a perfect-information scenario produce Pareto optimality (Rothchild and Stiglitz, 1976; Raviv, 1979). Moral hazard and adverse selection are issues which may cause the solution to depart from Pareto optimality. Moral hazard will cause farmers to reduce their efforts to prevent those losses covered by the insurance (Spence and Zekhauser, 1971), which may influence the probability function of losses.

Ahsan et al. (1982), recognizing the problems of moral hazard and adverse selection, recommended a second-best solution, subsidized public insurance. They contended that this type of insurance is more relevant in developing countries, where statistical information and the logistical support for gathering and processing the information are rudimentary.

Nelson (1987) proposed an alternative second-best solution, based on the self-selection principle. The self-selection principle, as originally proposed by Rothchild and Stiglitz (1979), involves a set of contracts to be proposed to the farmer. As farmers choose the suitable contract, their risk class is revealed to the insurer. Although the issues involved with the implementation of self-selection insurance schemes are theoretically attractive, the information needed for designing such schemes is not likely to be available.

Nelson's (1987) proposed second-best private-oriented insurance scheme for agricultural procedures is possible "at least theoretically" and does not necessarily contradict Ahsan's public insurance proposal. In a world of second-bests, it remains an empirical problem to show which of the two second-bests is "first best." For countries such as Jordan where the financial market, particularly in the rural areas, is underdeveloped, including the insurance sector, this may be an important reason to initiate a public insurance scheme for agricultural producers.

D. Factors Affecting the Demand for Crop Insurance

Those in favour of providing public crop insurance argue that existing risk-sharing arrangements are inadequate for farmers, particularly in dryland farming. The underlying concern is that the traditional risk-loss management mechanisms could be very costly in terms of farm survival. Restoring farm-productive capacity is a slow process, and the growth and equity implications of severe setbacks should be the concern of any public policy (Ray, 1981; Ahsan et al., 1981).

Crop-insurance schemes should be evaluated against all other alternatives, including farmers' decisions. For example, Hazell (1986) reports that in Mexico, a crop insurance scheme for maize would involve a 50 percent subsidy of the premium if it was to be acceptable to the farmers in the rainfed area.

Farmers' demand for insurance is affected by a number of factors. Generally, farmers will purchase insurance if expected benefits exceed the costs. As farmers may not plan over the long-term, they tend to look at insurance with a myopic view. Thus, farmers would buy insurance only if short-term benefits exceed the cost of purchasing the insurance policy.

Farmers' demand for insurance, at any particular point in time, is a function of the level of premiums, which is based on the expected net income from production and the occurrence of disasters in the recent past. The stability of the demand for insurance over time is strongly influenced by the farmers' perception and understanding of the particular scheme.

Niewuwoudt et al. (1985) found that the demand for subsidized crop insurance in the United States appears to be low. In their empirical study they attributed this low demand to a number of variables: expected rate of return with insurance, expected risk, crop specialization, land ownership, disaster payments and farm size.

More insurance will be purchased as higher risks are experienced. Specialization is also an important factor in determining the demand for insurance. In intensive wheat-growing areas in the United States, such as Montana and North Dakota, the percentage of acreage insurance reached between 40 percent and 50 percent in recent years, as compared to 4 percent for wheat acreage in Illinois and Indiana.

Farm-size parameter had a negative sign, indicating that an increase in the farm size was associated with a decline in the percentage of insured acreage and that risk premium declines as farm size increases. This suggests that wealthy farmers with large farms, who usually have better access to credit, may have less incentive for crop insurance. This also seems to support Biswanger's (1984) argument that demand for insurance by landless farmers may be significant, since the insurance contract could be used as collateral for production or investment loans.

Anthropological studies in Latin America indicated that farmers do not view insurance as a long-term financial investment. These studies also show that:

a) when insurance is made compulsory and tied to credit, farmers reject it because they view transaction costs and premiums as an additional cost of credit;

b) if farmers do not receive indemnities after the second or third year, they tend to leave the program; and

c) availability of insurance for individual crops will lead farmers to purchase insurance only for the riskier ones.

In addition to premium rates, the demand for insurance seems to be affected by the out-of-pocket and transaction costs if insurance is provided through the existing credit institutions.

E. The Supply of Agricultural Insurance

The long-term cost of insurance is determined by the cost of risk protection and the transaction cost. Depending on the insurer's portfolio, transaction costs generally include the cost of issuing the policy, preliminary inspection, disaster inspections and harvest or futures inspections. There are also the fixed costs of handling, processing, and retrieval of information. The cost of bearing risk is determined by the expected magnitude of the loss. Transaction costs are traditionally lower for area-approach insurance schemes than for individualized insurance schemes.

Government contributions have taken different forms, including subsidizing premiums, financing administrative cost and providing reinsurance. As premiums have not been set high enough to cover losses, reinsurance support has often been the largest financial contribution of governments. This is also partly due to the imperfect financial markets in LDCs.

It is widely recognized that one of the limitations to the implementation of crop insurance is the lack of adequate data to estimate premiums (Ray, 1981; Rustagi, 1983). There are two methods available for the calculation of premiums. The first is to use the insurer's actuarial experience to establish a set of initial premiums which are continuously adjusted as more information on indemnity is made available, as in the United States and Japan. The second approach uses yield data to establish premiums that are adequate to meet the expected indemnity in case of crop failure.

The actuarial principles involved in the administration of premiums using yield data have been discussed in detail by Halcrow (1949), Botts et al. (1958), Dandekar (1977), Togawa et al. (1979), Rustagi et al. (1983) and most recently by Skees et al. (1986). According to these principles:

a) those farmers who are experiencing the largest yield variability should pay the largest premium;

b) calculating premiums for each farmer is not practiced; and

c) if a uniform rate is applied for all farmers, those with less than average variability will subsidize the others.

The above three points will lead to unstable crop insurance, as some farmers may abandon the scheme, leaving the insurer facing an adverse selection problem.

Some of the problems associated with the use of yield data to determine the premium are: unstable government policies, level of application of inputs and scarcity or high price of insecticides. All these factors could contribute to variability in yields.

Dandekar (1977) proposed the homogeneous-area approach, which entails the following:

a) normal yields are estimated by geographical areas;

b) indemnities are paid at a uniform rate to all insured farmers in the area, irrespective of the actual yield of the crops on their respective farms;

c) area-uniform premiums are calculated on the basis of year-to-year variability of yields for the area; and

d) through continuous revisions, premiums are set at a higher level in areas where the year-to-year variability is larger.

An advantage of the area approach is its potential to reduce some of the transaction costs associated with inspection.

Because of the inability of crop insurance companies to distinguish between high-risk and low-risk farmers, they resort to using more easily observed variables, such as sex, age, race, caste, etc. (Hazell et al., 1986), which are thought to be correlated with risk. If differentiation cannot be achieved, insurers may set the premiums so high that only high-risk individuals will find insurance attractive.

F. The Experience with Crop Insurance

Agricultural insurance was introduced in Germany during the first half of the nineteenth century to protect farmers against hail damages. In the last half of the nineteenth century, livestock insurance was also in operation in Germany. Since then, agricultural insurance has been introduced in the United States, Japan, Sweden, Israel and Canada, and in LDCs including Mexico, Sri Lanka, Brazil, Costa Rica, Panama, Kenya, Mauritius and India. Some insurance plans are state-owned or the government meets or subsidizes the entire operation cost, while others are privately operated. Some are voluntary while others are compulsory, and some provide full coverage while others provide only limited coverage. Some are linked to credit, though the majority are not (see Table 4.1).

Countries such as the United States, Japan, Brazil, Sri Lanka, Mauritius, Sweden, and Mexico have had several decades of experience with

Table 4.1 Summary of Experience with Crop Insurance – by Country

Country	Type of Legislative Systems of Crop Insurance	Enactment of the Scheme	Does Government Bear Cost of Crop Insurance	Provision for Reserves	Participation by Farmers	Coverage	Is Crop Insurance Linked to Credit
Chile	State	1970	---	Yes	Voluntary	Direct farm outlays	
Israel	State	1966	In Part	Yes	Compulsory		No
Mauritius	State	1974	In Part	Yes	Compulsory for sugar crop loss against fire	75% of the average	No
Finland	State	1952	In Part	Yes	Voluntary if no credit Compulsory if credit sought		
Canada	State	1955	Wholly		Mixed depending on the crop and the risk	50% of average	No
Sri Lanka	State		Wholly		Compulsory for paddy	75% of average	Yes
Japan	Mixed	[illegible]	Wholly	Yes	Mixed	7?% of average	Yes
Sweden	Mixed	1961	Wholly	---	Compulsory for areas under or up to 2 ha		
Mexico	Private	1950	In Part	Yes		Direct outlay	Yes
Sweden	Private	1961					
U.S.A.	Private	1938	In Part	Yes	Voluntary	75% of appraised yield	No

Source: Compiled from Ray, 1981

publicly supported crop-insurance programs. Only the U.S. Federal Crop Insurance Corporation (FCIC), however, operates with a minimum of government subsidies, a situation achieved only after years of heavy losses and several bankruptcies (Buckler, 1950)."

Forty-seven years after the FCIC was created, its performance is still not completely satisfactory (Kramer, et al., 1982). Performance has been evaluated on the basis of the following: farmers' participation; number of farmers indemnified and served; and loss ratio (indemnities/premiums). During the period 1948-1978 the total indemnities amounted to US$ 1.26 billion, while the premiums paid amounted to US$ 1.21 billion. The FCIC administrative costs for the same period amounted to US$ 351 million. The loss ratio is about 1.33, suggesting a subsidy rate of about 33 percent. In addition, the national participation rate was 11 percent of the eligible cultivated area. Major reasons for the low participation rate by farmers in the FCIC scheme could include the following:

a) impact of the scheme on the variability of farm income may be insignificant;

b) other risk management strategies may be used; and

c) low protection is offered.

Strategies farmers use in risk management include:

a) other government programs, such as emergency loans, disaster payments, deficiency payments, etc.;

b) hedging of future markets and forward contracting; and

c) crop diversification.

Crop insurance in the United States has been criticized on two fundamental grounds:

a) premium rates charged may not be consistent with those that individual farmers expect; and

b) FCIC scheme does not take into account the interaction of price and yield uncertainty, i.e., the data used to establish premiums, compensation, etc. are based on incomplete information.

The current Japanese crop insurance program originated from the Agricultural Loss Compensation Law, enacted in 1947. Tsujii (1982) argues that the government subsidy to rice insurance in Japan is so large that its impact on supply has been negligible. Yamauchi (1964, 1980) argues that at the time of the introduction of crop insurance in 1947, rice production was dominated by small farmers, many of whom had become owner-occupiers under the 1947 land reform. Subsidized crop insurance was made compulsory in an attempt to prevent newly created owner-farmers from reverting to tenant status in disaster years through distress or land sales. Subsidies were biased in favour of farms located in riskier areas.

Initially, insurance coverage was based on the area approach, the result was that high-yield farmers were under-indemnified, while high-risk farmers were over-compensated during crop failures. Under the 1957 insurance reforms, the individual plot approach to premium determination was enacted and flexibility in the amount of coverage to farmers was introduced.

After World War II, many small farmers became "part-time" holders and crop insurance was unsuited to their needs. To maintain the viability of crop insurance, compulsory minimum acreage for various crops was imposed as a condition to qualify for the purchase of crop insurance.

Brazil's national crop-insurance program (PROAGRO) was established in 1973 as a voluntary program to assist farmers in repaying loans in the event of certain natural disasters. Initially it provided coverage of up to 80% of the amount of a loan with a standard premium of one percent. Loss ratios were high, and climbed to 40 percent in 1975. The program has survived with the aid of large government subsidies. In 1980, the subsidy from the Central Bank represented 58 percent of PROAGRO's total revenues.

According to Hazell et al. (1986), PROAGRO's poor performance is attributed to three basic causes: first, a low premium rate was charged and the cost of administration was high; second, because the program was voluntary, it attracted only a small number of participants, who tended to be high-risk producers; and third, the program was too specialized in wheat and upland rice.

A number of substantial changes have been made to PROAGRO since 1980. The program is now compulsory for all farmers who have experienced losses in previous years. The new reforms include high premium rates; however, the crop-insurance program in Brazil still depends on generous government subsidies.

Summary

In this chapter, the development of agricultural insurance was discussed, along with its advantages as a tool in mitigating risk, using graphic representations of risk-averse decision maker with and without insurance. The concept of revenue insurance was presented. A model depicting the impact of agricultural insurance under the assumption of risk aversion on resource allocation was elaborated. Other topics, including moral hazards, adverse selection, public versus private insurance schemes, and welfare considerations, were also discussed. Factors affecting the demand and supply, along with some empirical evidence, were also presented. Experiences of some developing countries with crop insurance were summarized.

In the next chapter, the MOTAD model, its data requirements, and its preparation will be elaborated, along with the methodology for incorporating various agricultural-insurance schemes into the model.

Notes

[1] This is similar to assuming that the cost of production is a function of share of land devoted to the crop, where the cost for function is homogeneous with degree zero in output in every state of nature (Kouadio, 1982, p. 14).

[2] This is valid only in risk-increasing input. If input is risk reducing, this is not necessarily valid (see Nelson, 1987).

[3] Pratt (1964) showed that with utility functions with constant relative risk aversions, profit must be strictly positive in order to have positive and diminishing marginal utility.

[4] The degree of government participation in financing crop insurance varies from program to program. Much debate has already been presented about the justification for government subsidies of insurance. According to Roumasset (1977), government support for crop insurance indicates that there is no significant demand for it; had demand been present, it would have been met by the private sector. Roumasset argues that, as government does not have any comparative advantage over the private sector in administering the scheme, creation of subsidized crop-insurance programs is a misallocation of public funds. He also argues that if crop insurance is made compulsory in order to attract large numbers of clients to make the scheme administratively and actuarially viable, then resource misallocation will take place at the farm level.

CHAPTER V: FRAMEWORK FOR ANALYSIS

A. Introduction

This chapter presents the details of the model used in this study as well as a number of practical extensions. In Part B, the formulation of the MOTAD is discussed which includes a description of the basic model and extensions. The decomposition of income variability to price and yield variability is also discussed. Part C deals with data requirements, preparation and shortfalls. Part D presents the steps followed in implementing the MOTAD model. The final part highlights the incorporation of hypothetical agricultural insurance schemes, namely yield/price insurance and revenue insurance.

B. Formulation of MOTAD Model

Hazell's (1971) Minimization of Total Absolute Deviation (MOTAD) model has been used to analyze the data in this study. On the basis of sample data on gross margins of different activities (gross revenues per dunum minus variable costs per dunum), the mean absolute income deviation, denoted by A, may be defined, using Hazell's original notation, as follows:

$$A = 1/s \sum_{h=1}^{s} \left| \sum_{j=1}^{n} (c_{hj} - g_j)x_j \right| \tag{5.1}$$

where s = number of observations in the time series gross margin date; n = number of activities in the model; c = gross margin for the jth activity on the hth observation; g = average gross margin for the jth activity; and x = level of the jth activity (in dunums).

The mean absolute income deviation as defined above accounts for the variability in gross margins of a single activity, as well as for interactions among activities affecting total income variations.

The objective is to minimize sA subject to a number of constraints which include land, crop rotation, capital, labor, marketing, family labor, etc. To convert sA to a legitimate linear-programming objective function, a procedure similar to that used by Ashar and Wallace (1963) is employed. This is achieved by defining new variables.

$$Y_h = \sum_{j=1}^{n} (c_{hj} - g_j)x_j \quad \text{(for } h = 1, 2 \ldots s) \tag{5.2}$$

such that $$sA = \sum_{h=1}^{s} |Y_h| \tag{5.3}$$

Now define new variables $\overset{+}{Y}_h$ and $\overset{-}{Y}_h$ such that

$$Y_h = \overset{+}{Y}_h - \overset{-}{Y}_h \tag{5.4}$$

and $$\overset{+}{Y}_h, \overset{-}{Y}_h \geq 0 \quad \text{(for } h = 1, 2, \ldots s) \tag{5.5}$$

$\overset{-}{Y}_h$ = absolute values of the total negative gross margin deviations around the total expected return of the hth year.

$\overset{+}{Y}_h$ = absolute values of the total positive gross margin deviations around the total expected return of the hth year.

This formulation represents Y_h by two positive numbers, $\overset{+}{Y}_h$ and $\overset{-}{Y}_h$, yet allows Y_h to be either positive or negative. Thus, $\overset{+}{Y}_h$ and $\overset{-}{Y}_h$ can be chosen in such a way that either can equal zero yet still satisfy equation (5.4).

Using this approach, Y_h could be represented as follows:

$$|Y_h| = \overset{+}{Y_h} + \overset{-}{Y_h} \tag{5.6}$$

since either $\overset{+}{Y_h}$ or $\overset{-}{Y_h}$ is always zero. Substituting $|Y_h|$ into equation (1) yields:

$$sA = \sum_{h=1}^{s} (\overset{+}{Y_h} + \overset{-}{Y_h}) \tag{5.7}$$

minimizing A is equivalent to minimizing sA since s is constant. The MOTAD model can be expressed as:

$$\text{Minimize } sA = \sum_{h=1}^{s} (\overset{+}{Y_h} + \overset{-}{Y_h}) \tag{5.8}$$

$$\text{such that: } \sum_{j=1}^{n} (c_{hj} - g_j)x_j - \overset{-}{Y_h} + \overset{+}{Y_h} = 0 \ (h = 1, 2...s) \tag{5.9}$$

$$\sum_{j=1}^{n} f_j x_j = \lambda \quad (\lambda = 0 \text{ to unbounded}) \tag{5.10}$$

$$\sum_{j=1}^{n} a_{ij} x_j \leq b_i \quad (\text{for } i = 1, 2...m) \tag{5.11}$$

$$x_j, \ \overset{+}{Y_h}, \ \overset{-}{Y_h} \geq 0 \ (\text{for all } h, j) \tag{5.12}$$

where f_j = expected gross margin of the jth activity; λ = expected net income; a_{ij} = technical requirements for the jth activity in the ith constraint; m = number of constraints; b_i = ith constraint level; and all other variables are used as defined previously.

Equations (5.9) through (5.12) are all linear in x, $\overset{+}{Y_h}$ and $\overset{-}{Y_h}$, therefore, a linear-programming algorithm can be applied to this model to minimize sA for each specified expected net income level. That is, expected income level is parametrized in equation (5.10) allowing minimization of mean absolute income deviation for each specified income level. Equation (5.11) corresponds to the ordinary linear-programming constraints, and equation (5.12) satisfies the non-negativity restrictions required for the linear-programming model.

The MOTAD model has m constraints in equation (5.11), s constraints in equation (5.9), and one constraint in equation (5.10) The total of the constraints equals m + s + 1. The model contains m + 2s activities, 2s more than the standard linear programming model because of Y_h^+ and Y_h^- (h = 1, 2, ..., s).

In this study, x_j will represent dunums allocated to the jth crop and Y_h are absolute values derived from the expected value of the hth crop. For a given farm plan:

$$Y_h^+ = |Y_h| = \left| \sum_{j=1}^{n} (c_{ij} - g_i)\, x_j \right| \tag{5.13}$$

when Y_h is positive; otherwise $Y_h^+ = 0$, so that Y_h^+ is the sum of the absolute values of the positive total gross margin deviates around the expected return, based on sample mean gross margins. Similarly, $Y_h^- = |Y_h|$ when Y_h is negative; otherwise $Y_h^- = 0$. Since g_j (j = 1, 2, ..., n) are sample mean gross margin, the sum of the absolute values of the negative total gross margin deviations must be equal to the sum of the positive total gross margin deviations, therefore equation (5.8) can be written as:

$$A = 2/s \sum_{h=1}^{s} (Y_h^-) \tag{5.14}$$

The minimization of A is equivalent to minimizing sA/2 as 2/s is constant. This suggests the formulation of MOTAD model in terms of Y_h only. This model is specified as follows:

$$\text{Minimize: } \sum_{h=1}^{s} \bar{Y}_h \tag{5.15}$$

$$\sum_{j=1}^{n} (c_{ij} - g_i)x_j + Y_h > 0 \tag{5.16}$$

$$\sum_{j=1}^{n} f_j x_j = \lambda \quad (\lambda = 0 \text{ to unbounded}) \tag{5.17}$$

$$\sum_{j=1}^{n} a_{ij} x_j \leq b_i \quad (\text{for } i = 1, 2, \ldots m) \tag{5.18}$$

$$x_j, \ \bar{Y}_h > 0 \ (\text{for all } h, j) \tag{5.19}$$

Equations (5.15) to (5.19) can be identified as Model A2.

This formulation is equivalent to the initial model involving the minimization of the sum of absolute values of gross margin. It is also a linear-programming problem which can be solved by conventional linear-programming codes with parameter options, and leads to the same results as the initial model in equation (5.1)

Equations (5.15) and (5.16) are the only equations that are different in the initial specification.

If, $\sum_{j=1}^{n} (c_{ij} - g_j)x_j < 0$, equations (5.15) and (5.16) result in

$$\bar{Y}_h = \left| \sum_{j=1}^{n} (c_{ij} - g_j)x_j \right| \tag{5.20}$$

and if $\sum_{j=1}^{n} (c_{ij} - g_j)x_j > 0$

then, equations (5.16) and (5.15) result in $\bar{Y}_h = 0$. This version is superior to the previous one as it requires only n + s activities, unlike the first which requires n + 2s.

The second version (equations (5.2) through (5.20)) was used for risk analysis and _ex ante_ evaluation of various hypothetical crop insurance scenarios in the rainfed agricultural sector of Jordan. This can be presented in a matrix format.

$$\text{Minimize } 1d^{-} \tag{5.21}$$

$$\text{such that } AX \leq B \tag{5.22}$$

$$Dx + Id^{-} \geq 0 \tag{5.23}$$

$$F'X = \lambda \quad \text{and } X, d^{-}, \lambda \geq 0 \tag{5.24}$$

where X = activity decision vector, as defined before; A = a matrix of input parameters; B = a vector of resource availability; F = a column vector of expected gross margins; D = a deviation matrix representing the difference between actual and gross margins and expected gross margins in a particular year; and d^{-} is a vector representing the total negative deviations summed over the years and multiplied by a row vector of ones (1's).

I is an Identity matrix. λ in the gross-margin constraint is a sector (defined previously) to be parametrized to determine a set of risk-efficient farm plans, and to trace the least-risk-efficiency frontier in the space of expected gross margin and total negative deviations (see Table 5.1).

If $1d^{-}$ is employed as a risk measure, then farm plans having minimum total negative deviation for a given expected total gross margin

Table 5.1 Initial MOTAD Tableau

Resources or Restrictions	DECISION VARIABLES						Constraints
	x_1	x_2	x_n	d^-_1	d^-	d^-	
Objective				1	1	1	Minimize
Resource 1	a_{11}	a_{12}	a_{1n}				B_1
Resource 2	a_{21}	a_{22}	a_{2n}				B_2
.		.	. . .				.
	.	.	.				
.			. . .				
Resource m	a_{m1}	a_{m2}	. . a_{mn}				B_m
Year 1	D_{11}	D_{12}	D_{1n}	1			0
Year 2	D_{21}	D_{22}	. . D_{2n}		1		0
	.						
.			.				
Year S	D_{1S}	D_{1S}	D_{Sn}			1	0
Gross Margin	F_1	F_2	. . . F_n				=

level are selected. If, however, risk measure is defined in terms of standard deviation, then ld^{-} according to Hazell (1971), Hazell and Scandizzo (1974), and Brink and McCarl (1978), could be extended by:

$$(ld^{-}) \cdot (2/s)\{\pi s/2(s - 1)\}^{1/2} \qquad (5.25)$$

where s is the number of years in a time series (= 22/7), provided that the population is normally distributed.

Assumption and Properties of the Model

The use of MOTAD requires that a certain number of assumptions be made at the outset.

a) MOTAD assumes that farmers' preferences between alternative farm plans can be explained by the expected income-absolute deviation utility function, that farmers maximize expected utility, and that utility is a function of return and return variability. There is no need to specify the functional form of utility function.

b) The probability distribution of gross margin for alternative farm plans is normally or approximately normally distributed.[1]

c) Ex post analysis of farm plans on the basis of past time-series data can be expected to result in an ex ante analysis which could hold for the foreseeable future. Cost of production causes no variation in gross margins. The only sources of constraint are yields and prices. This analysis does not necessarily hold true for long-term planning.

The approach employed in this study will use the original specification of MOTAD as proposed by Hazell (1971). In addition, the relationship between the shadow value of the expected gross constraint will be used to estimate the Pratt risk-aversion co-efficient at each optimal farm plan. This way, price and yield stabilization, as well as insurance schemes, could also be evaluated in relation to the risk-aversion parameter.

Results of the MOTAD model provide the least-risk-efficiency frontiers. Any specific policy instrument when introduced to the initial situation may change the original least-risk-efficiency frontier by shifting it upward or downward, and/or by changing its slope. Such a change in the frontier may be associated with changes in crop mix, land allocation, expected gross margin and the level of risk.

There are two steps in the process of modelling. The first is to formulate the model as a profit-maximizing problem, in which the maximum expected total gross margin is subject to the given resource constraints. The second is to reformulate the problem as a minimization of total negative deviations over the sample years, subject to the resource constraints and a given expected total negative margin, as specified in equations (5.20) to (5.24).

Confidence Intervals

The total negative deviation of optimal farm plans was used to estimate their variance (see equation (5.25)). This variance is a population variance only when the population is approximately normally distributed (Davis and Pearson, 1934).

Using the expected total gross margin associated with the optimal farm plans and the normal tables, the following confidence limits would be estimated (Anderson, 1975).

$$P\ (G < 0) = P_0$$

$$P\ (G_1 < G < G_2) = P_a \qquad (5.26)$$

P_0 denotes the probability that the optimal farm gross margin falls below zero, while P_a represents the probability that the optimal farm gross margin falls below G_1 and G_2.

Linear Risk Programming as a Maximization Problem

The minimization problem of the MOTAD linear-risk programming discussed in equations (5.20)-(5.24) can be expressed in lagrangian format:

$$\text{Min. } H_1 = 1d^- + k_1'(-B + Ax) - k_2'(Id^- + Dx) + k_3'(\ - F'X) \qquad (5.27)$$

where 1 is a 1xs vector of ones, d^- is a sx1 column vector. k_1, k_2 are row vectors representing shadow values relating to the resource constraint and the total negative deviation constraint. k_3 is a scalar representing the shadow value of the expected gross margin constraint.

The maximization equivalent of the problem in equations (5.20)-(5.24) can be expressed as a lagrangian form:

$$\text{Max. } H_2 = F'X - R_a 1d^- + r_1'(B - Ax) + r_2'(Id^- + DX) \qquad (5.28)$$

Where R_a is the Pratt risk-aversion parameter and r_1 and r_2 are vectors representing the shadow values associated with the relevant constraints. The other variables are as defined above.

MOTAD procedure involves varying the amount of expected gross margin λ. Equation (5.27) will generate a least-risk-efficiency frontier identical to the one which could be generated by (5.28) (Anderson *et al.*, 1975). λ is bounded $0 < \lambda < M^*$ where M^* is the risk-neutral level of expected gross margin.

Since A, B, and d^- are the same for equations (5.27) and (5.28), an optimum farm plan X_0 implies that the right-hand side of the expected gross margin constraints in equation (5.25) equals the objective function value FX_0 in equation (5.28).

The necessary and sufficient conditions for minimizing the condition in equation (5.27) are

$$(\partial H_1/\partial X)\Big|_{X = X_0} = 1(\partial d^-/\partial X) + k_1'A - k_2'I(\partial d^-/\partial X) - k_2'D + k_3'F' < 0 \quad (5.29)$$

$$(\partial H_1/\partial X)\Big|_{X = X_0} \cdot X = 1(\partial d^-/\partial X)X + k_1'AX - k_2'I(\partial d^-/\partial X)X - k_2'DX + k_3'F'X = 0 \quad (5.30)$$

The necessary and sufficient conditions for maximizing equation (26) are:

$$H_1/\partial X\Big|_{X = X_0} = F'-R_a 1(\partial d^-/\partial X) - r_1'A + r_2'I(\partial d^-/\partial X) + r_2'D > 0 \quad (5.31)$$

$$H_1/\partial X\Big|_{X = X_0} \cdot X = F'X - R_a 1(\partial d^-/\partial X)X - r_1'AX + r_2'I(\partial d^-/\partial X)X + r_2'DX = 0 \quad (5.32)$$

From equations (5.30) and (5.32) by transferring $F'X_0$ in both equations and comparing the terms, it follows that $R_a = 1/k_3$, since k_3 is a scalar.

This is consistent with Freund's (1964) interpretation of R_a. The risk-aversion parameter can therefore be explicitly defined as an "imputed shadow value which reflects the opportunity costs of foregoing or gaining income by accepting or rejecting an additional unit of money" (Turvey, 1986). This approach will be used in this study to evaluate farmers' attitudes towards risk.

R_a represents the last unit of risk the farmer is willing to take when resources are fully utilized, that is when certainty equivalent is positive (Paris, 1979; Weins, 1980).

The shadow values of the constraints change only when a change in basis occurs. This implies that the shape of the least-risk-efficiency frontier could theoretically change when the change in basis occurs. Thus in order to trace the least-risk-efficiency frontier, λ will be changed at suitable intervals, within which the change-in-basis solution are recorded.

The maximum value for λ is the risk-neutral gross margin. When resources are not fully utilized, the frontier tends to have a curvature. This is obviously so, because the shadow value of the constraints are not zero (Turvey, 1986).

Assessment of Yield/Price Variability

Income variability is broken down into its components: variability caused by prices, variability caused by yields and variability caused by the interaction of yield and price. The formula used is found in Houck (1974) and Matthew (1984) and summarized as:

$$\begin{aligned} Vr(P\,Y) = {} & (E(Y))^2 Vr(P) + (E(P))^2 Vr(Y) + 2E(P)\cdot E(Y)Cov(P,Y) + \\ & 2E(P)\cdot E\{(P-E(P))\cdot(Y - E(Y))\} - Cov(P,Y) + \\ & 2E(P)\cdot E\{(P-E(P))\cdot(Y - E(Y))\} + 2E(Y)E\{(P - E(P))(Y - E(Y))\} \end{aligned} \quad (5.33)$$

where $Vr(\cdot)$ = variance; Y = crop yield (kgs/dunum); P = crop price; Cov = covariance; E(P) = expected price; and E(Y) = expected yield.

Equation (5.31) can be rewritten as follows:

$$var(PY) = \underset{\text{variation}}{\text{price}} + \underset{\text{variation}}{\text{yield}} + \underset{\text{interaction of price/yield}}{\text{variation due to}}$$

where price variation can be approximated by the first term divided by the total of the right-hand side. Similarly, yield variation is approximated by the second term divided by the total of the right-hand side. The third term represents variation in income caused by the interaction between yield and price. E(P) and E(Y) are approximated by their respective sample means.

C. Data Preparation for MOTAD

The MOTAD model data requirements are:

- calculation of gross margins for 1975-1985; and
- standard-linear programming requirements, that is, land constraints, cropping rotation.

It is assumed that production costs do not cause any variation in gross margins; thus, calculation of gross margin deviation is accomplished by calculating deviations in total returns around the average total returns.

Estimates of annual gross margin for each crop without insurance were calculated by multiplying the actual yield per annum by 1985 adjusted prices and subtracting 1985 total production variable costs.

Yields and Prices

Yield data were obtained from the annual crop-cutting surveys conducted in the study area by the Ministry of Agriculture each year from 1975 to 1985. It is recognized that aggregate data in a specific region tend to underestimate yield variability at the farm-level, as shown by Eisgruber (1963). Recently, Siegfried (1985) showed that in Kentucky farm-level mean yields for corn, soybeans, wheat and tobacco were significantly above the county aggregate mean yield. The yield variance for the same farm-level data exceeded estimated farm-county aggregate data, implying that county aggregate yield variance underestimates farm-level variances.

Siegfried also derived, using MOTAD procedure, the least-risk-efficiency frontier for both county- and farm-level data. She found that the least-risk-efficiency frontier derived from county aggregate yield data dominates the frontier generated by the farm-level yield data. This indicates that at each level of risk the county level yield data overestimates the feasible expected gross margin.

Similarly, experimental data also tend to underestimate the yield variability because of their irreplicability. There is no empirical evidence available to demonstrate which data to use when farm-level data are not available. As there are no long-term experimental yield data on any of the crops under consideration in this study, this situation did not arise. Furthermore, available data from experiments carried out under the USAID Jordan Wheat Project (1976) and other agency-funded projects show similar or even higher variability of yield, in spite of the controlled environment.

Time series data from 1975 to 1985 were used in this study. Yield data were tested and adjusted for trend using simple linear regression (Y(t)=a+bt). Crop prices were those prices received by farmers after harvesting, adjusted for the 1985 price level using the index for prices received for all crops. The price series was also tested and adjusted for trend using simple linear regression.

Crop Budgets

Crop budgets are required for all the crops involved. Variable costs and net returns for each crop were computed using published 1985 crop-enterprise budgets.

To arrive at crop budgets for capital-intensive practices, both the cost of production and yield were adjusted using the research finding (see Chapter II). These adjustments reflect the minimum and maximum increase in yield achieved by various projects, that is, 30 and 70 percent of the observed yield average over the period under analysis.

Machinery was assumed to be available through the cooperative agricultural machinery station at Irbid. The agricultural season was divided into three sub-periods corresponding to the major operations carried out on the farm (November-January, February-May, June-September). The hired-labor constraint was set to reflect labor scarcity in the study area (Seccombe, 1981). Family labor constraints were set at a maximum of 86 man-days (Snobar, 1984; IFAD, 1986).

Family consumption requirement constraints were set equal to the average yearly consumption per head, that is 945 kgs of wheat, 420 kgs of barley and 150 kgs of lentils. These constraints were derived from the results of the 1983 Agricultural Census, and verified by published consumption statistics in Jordan (Haddad, 1985).

The land constraint was placed at 76 dunum, the average land holding for small farms in the study area. Land-renting activity is allowed for in the model at an ongoing rental fee of 2.5 JD/dunum (JCO, 1987). The operating-capital constraint reflects the practice of agricultural credit in Jordan, so that 80 percent of the total requirement is provided by credit institutions.

While 20 percent of the total requirement of operating capital is provided by the farmer himself, farmers' own funds are assumed equal to about 60 dinars (see IFAD's Small Farmers Agricultural Credit Project Appraisal Report, 1983). The annual interest rate is the ongoing rate of 7 percent. The full linear-risk model is provided in Table 5.2.

D. The MOTAD Implementation Procedures

Initially, the MOTAD procedure is used to determine an optimal alternative farm plan for the typical small farmer practicing labor-intensive cultivation techniques in the study area. Crop mix, expected gross margin, and trade-offs between risk (as measured by total negative deviation) and expected farm income associated with the optimal farm plans will be determined.

The traditional cultivation techniques, discussed in Chapter II, involve three crops (wheat, barley and lentils) and fallow in two- and three-year rotations. Traditional fallow, as discussed in Chapter II, is assumed, in the absence of chemical fertilization and herbicides, to be part of the ecological and cultural process which produces the observed yields for the crops concerned. This implies that the average annual production foregone by practicing traditional fallow is equivalent to the expected yield loss which may arise from deterioration of soil fertility as a result of permanent cropping. This appears to be a reasonable assumption because time-series data on cropping patterns over the last 11 years in the study area show an average yearly fallow of about 30 percent.

Table 5.2 INITIAL MOTAD MODEL UNDER LABOR-INTENSIVE PRACTICES

Activities			W/F	B/F	W/B/F	W/B/L	W/L	CONW	CONB	CONL	BREND	HLAB1	HLA2	HLAB3	RLAND	d1	d2	d3	d4	d5	d6	d7	d8	d9	d10	d11	
Objective Function			0 0	0 0	0 0	0.0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	1 0	1 0	1 0	1 0	1 0	1 0	1 0	1 0	1 0	1 0	MIN
Restraints	Column	Sign																									
Land	76.0	L	1 0	1 0	1 0	1 0	0 0	0 0	0 0	0 0	0 0				-1 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	
Own Fund	60 0	L	2 1	1 8	2 6	6.0	7.1	0 0	0 0	0 0	-1.0				0.0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	
FI (July-Sept)	86 0	L	0 4	0 3	0 4	1.9	2.8	0 0	0 0	0 0	0 0	-1 0			0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	
FI (Oct-Jan)	86 0	L	0 5	0 5	0 6	2 9	4 2	0 0	0 0	0 0	0 0		-1 0		0 0	0 0	0 0	0 0	0 0	0.0	0 0	0 0	0 0	0 0	0 0	0 0	
FI (Feb-June)	86 0	L	0 5	0 5	0 6	3.0	4 3	0 0	0 0	0 0	0 0			-1 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	
Credit Limit	304 0	L	0 0	0 0	0 0	0.0	0.0	0 0	0 0	0 0	0 0				0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	
Wheat Pool	0 0	L	-42 0	0 0	-28.6	-28 6	-42.9	1 0	0 0	0 0	0 0				0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	
Barley Pool	0 0	L	-0 0	-31 6	-21 1	-21.1	0 0	0 0	1 0	0 0	0 0				0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	
Lentils Pool	0 0	L	0 0	0 0	0 0	-26 3	-39 4	0 0	1 0	0 0	0 0				0 0	0.0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	
Wheat Cons	945 0	G						1 0																			
Barley Cons	420 0	G							1 0																		
Lentils Cons	150 0	G								1 0																	
LABH (July-Sept)	100 0	L										1.0															
LABH (Oct-Jan)	50 0	L											1 0														
LABH (Feb-June)	60 0	L												1.0													
LANDR	60 0	L													1 0												
GMDH1975	0 0	G	0.1	-1 1	0 7	-0 9	-0 3	0 0	0 0	0 0	0 0				0.0	1 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	
GMDH1976	0 0	G	0 7	-0 2	0 3	1 1	1 0	0 0	0 0	0 0	0 0				0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	
GMDH1977	0 0	G	0 8	-0 2	0 4	1 4	2 3	0 0	0 0	0 0	0 0				0 0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	
GMDH1978	0 0	G	1 2	1 0	1 5	3 1	3 6	0 0	0 0	0 0	0 0				0 0	0.0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	
GMDH1979	0 0	G	2 7	2 0	3 2	6.7	8.1	0 0	0 0	0 0	0 0				0 0	0 0	0 0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	0 0	
GMDH1980	0 0	G	-4 1	-2 1	-4 2	-8 6	-10 6	0 0	0 0	0 0	0 0				0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	
GMDH1981	0 0	G	-0 7	0 1	-0 4	-1.9	-2 9	0 0	0 0	0 0	0.0				0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	
GMDH1982	0 0	G	2 4	1 2	2 4	2 7	2.9	0 0	0 0	0 0	0 0				0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	0 0	0 0	
GMDH1983	0 0	G	-5 3	-1 2	4 3	-6 7	-8 9	0 0	0 0	0 0	0 0				0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	0 0	
GMDH1984	0 0	G	1 9	0 7	1 7	2 3	2 6	0 0	0 0	0 0	0 0				0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	
GMDH1985	0 0	G	0 3	0 1	0 9	-6 7	1 5	0 0	0 0	0 0	0 0				0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	
Average Gross Margin		E	4 9	2 9	5.2	10 6	13 0	0 0	0 0	0 0	-0 1	-3.5	-3 5	-3 5	-3 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	

Although no research in Jordan has been carried out to estimate the economic value of weeds growing on the traditional fallow, some results from Turkey suggest that the value of weeds growing on traditional fallow is higher than the value of an additional increase in yield, if clean fallow is practiced (Mann, 1980).[1]

In this study an ex post value not exceeding the results arrived at in Turkey are considered with and without variability. To explore the effects of yield and price variability on income variability, the MOTAD model will be implemented by fixing, one at a time, the prices and the yields at their respective 11-year averages.

E. Treatment and Incorporation of Insurance

In this study, three types of hypothetical agricultural insurance are incorporated into the linear-risk analysis. The first type is an actuarially fair insurance scheme, involving revenue insurance and yield/price insurance. The coverage rate is 80 percent of the average gross margin. When any of the 11 observations on gross margins was less than 80 percent of the average value, the difference between the actual gross margin and 80 percent of the average gross margin is remanded to the producer as an indemnity. The total indemnity mandated over the period under examination is divided by the number of years to arrive at an annual premium. The insured stream of gross margins equals actual gross margin each year, minus the annual premium, plus the indemnity payment, when applicable.

Obviously, the mean gross margin remains at the same level as without insurance; the variance and the co-efficient of variations are reduced, since the fluctuations of the gross margin are smoothed. It should be noted that since total variable costs are assumed to cause no variability in income, insurance applied to revenues or to gross margin results in the same conclusions.

Incorporation of price/yield insurance into the MOTAD model requires slightly different calculations. The gross-margin insured stream was calculated so that when either the price or yield falls below 80 percent of their respective mean value, price indemnity equal the difference between the insured price and the actual price received, multiplied by the insured yield. If, on the other hand, yields fall below 80 percent of the average yield, the indemnity paid equals the difference between the insured yield and the actual yield, multiplied by the insured price. The insured gross-margin stream for price/yield insurance is a result of the sum of the product of the actual yield and its price, the price indemnity and the yield indemnity, and the netting out of the annual premium.

Since price/yield insurance is an actuarially fair scheme, it preserves the mean and reduces the variance of the gross-margin stream. These two types of insurance are used in the cases of traditional and capital-intensive agricultural practices under various scenarios.

Normality Assumptions of the Crop Yields and Insurance

This approach will also be used to estimate the annual premium indemnity under a number of scenarios. This type of insurance is based on the method developed by Botts and Boles (1958). This insurance is similar to that offered in most countries that have opted for crop insurance. It basically offers protection against yield fluctuations, but no coplete protection against price variability. The validity of this type of insurance depends on whether yield distribution is symmetrical. Fifty precent, 65 percent, and 80 percent (of the average historical yield in the study area) insurance schemes for yield will be proposed and the linear-risk analysis will be applied. The method used to incorporate this type of insurance into the MOTAD model is similar to the method used for the actuarially fair scheme. This type of insurance is not mean-preserving and may not reduce the variance either.

Summary

In this chapter, a complete mathematical formulation of the MOTAD model was presented, including its property and assumptions, data preparation, and full specification, along with a mathematical relationship showing an intuitive approach to deriving the level of risk aversion from the MOTAD model without the need to reformulate the model. An outline of the proof was provided.

The next chapter will provide the empirical results of the MOTAD application in deriving optimal farm plans and risk-efficiency frontiers for the options set out in Chapter I.

Notes

[1]Levey and Markowitz (1979) have shown that E - V approach is a close approximation to a wide range of situations where the normality assumption does not hold.

[2]The proof relates a risk-aversion parameter to the inverse of the shadow value of the gross margin constraint in minimization of the total negative deviation problem. This proof is, however, provided for by the quadratic programming programme in which a constant risk aversion parameter and a trend utility function is utilized. The results have been extended by the author to MOTAD for which an outline of the proof is provided.

[3]"The crude protein content of the weeds was about 60 percent that of the barley. This differential coincides quite closely with what was reported by the farmers. Conservatively, it appears that the value of the weeds as forage in the spring of 1977 was at least 1 TL/kg.

For the 1977 harvest, the wheat price was approximately 3 TL/kg. This means that for every three kilograms dry weight of weeds plowed under, the farmer would have to realize more than one additional kg of wheat from the practice (i.e., clean fallow) in order to justify it economically," (Mann 1980, p.98).

CHAPTER VI: FARM RISK ANALYSIS

A. Introduction

This chapter examines the potential trade-offs between expected net income and income variability under different crop-diversification plans. It also examines the separate effects in Jordan of yield and price variability on income variability. The chapter is divided into seven sections. Section A summarizes some relevant statistical indicators, while Section B presents the results of optimum crop diversification, assuming risk neutrality, using classical linear programming. In section C, the initial efficiency frontier (IEF) is derived employing the MOTAD procedure, and the results are discussed in terms of crop mix, resource allocation, and income variability. Section D explores the sources and magnitudes of yield fluctuations, and their effect on income variability by deriving the IEFs for price and yield. Section E deals with income variability arising from price variability. Section F analyzes why small farmers showed so little interest in adopting improved capital-intensive agricultural practices between 1975 and 1985. Sections C through F also employ the MOTAD procedures. Section G provides a summary and conclusion of the chapter.

B. Data Summary

Treatment of Fallow

The approach used in this thesis, and particularly in this chapter, is based on the assumption that fallow provides an additional economic value associated with voluntary weeds as grazing materials. Since no agronomical research has been carried out in Jordan to establish the magnitude of the value of voluntary weeds, the approach in this study though arbitrary is based on results of some research which was carried out elsewhere in the region (Mann, 1980).

The economic value of weeds in the context of the traditional labor-intensive agricultural practices (as grazing materials for the farmers' small ruminants) has been incorporated in farm budgets in two different ways:

(i) value of weeds was assumed to be fixed with no variability and given arbitrary values, JD 0.0-JD 0.5 and JD 1.00 per dunum of fallow land on the farm; and

(ii) the value of weeds was assumed to be equal to 60% of the value of the yield per dunum of barley, it was further assumed that the weeds' production variability was reduced to reflect certain agronomical assumptions which speculate that weeds are more efficient in moisture use than cereal crops. Average weed yield was maintained but variability was reduced by 50%.

Calculation of the coefficient of variation and standard deviation of the net income per dunum[1] for the three crops under consideration (wheat, barley, lentils) shows that the net income per dunum of the wheat crop exhibits the least variation, followed by barley, and then lentils (Table 6.1).

Crop rotations involving fallow have a risk-pooling effect in that they reduce both net income and income variance. A three-year crop rotation, wheat/fallow/barley for example, reduces the net income per dunum below that for wheat (the crop with the highest net income per dunum) but maintains it above barley's net income per dunum. The variance is reduced in the same way. The wheat/fallow/barley rotation for example, generates a net income of dunum JD 2.460/dunum with a standard deviation of JD 2.29/dunum and a coefficient of variation of 85.6 percent. Net income per dunum of composite crops involving fallow in a two- or three-year rotation is relatively more stable than the income for the individual crops involved. The zero cost of production of weed and the pooling affect of fallow tend to stabilize the per dunum net income of each rotation involving fallow as compared to the situation of continuous cropping.

Table 6.1: Traditional Fallow: Average Net Income per Dunum Standard Deviation and Coefficient of Variation for Different Values of Fallow

Crops	Fallow = 0.0 Net Income JD/du	STD JD/du	CV %	Fallow = 0.5 Net Income JD/du	STD JD/du	CV %	Fallow = 1.0 Net Income JD/du	STD JD/du	CV %
Wheat	5.689	4.87	85.58	5.689	4.87	85.58	5.689	4.87	85.58
Barley	1.693	2.28	134.79	1.693	2.28	134.79	1.693	2.28	134.79
Lentils	4.477	6.12	136.67	4.477	6.12	136.67	4.477	6.12	136.67
Wheat/Fallow[b]	2.844	2.43	85.58	3.095	2.43	78.66	3.345	2.43	72.78
Barley/Fallow	0.846	1.14	134.79	1.096	1.14	104.06	1.346	1.14	84.74
Wheat/Fallow/Barley[c]	2.460	2.29	93.17	2.627	2.29	87.26	2.794	2.29	82.06
Wheat/Lentils/Barley[d]	3.956	4.21	106.50	3.956	4.21	106.50	3.956	4.21	106.50
Wheat/Lentils	5.083	5.29	104.26	5.083	5.29	104.26	5.083	5.29	104.26

[a]The imputed value of fallow, as weeds, is assumed to range between JD 0.0 and JD 1.0 per dunum with no variability.
[b]This is a two year crop rotation involving wheat and fallow.
[c]This is a three year crop rotation involving wheat, fallow and barley.
[d]This is a three year crop rotation involving wheat, barley and fallow.

If a dunum of fallow generates JD 0.5/dunum, the coefficient of variation of the composite crop wheat/fallow/barley declines from 93.17 to 87.26 percent. If the value of fallow is increased to JD 1.00/dunum, the coefficient of variation of the same composite crop declines further, to 82.06 percent. As the value per dunum of fallow increases, net income/dunum generated by a two-year crop rotation involving fallow becomes relatively more stable than that of the individual crops involved. This result, though trivial because the return to fallow is assumed constant, its implication in the analysis of risk is very important, as shall be seen later.

Similar results are obtained if weedy fallow is assumed to produce an imputed economic value proportional to barley yield. The coefficient of variation for wheat/fallow/barley declines from 93.17 percent, in the case where the fallow value is assumed to be zero (Table 6.1), to 77.23 percent when the value of fallow is assumed to be proportional to the yield of barley (60 percent of the barley yield). The standard deviation, on the other hand, has increased slightly from JD 2.29 to JD 2.72. When variability of fallow yield is reduced by 50 percent the coefficient of variation declined further to 73.42 percent (see Table 6.2) while the standard deviation increased slightly.

In Table 6.2, the net income per dunum of wheat/fallow is reduced by about 23 percent while the standard deviation is reduced by 38 percent, as compared to wheat as a continuous crop. For the barley/fallow rotation, the net income per dunum increased by 43 percent while the standard deviation was reduced by 31 percent, as compared to barley as a continous crop. Similar results are also observed in three-year crop rotations involving fallow namely wheat/fallow/barley.

Table 6.2: Traditional Fallow: Average Net Income per Dunum Standard Deviation and Coefficient of Variation for Different Values of Fallow

Crops[c]	Fallow Yield Equals 60% of Barley Yield with the same Barley Yield Variability[a]			Fallow Yield Equals 60% of Barley Yield with a 50% Reduction in Variability[b]		
	Net Income JD/du	STD JD/du	CV %	Net Income JD/du	STD JD/du	CV %
Wheat	5.69	4.87	85.58	5.69	4.87	85.58
Barley	1.69	2.28	134.79	1.69	2.28	134.79
Lentils	4.45	6.12	136.67	4.48	6.12	136.67
Wheat/Fallow[d]	4.43	3.03	65.58	4.43	2.83	63.79
Barley/Fallow	2.43	1.83	75.02	2.43	1.64	67.51
Wheat/Fallow/ Barley[e]	3.52	0.72	77.23	3.52	2.58	73.42
Wheat/Lentils/ Barley[f]	3.95	4.21	106.5	3.95	4.21	106.5
Wheat/Lentils	5.08	5.30	104.26	5.08	5.30	104.26

[a]The imputed value of fallow as weeds is assumed to be equal to 60% of barley yield with no variability.

[b]The economic imputed value of fallow as weeds is assumed to be equal to 60% of barley yield with yield variability assumed to be equal to 50% of barley yield variability.

[c]The difference between (a) and (b) is manifested only in the variability of the yield of fallow, the net income per dunum is maintained the same by design.

[d]This is a two year crop rotation involving wheat and fallow.

[e]This is a three year crop rotation involving wheat, fallow and barley.

[f]This is a three year crop rotation involving wheat, barley and fallow.

It should be noted that the analysis presented above pertains to the net income per dunum and not to the overall farm plan.

To summarize, imputed value for fallow makes crop rotations involving fallow more attractive under all three scenarios mentioned above although the net income per dunum of each of the rotations (two and three-year rotations) is slightly reduced, the variability of the net on a per-dunum basis is also reduced substantially. The important point is that the percentage decline in net income is much less than the percentage decline in the variability of income, which suggests that crop rotations involving fallow may be risk efficient, as we shall see later. This is validated by a comparison between crop rotation involving fallow and continuous cropping.

Table 6.3: Average Net Income per Dunum, Standard Deviation and Co-efficient of Variation - Traditional Fallow

	Case 1			Case 2			Case 3		
Crop	Net Income JD/du	SD	CV	Net Income JD/du	SD	CV	Net Income JD/du	SD	CV
Continuous Wheat	5.69	4.87	85.58	5.69	5.87	85.58	5.69	4.87	85.58
Wheat/Fallow	3.34	2.43	68.27	4.43	3.03	68.27	4.43	2.83	63.79
Wheat/Fallow/Barley	2.79	2.29	77.23	3.52	2.72	77.23	3.52	2.58	73.42

Case 1 assumes fallow generates JD 1.00/dunum with no variability.
Case 2 assumes fallow generates a value proportional to the yield of barley, and variability of fallow yield is the same as that of barley yield.
Case 3 assumes fallow generates a value proportional to the yield of barley, and its variability is reduced by 50% of that of barley.

Breakdown of Income Variability

Using equation (5.23), income variability is broken down into variabilities of price and yield, and into the interaction between price and yield (Table 6.4).

It is reasonable to conclude from Table 6.4 that yield fluctuation is the main source of income variability. However, it is difficult to accurately interpret the interaction between price and yield, and caution must be exercised in concluding that price fluctuation is an insignificant source of income variability (if demand is downward sloping; the price and yield covariation will be negative).

Table 6.4: Breakdown of Per Dunum Net Income Variability[a]

	Total Variation	Variation in Net Income Caused By		
		Price	Yield	Price/Yield Interaction
Wheat	100%	13.35	47.16	39.49
Barley	100%	15.86	88.37	-4.24
Lentils	100%	24.70	42.27	33.02

[a]Costs are assumed to cause no variability in gross income.

C. Farm Organization and Profit Maximization

The farm plan that maximizes expected gross margin (risk-neutral) subject to the set of constraints discussed in Chapter V using linear programming (LP) is considered first.

The maximum expected gross margin was JD 224 (see Table 6.5). The profit-maximization plan calls for planting 34.13 dunums of wheat, 6.6 dunums of barley, 6.13 dunums of lentils and 28.54 dunums of fallow. The production is carried out in a combination of one two-year rotation involving wheat/fallow, and two three-year rotations involving barley/fallow/wheat and wheat/lentils/barley.

The risk-neutral profit-maximization plan does not change as positive value of fallow is incorporated. However, when the imputed value of fallow is parametrized as explained in the previous section, the expected gross margin changes accordingly (see Table 6.5). In all cases, the resulting farm plans are dominated by the wheat/fallow rotation: barley/fallow does not figure in the optimal farm plan. The marginal revenue generated by devoting an additional dunum to barley/fallow rotation, given the constraints of the LP, is lower than the marginal revenue for wheat/fallow rotations. The risk associated with risk-neutral farm plans is obviously higher in the case where fallow yield variability was assumed to follow that of barley (see Table 6.5). A wheat/lentil rotation is a different case since lentil production is sensitive to labour and capital constraints.[3] Even so, when the credit limits and land constraints are relaxed, the wheat/fallow rotation prevails, leading to a farm plan which specializes entirely in that rotation.[1]

Table 6.5: Risk-Neutral Profit-Maximization Farm Plan vs. Imputed Value of Fallow (JD/du)

Enterprise	Units	Fallow Value Fixed at: 0.0[a]	0.5[b]	1.0[c]	Proportional to Barley Yield[d]
Wheat/Fallow	Dunum	56.07	56.07	56.07	56.07
Wheat/Fallow/Barley	Dunum	1.54	1.54	1.54	1.54
Wheat/Lentils/Barley	Dunum	18.38	18.38	18.38	18.38
Expected Net Income	JD	224.10	238.43	252.65	314.89
Total Negative Deviation	JD	907.45	907.45	907.45	1,014.01
STD of Net Income	JD	216.88	216.88	216.88	242.35
CV of Net Income	Percent	96.76	90.96	85.84	76.96
Fallow as Percentage of Cropped Land	Percent	60.15	60.15	60.15	60.15
Fallow as Percentage of Total Land Holding	Percent	37.55	37.55	37.55	37.55

[a]No economic value is imputed to fallow crops (i.e., weeds at a fixed value per dunum)
[b]Fallow weeds are assumed to produce equivalent to JD 0.5
[c]Fallow weeds are assumed to produce equivalent to JD 1.0
[d]Fallow weeds are assumed to be proportional to barley crop, i.e. 60 percent of barley yield with its variance reduced by 50%.

D. The Initial Efficiency Frontier

The expected gross margin-total negative deviation frontier was traced by parametrically varying the expected gross margin constraint.[5] The initial-efficiency frontier (IEF) represents the minimum-risk farm plan for each level of expected total returns over variable costs. Figure 6.1 shows the IEF for the representative small land holding under study. Each point on the frontier represents a minimum-risk farm organization for the corresponding level of expected gross margin.

The slope of the IEF, between changes in basis solution, is constant (see Chapter V). The slope flattens gradually as gross margin increases. This is consistent with similar work done in this area using quadratic programming (Turvey et al., 1986). Since the slope of the frontier at each line segment generated by changes in basis solution is the inverse of the marginal risk, this implies that there is additional risk per JD as the margin increases.

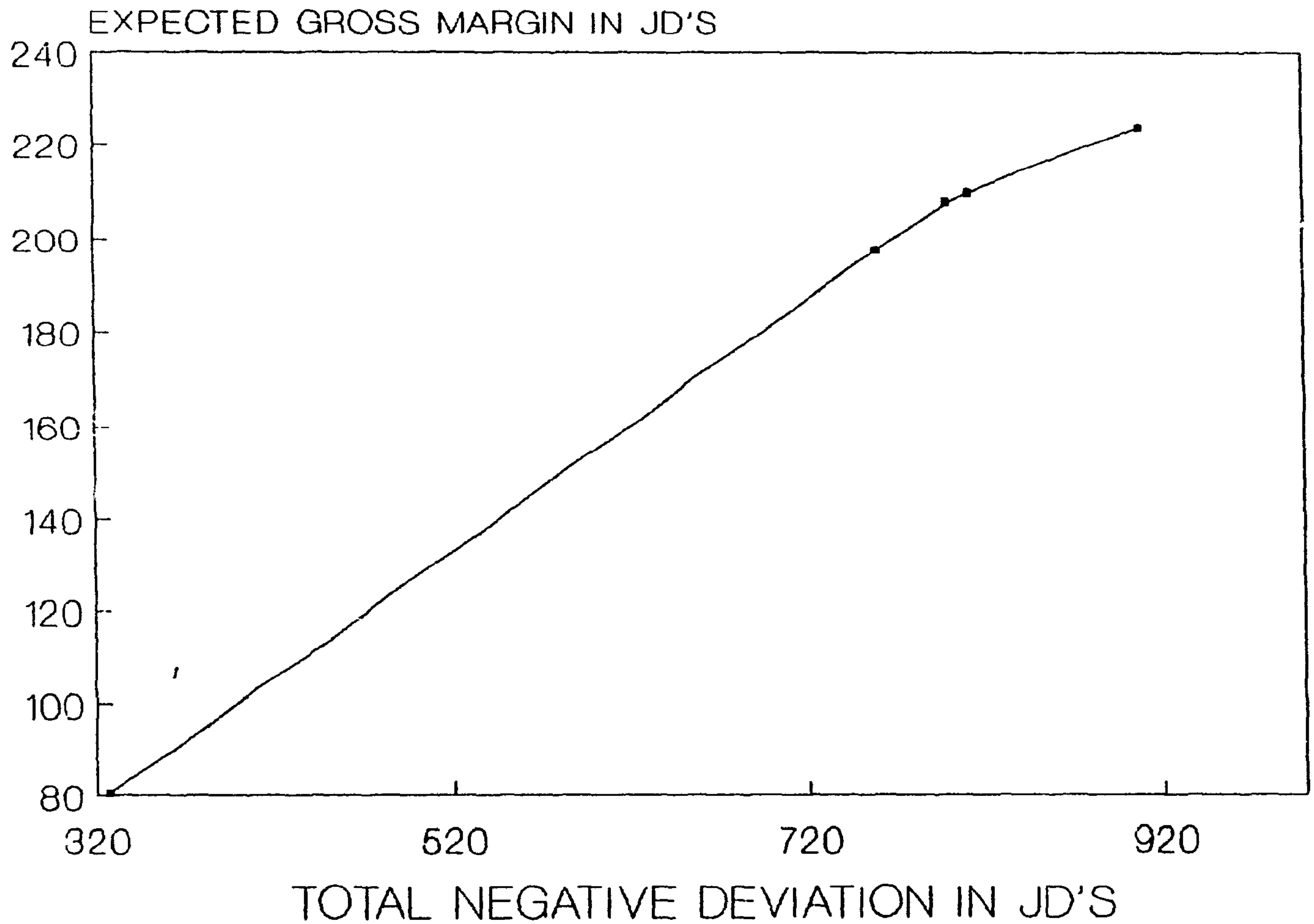
The slope of the IEF is about 0.36 when expected gross margin is increased from JD 80 to JD 82.5, while the slope associated with a gross margin increase from JD 208 to JD 210 is about 0.15. As marginal risk increases, the movement along the frontier in the northeast direction also increases.[6]

The last point on the IEF represents the maximum gross margin that can be obtained by a 76 dunum land holding in the study area, under the assumed constraints. Total negative deviation and farm organization for each solution point in the IEF are presented in Table 6.6.

LEAST RISK EFFICIENCY FRONTIER **fig:6.1**

LABOR INTENSIVE PRACTICES

BASIC MODEL



It should be noted that for Table 6.6, the MOTAD procedure takes advantage of the fact that the dual of the gross margin constraint in the minimization problem is the inverse of the risk-aversion parameter in the equivalent maximization problem (see Chapter V).

Risk-aversion parameter (RAP) (row 1 in Table 6.6) can be interpreted in conjunction with the certainty-equivalent row (row 3) in the following way: as RAP increases, the cost of risk, which is equal to the total negative deviation multiplied by the value of RAP, also increases. Thus, by multiplying RAP by the corresponding value of total negative deviation (row 11) and subtracting the result from expected gross margin (row 2), the corresponding value of the certainty-equivalent (row 3) is obtained. The results can, therefore, be interpreted as if expected gross margin is maximized in which case the objective function is the certainty-equivalent expected gross margin (row 3), or as if the total negative deviation (row 11) (the objective function) is minimized. Direct comparison between expected gross margin and risk aversion is intuitively more appealing.

Although we shall continue to refer to total negative deviation as a measure of risk in deriving the IEF, the variance of the expected gross margin at each optimal farm plan was also calculated to derive the confidence intervals (row 11) (see Chapter V). To provide comparison of the variation of the expected gross margin along the IEF, the coefficient of variation was also calculated (row 13).

The lower part of Table 6.6, rows 14-23, provides a direct interpretation of the optimum farm plan's crop mix.

Table 6.6 Summary of Risk Efficient Farm Plan Under Labor-Intensive Practices
Basic Model

		UNIT								
1	RAP[a]	-	0 000	0 100	0 146	0 200	0 250	0 271	0 271	0 300
2	EGM[b]	JDs	221 100	224 096	210 000	208 128	208.125	197 500	52 500	50 000
3	CEGM[c]	JDs	224.100	133 350	91 520	48.460	8 540	-7 825	-7 951	-17 977
	ENTERPRISE[d]									
4	LENTILS	Dunum								
5	WHEAT/FALLOW	Dunum	56 070	56 070	56 070	56 080	56 080	60 050	18 970	18 [illegible]
6	BARLEY/FALLOW	Dunum						7 630	9 470	9 470
7	WHEAT/BARLEY/FALLOW	Dunum	1 530	1 530	12 790	14 210	14 210	2 310		
8	WHEAT/BARLEY/LENTILS	Dunum	18 400	18.400	7 140	5.710	5 710	5 710	5 710	5 710
9	WHEAT/LENTILS	Dunum								
10	UNUSED	Dunum	0 000	0 000	0' 000	0 000	0 000	0 300	41 850	42 590
11	TOTAL NEGATIVE DEVIATION[e]	JDs	907 460	907 460	810 630	798.340	798 340	758.790	334 030	326.590
12	STD[f]		216 881	216 881	193 739	190.801	190 801	181 349	79 832	78 051
13	CV[g]		96.779	96 780	92 256	85.143	91 675	87.135	40 421	37 504
14	LENTILS[h]		6 133	6.133	2 380	1 903	1 903	1 903	1 903	1 903
15	WHEAT[h]		34 678	34 678	34 678	34 680	34 680	32.698	11 388	11 018
16	BARLEY[h]		6 643	6.643	6 643	6.640	6.640	6.488	6 638	6 638
17	FALLOW[h]		28 545	28.545	32 298	32.777	32.777	34.610	14 220	13.850
18	UNCROPPED		0 000	0 000	0 000	0 000	0 000	0 300	41 850	42 590
19	FALLOW IN TWO[i]		28.035	28 035	28.035	28 040	28 040	33 840	14 220	13 850
20	FALLOW IN THREE[j]		0 510	0 510	4 263	4 737	4 737	0.770	0 000	0 000
21	FALLOW IN CROPPED LAND[k]		60 152	60 152	75.906	75 831	75.831	84 230	71 350	70 808
22	FALLOW2 IN TOTAL FALLOW[l]		98.213	98 213	86 800	85 549	85 519	97 775	100.000	100 000
23	FALLOW3 IN TOTAL FALLOW[m]		1 787	1.787	13 200	14 451	14 451	2 225	0 000	0 000

[a] Risk aversion parameter
[b] Expected gross margin
[c] Certainty equivalent expected gross margin
[d] Crop rotations
[e] Risk as measured by total negative deviation
[f] Standard deviation of the expected gross margin
[g] Coefficient of variation of expected gross margin
[h] Actual crops grown on the farm
[i] Total fallow results from two-year crop rotation
[j] Total fallow results from three-year crop rotation
[k] Percentage of fallow land in total cropped land
[l] Two year fallow as a percentage of total fallow
[m] Three year fallow as a percentage of total fallow

Notes Rows 14 - 23 are derived from rows 4 - 10.

E. Expected Income and Crop Mix and Risk

Risk-Neutral Farmers

As discussed earlier, if the farmer is risk-neutral the maximum expected net income that can be achieved in the land holding is about JD 224.10. The total negative deviation, as a minimum risk associated with this level of income, is JD 907.46.

With a standard deviation of JD 216, this level of income exhibits very high variability -- about 97 percent. The crop mix generating this income level involves rotations with the highest coefficient of variation and standard deviation. Since the farmer is risk-neutral, the certainty-equivalent income is also JD 224.10. With the total land holding fully cropped, the total fallow share is about 36 percent. Wheat, barley and lentil acreage comprise 45.60, 8.74 and 8.60 percent, respectively, of the total land holding. Further analysis shows that no barley is grown beyond what is needed for auto-consumption. Ninety-eight percent of the fallow is used in a two-year rotation with wheat, and about two percent is used in a three-year rotation with wheat and barley. This is expected, because the gross margin per dunum of the barley/fallow rotation is the lowest. Since the farmer is risk-neutral this crop drops out of the optimal plan.

Risk-Averse Farmers

At a very high risk-aversion parameter (RAP = 0.3), the optimal farm plan is characterized by the following:

a) A high portion of the land is not farmed, about 36 percent.

b) The percentage of fallow is 11 percent higher than in the case of risk-neutrality, due to the entrance of a relatively low-risk crop, barley/fallow. All of the fallow is produced in two-year rotations of wheat/fallow and barley/fallow.

c) The expected income associated with this optimum farm plan is substantially lower than with the risk-neutral situation: JD 80, as compared to JD 224.

d) The total negative deviation associated with this level of income is JD 326, which is also substantially lower than that for the risk-neutral profit maximization plan.

e) Coefficient of variation of expected gross margin is also very low, at 38 percent.

At a moderate risk-averse level (RAP = 0.15), the land is fully utilized, income and total negative deviations are slightly reduced and the crop mix changes noticeably. Moderately risky crops enter the plan and high-risk crops leave it. Fallow increases to about 14 percent more than in the risk-neutral case because the wheat/fallow/barley rotation, which has a relatively low standard deviation compared to the other crops, is indicated in the optimal crop mix. Comparison of the three cases discussed above is summarized in Table 6.7.

Table 6.7: Land Use and Risk Aversion

	Risk Aversion Parameter (RAP)		
	0.0	0.15	0.3
% Unused Land in Total Land Holding	0	0	56
Total Fallow as % of Cropped Land	60	74	71
Two Years Fallow Rotation as % of Total Fallow	98	87	100
Three Years Fallow Rotation as % of Total Fallow	2	13	0

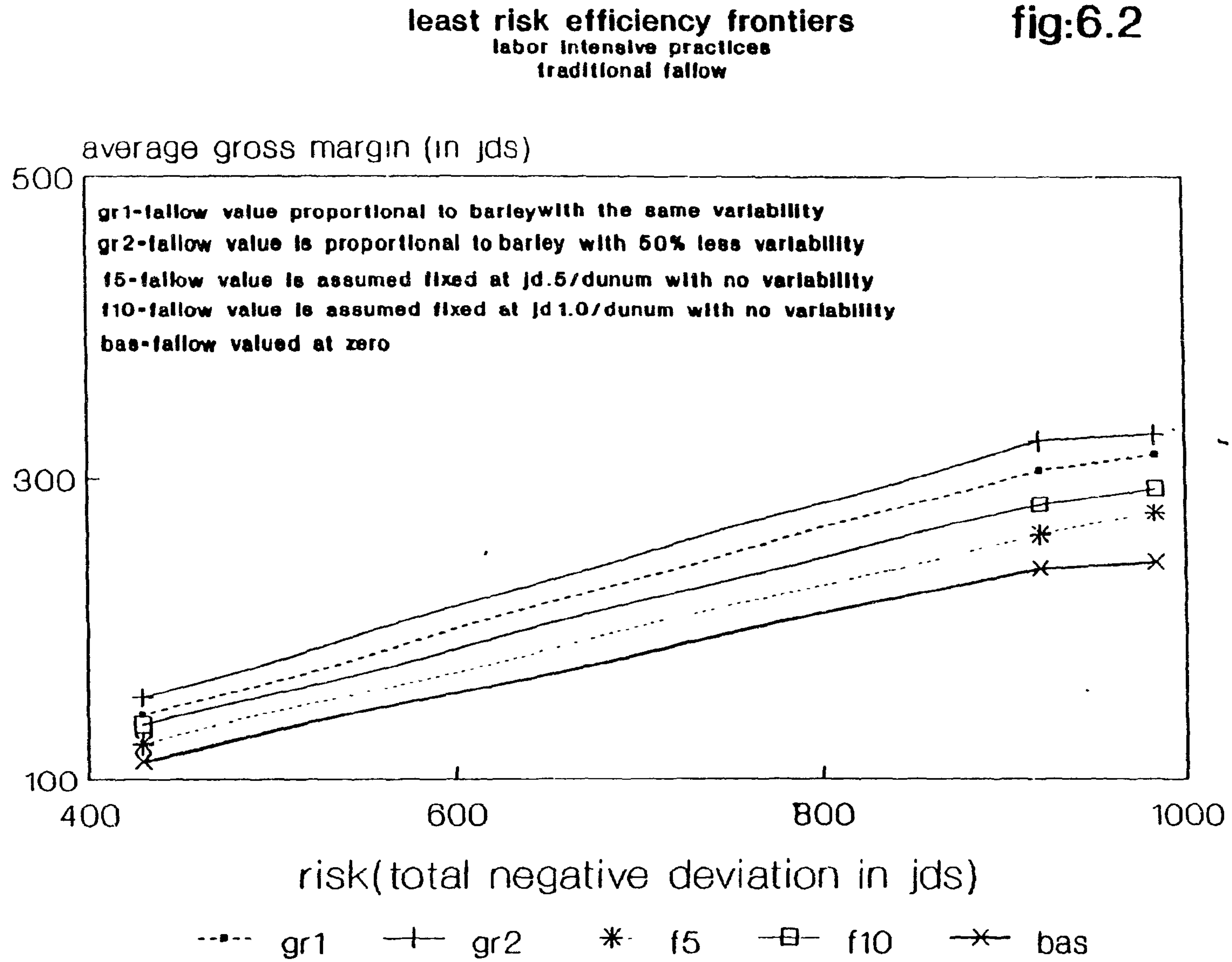
F. Least-Risk-Efficiency Frontier and the Value of Fallow

Thus far, the analysis has been carried out with the assumption that traditional fallow generates no tangible economic value. As discussed in Chapter II, although no data are available that assign accurate economic values to fallow, for the purpose of this section a small positive value (with and without variability, see Part B) has been arbitrarily assigned to it, and the MOTAD procedure was conducted.

Positive value for fallow has two effects on the average gross margin per dunum. First, it increases the average gross margin on a per dunum basis for all composite crops rotating with fallow, in both two and three-year rotations. Second, it maintains the standard deviation at the same level or increases it slightly but, reduces the coefficient of variation (because the value of weeds as a grazing material for livestock does not carry a cost of production). From the point of view of the whole farm plan, the least-risk-efficiency frontier reduces the risk at each level of expected margin as compared to the initial model, and the higher the economic value of fallow the higher the risk reduction.

The maximum expected gross margin also increases. The percentage of fallow in rotation increases as RAP increases, and decreases with lower risk-aversion levels, thus, the value of the income foregone from not cropping the land is relatively higher with higher risk aversion. As the value of fallow increases, farmers with lower risk aversion increase the proportion of fallow in their cropping patterns. The least-risk-efficiency frontiers were derived for different values of fallow, and compared to the initial model (fallow value is zero) in Figure 6.2. Optimal farm plans at the change of basis are presented in Tables 6.8-6.10.

fig:6.2



least risk efficiency frontiers
labor intensive practices
traditional fallow
average gross margin (in jds)
500
300
100
gr1-fallow value proportional to barleywith the same variability
gr2-fallow value is proportional to barley with 50% less variability
f5-fallow value is assumed fixed at jd.5/dunum with no variability
f10-fallow value is assumed fixed at jd 1.0/dunum with no variability
bas-fallow valued at zero
400
600
800
1000
risk(total negative deviation in jds)
gr1
gr2
f5
f10
bas

Table 6.8: Summary of Risk Efficient Farm Plan under Labor-Intensive Practices Basic Model Fallow Valued at 0.5/du: No Insurance

	UNIT				
1. RAP[a]	-	0.127	0.246	0.246	0.296
2. EGM[b]	JD	225.000	215.000	205.000	90.000
3. CEGM[c]	JD	123.096	28.576	28.016	-7.375
Enterprise[d]					
4. LENTILS	Dunum			1.630	1.900
5. WHEAT/FALLOW	Dunum	56.060	59.990	60.810	22.180
6. BARLEY/FALLOW	Dunum		7.830	12.730	13.280
7. WHEAT/BARLEY/FALLOW	Dunum	13.830	2.470		
8. WHEAT/BARLEY/LENTILS	Dunum	6.090	5.710	0.830	
9. WHEAT/LENTILS	Dunum				
10. UNUSED	Dunum	0.020	0.000	0.000	38.640
11. TOTAL NEGATIVE DEVIATION[e]	JD	801.650	759.320	718.690	329.200
12. STD[f]	JD	191.592	181.476	171.765	78.678
13. CV[g]	%	85.152	84.407	83.788	87.420
14. LENTILS[h]	Dunum	2.030	1.903	1.907	1.900
15. WHEAT[h]	Dunum	34.670	32.722	30.687	11.090
16. BARLEY[h]	Dunum	6.640	6.642	6.642	6.640
17. FALLOW[h]	Dunum	32.640	34.733	36.775	17.730
18. UNCROPPED	Dunum	0.020	0.000	-0.010	38.640
19. FALLOW IN TWO[i]	Dunum	28.030	33.910	36.770	17.730
20. FALLOW IN THREE[j]	Dunum	4.610	0.823	0.000	0.000
21. FALLOW % IN CROPPED LAND[k]	%	75.311	84.168	93.730	90.321
22. FALLOW2 % IN TOTAL FALLOW[l]	%	85.876	97.630	99.986	100.000
23. FALLOW3 % IN TOTAL FALLOW[m]	%	14.124	2.370	0.000	0.000

[a]Risk aversion parameter
[b]Expected gross margin
[c]Certainty equivalent expected gross margin
[d]Crop rotations
[e]Risk as measured by total negative deviation
[f]Standard deviation of the expected gross margin
[g]Coefficient of variation of expected gross margin
[h]Actual crops grown on the farm
[i]Total fallow results from two-year crop rotation
[j]Total fallow results from three-year crop rotation
[k]Percentage of fallow land in total cropped land
[l]Two year fallow as a percentage of total fallow
[m]Three year fallow as a percentage of total fallow

Notes: Rows 14 - 23 are derived from rows 4 - 10.

Table 6.[illegible]: Summary of Risk Efficient Farm Plan under Labor-Intensive Practices Basic Model Fallow Valued at 1.0/du: No Insurance

	UNIT				
1. RAP[a]	-	0.108	0.221	0.221	0.321
2. EGM[b]	JD	242.500	232.500	222.500	100.000
3. CEGM[c]	JD	154.980	64.913	64.890	-6.692
Enterprise[d]					
4. LENTILS	Dunum			1.830	1.900
5. WHEAT/FALLOW	Dunum	56.080	59.930	60.820	22.620
6. BARLEY/FALLOW	Dunum		7.710	13.130	13.290
7. WHEAT/BARLEY/FALLOW	Dunum	12.570	2.650		
8. WHEAT/BARLEY/LENTILS	Dunum	7.350	5.710	0.220	
9. WHEAT/LENTILS	Dunum				
10. UNUSED	Dunum	0.000	0.000	0.000	38.190
11. TOTAL NEGATIVE DEVIATION[e]	JD	812.520	759.920	714.680	332.480
12. STD[f]	JD	194.190	181.619	170.807	79.462
13. CV[g]	%	80.078	78.116	76.767	79.462
14. LENTILS[h]	Dunum	2.450	1.903	1.903	1.900
15. WHEAT[h]	Dunum	34.680	32.752	30.483	11.310
16. BARLEY[h]	Dunum	6.640	6.642	6.638	6.645
17. FALLOW[h]	Dunum	32.230	34.703	36.975	17.955
18. UNCROPPED	Dunum	0.000	0.000	0.000	38.190
19. FALLOW IN TWO	Dunum	28.040	33.820	36.975	17.955
20. FALLOW IN THREE	Dunum	4.190	0.883	0.000	0.000
21. FALLOW % IN CROPPED LAND[k]	%	73.635	84.034	94.747	90.431
22. FALLOW2 % IN TOTAL FALLOW[l]	%	87.000	97.455	100.000	100.000
23. FALLOW3 % IN TOTAL FALLOW[m]	%	13.000	2.545	0.000	0.000

Risk aversion parameter
Expected gross margin
Certainty equivalent expected gross margin
Crop rotations
Risk as measured by total negative deviation
Standard deviation of the expected gross margin
Coefficient of variation of expected gross margin
Actual crops grown on the farm
Total fallow results from two-year crop rotation
Total fallow results from three-year crop rotation
Percentage of fallow land in total cropped land
Two year fallow as a percentage of total fallow
Three year fallow as a percentage of total fallow

Notes: Rows 14 - 23 are derived from rows 4 - 10.

Table 6.10: Summary of Risk Efficient Farm Plan under Labor-Intensive Practices: Basic Model Fallow Valued at 60% of Barley Yield Value with Fallow Variability Assumed Equal to 50% of Barley Yield Variability

	UNIT				
LAMDA		38.28	7.31	2.84	2.75
1. RAP[a]	-	0.03	0.14	0.35	0.36
2. EGM[b]	JD	314.89	305.00	285.00	150.00
3. CEGM[c]	JD	288.40	186.53	2.88	-5.75
Enterprise[d]					
4. LENTILS	Dunum		1.90	1.90	1.90
5. WHEAT/FALLOW	Dunum	56.07	58.97	51.74	22.79
6. BARLEY/FALLOW	Dunum		9.57	22.36	17.67
7. WHEAT/BARLEY/FALLOW	Dunum	1.54	5.56		
8. WHEAT/BARLEY/LENTILS	Dunum	18.39			
9. WHEAT/LENTILS	Dunum	0.00			
10. UNUSED	Dunum	0.00	0.00	0.00	33.64
11. TOTAL NEGATIVE DEVIATION	JD	1,014.01	866.48	800.55	428.76
12. STD[f]	JD	242.35	207.09	191.33	102.47
13. CV[g]	%	76.96	67.90	67.13	68.32
14. LENTILS[h]	Dunum	6.13	1.90	1.90	1.90
15. WHEAT[h]	Dunum	34.68	31.34	25.87	11.40
16. BARLEY[h]	Dunum	6.64	6.64	11.18	8.84
17. FALLOW[h]	Dunum	34.17	36.12	37.05	20.23
19. FALLOW IN TWO[i]	Dunum	28.04	34.27	37.05	20.23
20. FALLOW IN THREE[j]	Dunum	6.13	1.85	0.00	0.00
21. FALLOW % IN CROPPED LAND[k]	%	72.00	90.59	95.12	91.41
22. FALLOW2 % IN TOTAL FALLOW[l]	%	82.06	94.87	100.00	100.00
23. FALLOW3 % IN TOTAL FALLOW[m]	%	17.94	5.13	0.00	0.00

[a]Risk aversion parameter
[b]Expected gross margin
[c]Certainty equivalent expected gross margin
[d]Crop rotations
[e]Risk as measured by total negative deviation
[f]Standard deviation of the expected gross margin
[g]Coefficient of variation of expected gross margin
[h]Actual crops grown on the farm
[i]Total fallow results from two-year crop rotation
[j]Total fallow results from three-year crop rotation
[k]Percentage of fallow land in total cropped land
[l]Two year fallow as a percentage of total fallow
[m]Three year fallow as a percentage of total fallow

Notes: Rows 14 - 23 are derived from rows 4 - 10.

G. Farm Income Response to Yield Variability

As shown in earlier, the variation in farm income caused by yield variation is substantial, amounting to 47.16 percent of variation in expected gross margin per dunum of wheat. The variation in gross margin per dunum caused by yield variation in barley and lentils is estimated at 88.37 percent and 42.27 percent, respectively. When the same calculations are made over a longer period, 1962-1984, yield variation as a source of farm-income variation was slightly less.' The reason for the lower variation is that between 1975 and 1985, the years 1975, 1979, 1984 and 1985 were drought years. The lowest yield recorded during the period under study was in 1979 and the highest was in 1980 (see Appendix).

Yield Stability and Crop Mix

The main focus of this section is to analyze the relationship of income variability to yield variability. The analysis assumes constant yields during the period in question. Yields for the three crops (wheat, barley and lentils) were fixed at their 11-year historical average thus reducing yield variability by 100 percent

Yield stability has a significant impact on the optimal farm plans. Land utilization has increased substantially (Table 6.6); for a risk-averse farmer with RAP = 0.27, the unused land declines by 54 percent. At the same time, land allocated to wheat and lentils increases by 304 and 286 percent, respectively, without a decline in land allocated to barley. Two-year fallow rotation, as a percentage of total cropped land, is reduced by 10 percent; as a percentage of total fallow it is reduced by 3 percent. On the other hand, fallow in three-year rotation, as a percentage of total fallow, is increased by 3 percent (Table 6.11).

At a low level of risk aversion ($0 < RAP < 0.2$), the optimal farm plans are identical to those in the initial situation as the risk-aversion coefficient and share of low-risk crops in the farm plan increases.

The level of total negative deviations (at every level of expected net income) is much lower when yields are stabilized as compared to the initial model (Figure 6.3). Crops which entered the plan at a much lower RAP in the initial plan now enter at a relatively higher RAP. This explains the higher proportion of three-year fallow rotation to total fallow, as compared to the initial model. The increase in three-year fallow rotation, along with a slight decrease in two-year fallow rotation, is the reason for a general decline in percentage of total fallow with respect to total cropped land (Table 6.11).

Yield Variability and Farm Income

The expected net income is slightly reduced throughout the frontier. The reduction in expected income is less sensitive to risk at higher levels of risk aversion. As risk aversion increases from zero to 0.4, for example, the decrease in expected income amounts to less than 11 percent of the expected income of the risk-neutral situation, while in the initial model the difference over the same range is about 200 percent. The variance of expected income has been reduced by more than 130 percent. The 95 percent confidence interval is much narrower than in the initial model. The stability of income is also apparent at a very high risk-aversion coefficient. The expected net income increases substantially (certainty equivalent is positive) and the variance decreases. However, the stabilization effect at a high risk-aversion

LEAST RISK EFFICIENCY FRONTIER fig:6.3

YIELD VARIABILITY

LABOR INTENSIVE PRACTICES

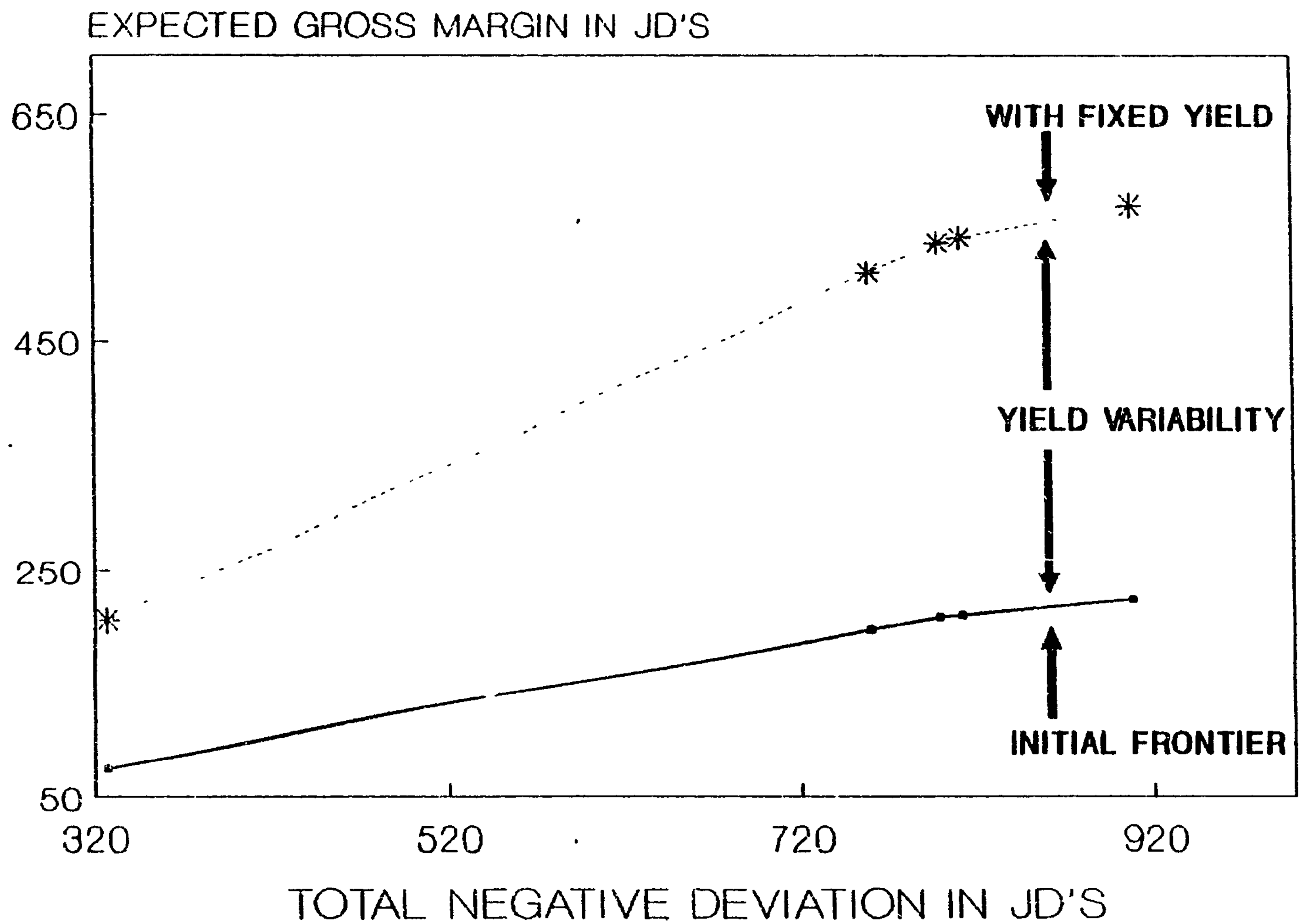


Table 6.11: Summary of Risk Efficient Farm Plan Under Labor-Intensive Practices
Basic Model with Fixed Yield: No Insurance

	UNIT							
1. RAP[a]	-	0.000	0.050	0.100	0.150	0.200	0.300	0.400
2. EGM[b]	JDs	207 610	207.608	207 616	207 614	207.614	193.408	185.158
3. CEGM[c]	JDs	207.610	190.870	174.140	157.400	140.660	108.430	80.290
Enterprise[d]								
4. LENTILS	Dunum							
5. WHEAT/FALLOW	Dunum	56 080	56.080	56 080	56.080	56.080	56.080	32.000
6 BARLEY/FALLOW	Dunum							
7. WHEAT/BARLEY/FALLOW	Dunum	1.540	1.540	1 540	1.540	1 540	14.210	38.280
8 WHEAT/BARLEY/LENTILS	Dunum	18 380	18.380	18 380	18.380	18 380	5 710	5 710
9. WHEAT/LENTILS	Dunum							
10 UNUSED	Dunum	0.000	0.000	0 000	0.000	0.000	0.000	0 010
11. TOTAL NEGATIVE DEVIATION[e]	JDs	334 760	334 760	334.760	334 760	334 770	283 260	262.170
12. STD[f]		80.007	80 007	80.007	80.007	80 009	67.698	62.658
13 C V[g]		38 537	38 537	38 536	38.536	38.537	35 003	33 840
14. LENTILS[h]		6.127	6 127	6.127	6.127	6.127	1 903	1 903
15 WHEAT[h]		34 680	34.680	34 680	34 680	34.680	34 680	30 663
16 BARLEY[h]		6 640	6.640	6 640	6 640	6 640	6 640	14 663
17 FALLOW[h]		28.553	28 553	28 553	28 553	28 553	32 777	28 760
18. UNCROPPED		0.000	0.000	0 000	0.000	0.000	0.000	0.010
19 FALLOW IN TWO[i]		28.040	28.040	28.040	28 040	28.040	28.040	16.000
20 FALLOW IN THREE[j]		0 513	0.513	0 513	0 513	0 513	4 737	12 760
21. FALLOW % IN CROPPED LAND[k]		60 180	60 180	60.180	60 180	60 180	75 831	60 893
22. FALLOW2 % IN TOTAL FALLOW[l]		98 202	98.202	98 202	98 202	98 202	85 549	55.633
23 FALLOW3 % IN TOTAL FALLOW[m]		1.798	1 798	1 798	1 798	1.798	14 451	44 367

[a]Risk aversion parameter
[b]Expected gross margin
[c]Certainty equivalent expected gross margin
[d]Crop rotations
[e]Risk as measured by total negative deviation
[f]Standard deviation of the expected gross margin
[g]Coefficient of variation of expected gross margin
[h]Actual crops grown on the farm
[i]Total fallow results from two-year crop rotation
[j]Total fallow results from three-year crop rotation
[k]Percentage of fallow land in total cropped land
[l]Two year fallow as a percentage of total fallow
[m]Three year fallow as a percentage of total fallow

Notes Rows 14 - 23 are derived from rows 4 - 10 level is more significant than at a low-risk aversion level. At a risk aversion level of 0.4, the expected gross margin increases by over 120 percent, compared to the initial model, in both the standard deviation and the coefficient of variation. This increase in income is obviously associated with more extensive land use and, more importantly, with the lower cost of risk. The following example illustrates this point.

At a high risk-aversion level (RAP = 0.4) in the initial model, the cost of risk is approximately JD 128.4. When yield variability is eliminated, the cost of risk at the same RAP is approximately JD 104. This reduction in the cost of risk induces the farmer to increase his land use by 56 percent, and thus increase his expected net income by over 25 percent.

H. Farm Income Response to Price Variability

As discussed earlier, price variability is an important source of farm income variability. About 13.5 percent of the variability in farm income generated from wheat production on a per dunum basis is traceable to the variability of the price of wheat. Similarly, farm income variability on a per dunum basis arising from price variability of barley and lentils is estimated at 15.82 percent and 24.70 percent, respectively.

For the purposes of the rest of this section, prices for wheat, barley and lentils will be fixed at their 1975–1985 average to eliminate all variations caused by price.

Price Variability and Crop Mix

The optimal farm plans were markedly modified as a result of price stability (Table 6.12). The most significant changes are that:

a) The amount of unused land decreases at high risk-aversion levels.

b) All fallow land is used in a two-year rotation with other crops. This is expected because wheat/fallow/barley crop rotation has a relatively low gross margin as compared to wheat/fallow or wheat/lentils/barley.

c) Fallow in two-year crop rotation is reduced, mainly because the fallow/barley gross margin is lowered; furthermore, when price variability is eliminated, the standard deviation of the wheat/barley/lentils rotation is significantly reduced.

d) Fallow land decreases at the low risk-aversion level and increases at higher risk-margin levels as compared to the initial model.

Price Variability and Net Income

The maximum expected gross margin increases over the initial model by about 4 percent. The expected gross margin at a RAP of 0.4 increases by over 400 percent, while the risk, as measured by total negative deviation, increases only by 52 percent. In other words, at the same risk level the RAP would be over 0.3, and expected gross margin would increase by around 50 percent. As an example, consider a total negative deviation of JD 907.24 and a RAP of 0.1 in the initial model. The level of expected gross margin for the optimal farm plan is JD 224. When price variability

Table 6.1. Summary of Risk Efficient Farm Plan Under Labor-Intensive Practices Basic Model with Fixed Prices, No Insurance

		UNIT							
1	RAP[1]	–	0.000	0.050	0.100	0.200	0.250	0.300	0.400
2	EGM[2]	JDs	234.710	234.710	231.711	234.712	193.410	193.412	193.416
3	CEGM[3]	JDs	234.710	200.710	166.770	98.830	69.000	14.120	-5.610
	Enterprise[4]								
4	LENTILS	Dunum							
5	WHEAT/FALLOW	Dunum	40.910	40.910	40.910	40.910	56.070	56.070	56.070
6	BARLEY/FALLOW	Dunum							
7	WHEAT/BARLEY/FALLOW	Dunum							
8	WHEAT/BARLEY/LENTILS	Dunum	19.930	19.930	19.930	19.930	14.220	14.220	14.220
9	WHEAT/LENTILS	Dunum	15.160	15.160	15.160	15.160	5.710	5.710	5.710
10	UNUSED	Dunum	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	TOTAL NEGATIVE DEVIATION[5]	JDs	679.410	679.410	679.410	679.410	497.640	497.640	497.640
12	STD[6]		162.377	162.377	162.377	162.377	118.935	118.935	118.935
13	CV[7]		182	69.182	69.182	69.182	61.494	61.495	61.492
14	LENTILS[8]		14.223	14.223	14.223	14.223	7.595	7.595	7.595
15	WHEAT[8]		34.678	34.678	34.678	34.678	35.630	35.630	35.630
16	BARLEY[8]		6.643	6.643	6.643	6.643	4.710	4.710	4.710
17	FALLOW[8]		20.455	20.455	20.455	20.455	28.035	28.035	28.035
18	UNCROPPED		0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	FALLOW IN TWO[9]		20.455	20.455	20.455	20.455	28.035	28.035	28.035
20	FALLOW IN THREE[10]		0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	FALLOW IN CROPPED LAND[11]		36.826	36.826	36.826	36.826	58.449	58.449	58.449
22	FALLOW2 IN TOTAL FALLOW[12]		100.000	100.000	100.000	100.000	100.000	100.000	100.000
23	FALLOW3 IN TOTAL FALLOW[13]		0.000	0.000	0.000	0.000	0.000	0.000	0.000

[1] Risk aversion parameter
[2] Expected gross margin
[3] Certainty equivalent expected gross margin
[4] Crop rotations
[5] Risk as measured by total negative deviation
[6] Standard deviation of the expected gross margin
[7] Coefficient of variation of expected gross margin
[8] Actual crops grown on the farm
[9] Total fallow results from two-year crop rotation
[10] Total fallow results from three-year crop rotation
[11] Percentage of fallow land in total cropped land
[12] Two year fallow as a percentage of total fallow
[13] Three year fallow as a percentage of total fallow

Note: Rows 11 - 23 are derived from rows 4 - 10 is eliminated, the level of risk at the same RAP is reduced to ID 679, while the expected income rises to ID 234. Because lentil production at a low level of risk aversion is more attractive in rotation with wheat alone than in rotation with barley and wheat, the wheat/lentil rotation is a riskier crop. At a high risk-aversion level, lentils are rotated with barley and wheat because of the latter's relatively low standard deviation, thus, less and less land is used for fallow, compared to the initial model. Wheat and barley production is more or less stable in comparison to the initial model. Lentil production increases considerably, because the price variability of lentils is the highest of the three crops.

The effect of price variability on farm income is significantly less than that of yield variability. Although elimination of price variability brings more land into production at a 0.4 RAP, the cost of risk remains higher than in the initial model (Table 6.12). The 95 percent confidence interval at each level of expected income remains wider in comparison to the same income when yield variability is eliminated, but is significantly narrower than that of the initial model. Similarly, at each level of income the standard deviation and the coefficient of variation are substantially reduced.

A substantial reduction in price variability was already effected when the price series was adjusted to eliminate the effect of price inflation (i.e., set at the 1985 price level). Furthermore, price support which was introduced in 1980 may have had some effect on the magnitude of income variability resulting from price fluctuation.

Least-Risk-Efficiency Frontier

The least-risk-efficiency frontier associated with the elimination of price variability lies above the frontier representing the initial model in Figure 6.4. The IEF is also presented in that figure. At each level of expected income the associated risk was reduced. Similarly, when price variability was eliminated, the expected income at each level of risk increased.

The relationship between the two frontiers can best be explained in terms of a simple mathematical relationship. We have seen earlier (Chapter V) that between changes in basis the portion of the frontier is a segment of a straight line. Since between each change in basis the inverse of the dual value associated with the constraint of the expected gross margin is the RAP, this coefficient changes only when the basis changes. It follows that the equation of any straight line segment of the least-risk-efficiency frontier can be expressed as follows:

$$I_i = C^*_i + a_1 R \quad (6.1)$$

$$I_f = C^*_f + a_2 R \quad (6.2)$$

where I_f and I_i are net income associated with fixed prices and initial model, respectively, and R is total negative deviation. C_i^* and C_f^* are certainty-equivalent incomes which are fixed at each risk-aversion level; a_1 and a_2 are the values of the risk-aversion coefficient. Therefore, the slope of the least-risk-efficiency frontier at various line segments is determined by the magnitude of the RAP.

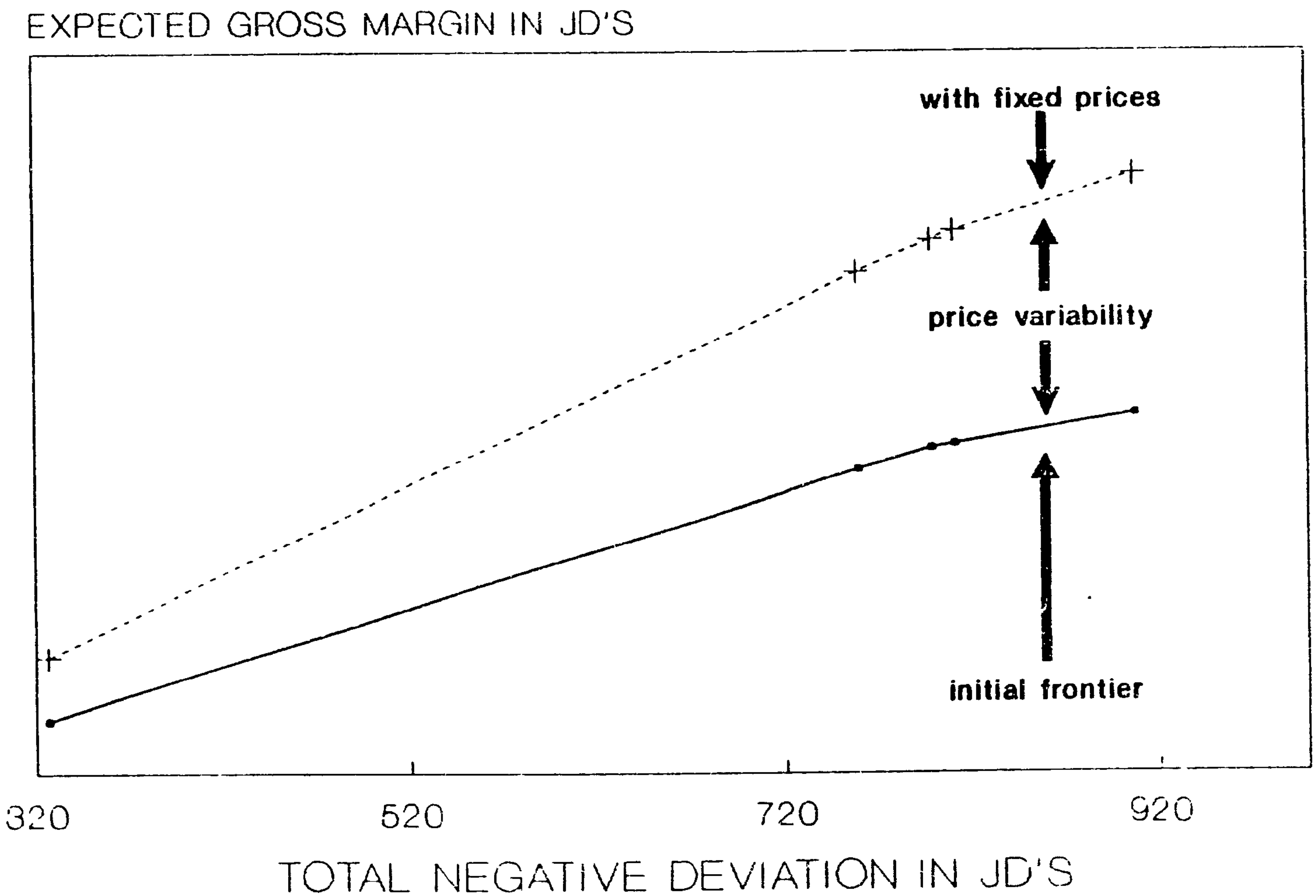
$$dI_i/dI_f = a_1/a_2 \quad (6.3)$$

LEAST RISK EFFICIENCY FRONTIERS

PRICE VARIABILITY

LABOR INTENSIVE PRACTICES

fig:6.4



The relative change in net income with and without price stability is proportional to the ratio of the RAP for a given level of risk.

Since (dI /dI) (R = R*) < 1, it follows that $a_1/a_2 < 1$ $a_2 > a_1$, and since the marginal risk is the inverse of the risk-aversion parameter, it follows that the IEF is relatively flatter in comparison to the new frontier with price stability, i.e., the marginal risk is lower with price stabilization. The separate effects of price risk and yield risk are presented in Figure 6.5.

I. Capital-Intensive vs. Labor-Intensive Agricultural Practices

In this section the relationship between capital-intensive agricultural practices and labor-intensive agricultural practices is examined. Two scenarios are explored using capital-intensive practices. In the first, the yield is increased by 30 percent over that of labor-intensive practices; in the second, yield is increased by 70 percent. The standard deviation of the yield is assumed to remain unchanged (see Chapter II).

These scenarios are compared to the labor-intensive practices and to each other when: fallow is assumed to have zero value, a positive value of JD 0.5/dunum and a positive value of JD 1.0/dunum (see Chapter V). The analysis is carried out using the MOTAD procedure.

Expected Income and Crop Mix

With the hypothesized 30 percent increase in yield, the results (Table 6.13) indicates that in the risk-neutral profit- maximization solution the expected gross margin increases by 33 percent over

LEAST RISK EFFICIENCY FRONTIERS

UNDER PRICE AND YIELD VARIABILITY

LABOR INTENSIVE PRACTICES

fig:6.5

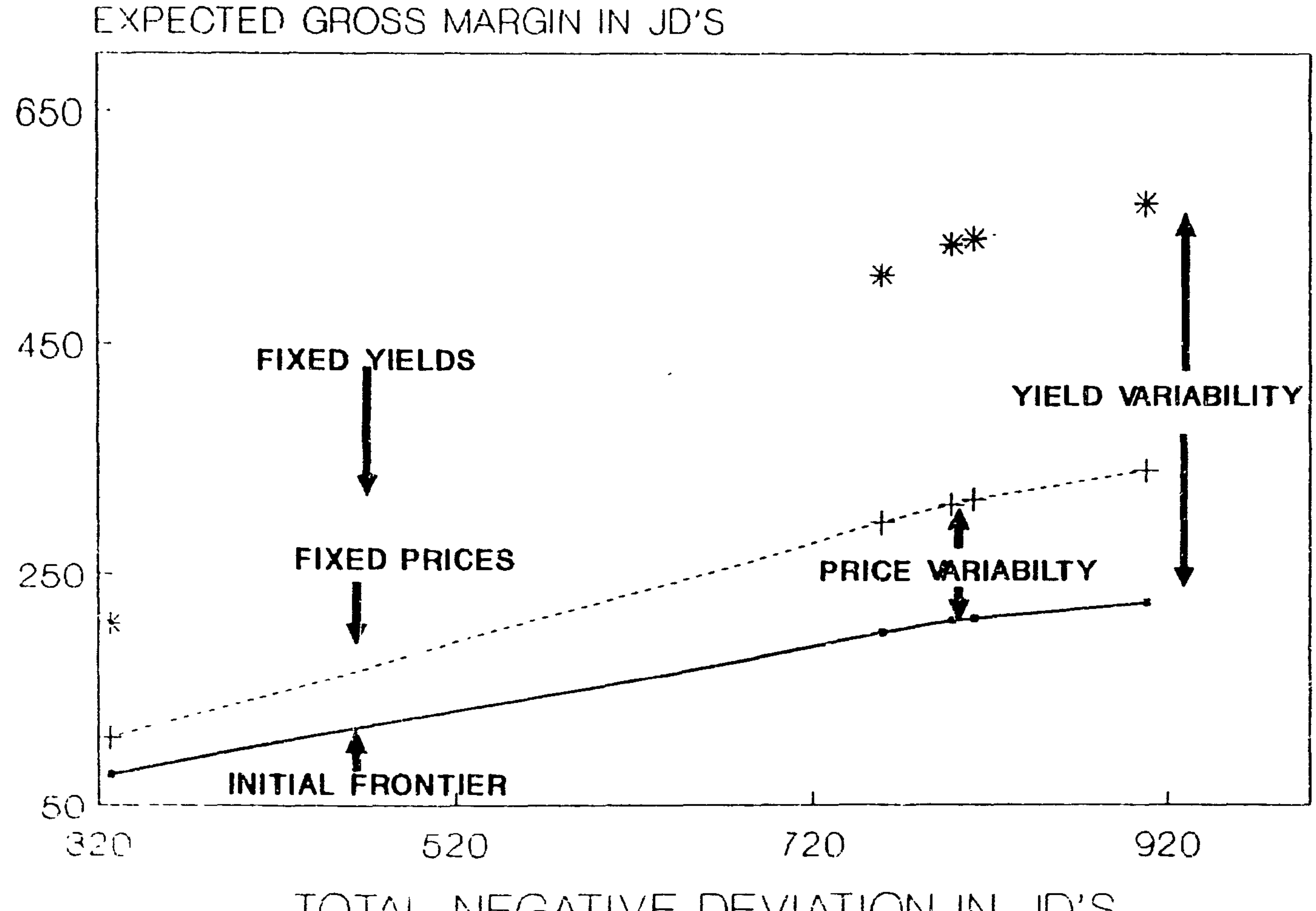


Table 6.13: Summary of Risk Efficient Farm Plan under Capital-Intensive Agricultural Practices: Basic Model

	UNIT							
30% Yield Increase over Labor-Intensive Practices								
1. RAP[a]	-	0.00	0.05	0.10	0.15	0.20	0.25	0.30
2. EGM[b]	JD	297.65	297.65	297.65	296.87	297.69	71.13	71.13
3. CEGM	JD	297.65	232.90	168.15	103.39	38.68	-10.52	-26.85
Enterprise[d]								
4. LENTILS	Dunum	1.59	1.59	1.59	1.59	2.12	1.58	1.58
5. WHEAT	Dunum	45.65	45.65	45.65	45.65	44.86	8.44	8.44
6. BARLEY	Dunum	5.09	5.09	5.09	5.09	5.09	5.09	5.09
10. UNUSED	Dunum	23.67	23.67	23.67	23.67	23.93	60.89	60.89
11. TOTAL NEGATIVE DEVIATION[e]	JD	1295.07	1295.07	1295.07	1295.07	1289.85	326.59	326.60
12. STD[f]	JD	309.52	309.52	309.52	309.52	308.27	78.05	78.06
13. CV[g]	%	103.99	103.99	103.99	103.99	103.84	26.22	107.74
70% Yield Increase over Labor-Intensive Practices								
1. RAP[a]	-	0.00	0.05	0.10	0.15	0.20	0.25	0.30
2. EGM[b]	JD	453.66	453.66	453.66	453.66	453.66	453.65	105.08
3. CEGM[c]	JD	453.66	369.96	286.27	202.58	118.88	35.18	-18.17
Enterprise[d]								
4. LENTILS	Dunum	1.59	1.59	1.59	1.59	1.59	1.59	1.58
5. WHEAT	Dunum	45.65	45.65	45.65	45.65	44.86	8.44	8.44
6. BARLEY	Dunum	5.09	5.09	5.09	5.09	5.09	5.09	5.09
10. UNUSED	Dunum	23.67	23.67	23.67	23.67	23.67	23.67	23.67
11. TOTAL NEGATIVE DEVIATION[e]	JD	1673.89	1673.89	1673.89	1673.89	1673.89	1673.89	410.83
12. STD[f]	JD	400.06	400.06	400.06	400.06	400.06	400.06	98.19
13. CV[g]	%	88.18	88.18	88.18	88.18	88.18	88.18	21.64

[a]Risk aversion parameter
[b]Expected gross margin
[c]Certainty equivalent expected gross margin
[d]Crop rotations
[e]Risk as measured by total negative deviation
[f]Standard deviation of the expected gross margin
[g]Coefficient of variation of expected gross margin

labor-intensive cases, while the risk (as measured by the total negative deviation) increases by 43 percent. The risk/income ratio increases from 4.05 in the labor-intensive case to 4.36.

When the yields are assumed to increase by 70 percent, the risk-neutral solution yields a maximum expected gross margin of JD 453 and a total negative deviation of JD 1,674. The labor-intensive case shows a 203 percent increase in expected income and an 186 percent increase in risk as measured by the total negative deviation, or a decrease in risk/income ratio from 4.05 to 3.69.

In both capital-intensive cases, about 31 percent of the land is uncropped. This implies that for risk-neutral farmers, production and income could be increased substantially if capital-intensive practices were adopted. The uncropped land is a result of the capital constraint imposed by the model. However, even though formal credit institutions provide credit equivalent to 80 percent of the production costs, farmers with limited working capital are unlikely, even when they are risk-neutral, to take advantage of the potential benefits of capital-intensive agricultural practices.

In the capital-intensive model the crop mix is dominated by wheat. Barley and lentils are produced solely for the family's consumption. Since price ratios of crops remain unchanged, production of barley stays more or less at the same level.

At a RAP of 0.2, the risk/income ratio is 4.3 when yields increased by 30 percent; for the labor-intensive case it is 3.64. When yields are assumed to increase by 70 percent, the risk/income ratio is 3.69, which is marginally higher than the labor-intensive case.

At a higher risk-aversion level (RAP > 0.[illegible]), labor-intensive practices outperform capital-intensive practices with a yield increase of [illegible]0 percent. At yield increases of 70 percent, labor- and capital-intensive practices are more or less comparable. Figure 6.6 shows that as the gross-margin level rises above JD 800, the frontier of the labor-intensive model lies below that of the capital-intensive model with 70 percent increase in yield.

When fallow is assumed to produce an imputed positive value (JD 0.5/dunum), the labor-intensive practices frontier lies above both capital-intensive practices' frontiers (Tables 6.8 - 6.10 and Figure 6.7).

The following conclusions can be drawn from this section:

a) Improved practices are potentially beneficial to small farmers under the existing input/output price relations and if these practices bring about a minimum of 70 percent increase in yield.

b) If the value of fallow is more than 0, then the 70 percent increase in yield is not sufficient for farmers to adopt these capital-intensive practices.

J. Summary

Price and yield variability are a major source of the variability in income of small farmers, particularly those who are highly risk-averse.

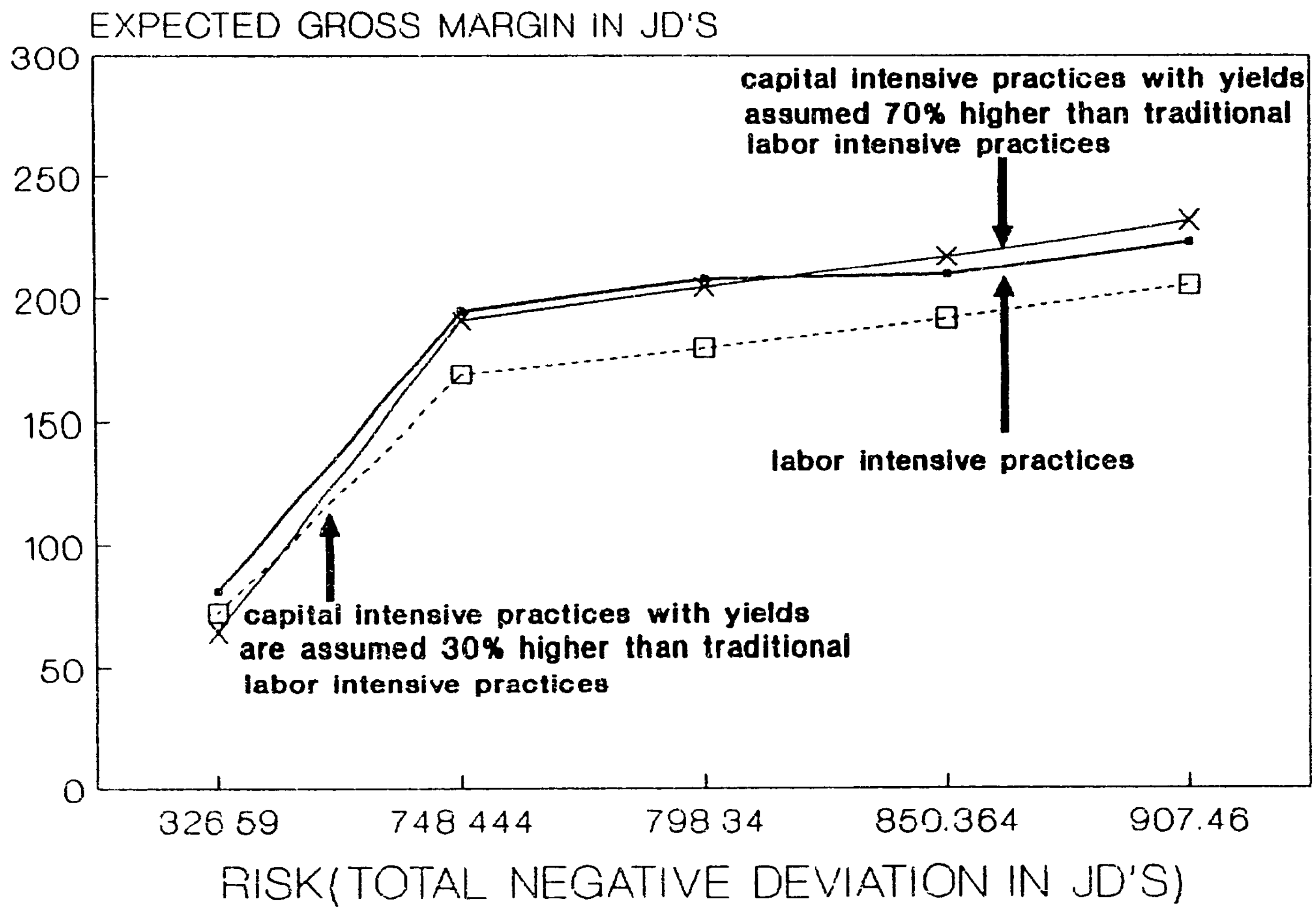
Yield risk is substantially more important than price risk, contributing about 61 percent of income variability. Price risk on the other hand, contributed about 39 percent. In the presence of yield and price risks the farmer's decision to adopt various crop rotations as a

LEAST EFFICIENCY FRONTIERS

CAPITAL INTENSIVE VS LABOR INTENSIVE

AND TRADITIONAL FALLOW

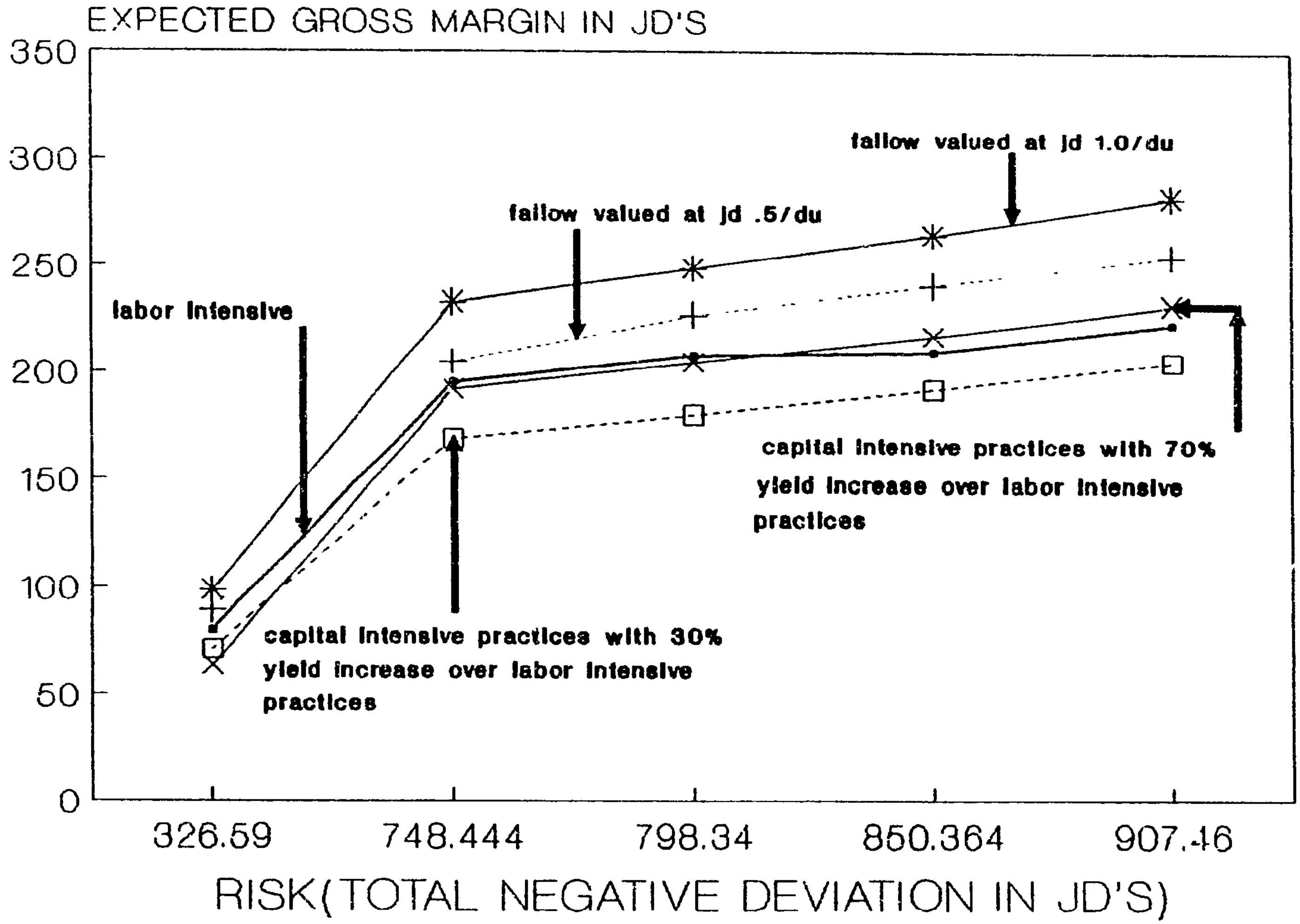
fig:6.6



IMPUTED VALUE FOR FALLOW IS ZERO

LEAST EFFICIENCY FRONTIERS
LABOR INTENSIVE VS CAPITAL INTENSIVE
AT DIFFERENT VALUES FOR FALLOW

fig:6.7



means of risk pooling is a rational one. Results confirm that wheat production in rotation with fallow is also risk-efficient.

The rationale for farmers' production of barley and lentils, in spite of the disadvantages of these crops as compared to wheat, is explained by their risk aversion and subsistence needs.

Although adoption of technology improves the overall farm income (expected gross margin), the associated risk at each level of net income is higher than with the labor-intensive methods. This is due to a number of factors:

a) Capital-intensive techniques increase the overall yield average without significantly reducing its variability.

b) Adoption of capital-intensive techniques is inversely related to the economic value of fallow. If traditional fallow assumes a positive value, the increase in yield required to provide sufficient incentive to small farmers would have to be substantially higher than the assumed 70percent increase.

c) Farmers' perception of the technique may not be shared with those of the research stations. Farmers may feel that the projected increases in yields resulting from the adoption of such techniques cannot be realized, or that the percentage of increase is lower than that predicated by experiments. This is plausible because availability of technology does not necessarily imply an adequate use of it (El Hurani, 1975).

d) Price fluctuations complicate the picture further, it is conceivable that farmers can apply modern technology and achieve excellent crops in a specific year, only to have the improvement in yields wiped out by a decline in prices. This situation is likely to happen in the context of Jordan, where storage facilities and marketing infrastructures are still poor. This situation has, in fact, happened in the irrigated sector of Jordan. Farmers have introduced a number of innovative techniques, such as drip irrigation, plastic houses and high-yielding varieties. The results have been spectacular; yields of vegetable crops in the Jordan Valley are comparable to international yields. However, with vegetable export markets shrinking in the last few years and a limited domestic market, the prices of vegetables have declined dramatically, exposing farmers to price risk, and thus to income instability.

Notes

[1]Since cost is assumed to cause no variability in income, analysis of gross income and net income leads to the same results.

[2]The maximum expected gross margin determined in the LP solution without risk was then specified as the gross margin constraint in the MOTAD model. The farm plan determined by MOTAD for this gross margin level was identical to the linear-programming solution.

[3]In spite of its large gross margin, as compared to the other crops, lentil production is labour-intensive. This margin becomes significantly low if labour needed goes beyond available family labour.

Note that the cost of production for barley is insignificantly lower than wheat; at the same time, the barley's price and yield are significantly lower than those of wheat. Barley is used basically as animal feed (Arabiat, 1985). The government policy to encourage livestock production by subsidizing imported animal feed could play a negative role in encouraging barley production. This suggests also that barley production is carried out in dryland areas of Jordan to meet farmers' own family needs and/or in marginal lands where wheat and other crops are not suitable.

[5]The value by which gross margin changes as risk increases or decreases between any two changes in basis solution is the dual of the gross margin constraint.

"The slope of the frontier is dY/dR as dY/dR decreases dR/dY increases where Y is the gross margin and R is the total negative deviation.

'For the period 1962-1985, coefficient of yield variation per dunum for wheat and barley was also 43 and 67 percent, respectively.

"Coefficient of variation for wheat, barley and lentil prices calculated for the period, 1975-1985, were 17, 20 and 22 percent respectively. It should be noted that the coefficient of variation of wheat prices in Jordan over the period 1975-1985 was similar to the coefficient of variation of FOB prices of wheat in Atlantic ports of the U.S. In fact, the coefficient of variation for wheat prices in the period 1971 to 1981 in Ohio, for example, was about 18 percent (Djogo, 1983). This implies that any price intervention which may have been put in place by the government of Jordan has not been effective in reducing the price variability of wheat. It has been argued that support prices have not worked simply because of marketing bottlenecks and storage problems and also because of the possibility that the prices were not announced at the right time (Gotsch, 1980).

CHAPTER VII: AGRICULTURAL INSURANCE AND FARM INCOME

A. Introduction

This chapter considers the role of agricultural insurance as a policy instrument for stabilizing farm income. Two hypothetical insurance schemes are proposed and analyzed in terms of their potential impact on improving land use and stabilizing the income of small farmers. These two schemes are: classical yield price/yield insurance and the relatively new concept of revenue insurance. Actuarially fair schemes as well as schemes designed using the normal probability density function are discussed. The comparison is carried out in terms of optimal farm plans generated by MOTAD procedures.

The chapter is divided into five sections. The first section contains preliminary analysis and relevant statistical indicators. The second section deals with actuarially fair insurance schemes and their potential benefits. The third section presents the insurance scheme designed according to Botts and Boles' (1954) procedure; some problems relating to yield distribution are discussed. In section four, revenue insurance for small farmers using capital-intensive practices is examined. Section five provides a summary and conclusion of the chapter.

B. Data Summary

Data on average gross margin, standard deviation and coefficient of variation of the gross revenues with and without hypothesized insurance schemes are presented in Table 7.1. Compared to the initial model (without insurance), the proposed revenue and yield/price insurance schemes maintain the average gross margin on a per dunum basis (under the assumption of actuarially fair premiums) and reduce its variance.

Table 7.1: Average Gross Margins, Standard Deviation and Coefficient of Variation of Insurance Schemes Considered

Crop Code[1]	W/F	B/F	W/B/F	W/B/L	W/L
Basic Model					
Average Gross Income (JDs/Du)	4.93	2.65	5.05	9.91	12.23
Standard Deviation (JDs)	2.43	1.14	2.29	4.21	5.30
Coefficient of Variation	49.33	43.14	45.37	42.47	43.36
Revenue Insurance[2]					
Average Gross Income (JDs/Du)	4.93	2.64	5.05	9.91	12.22
Standard Deviation (JDs)	2.11	0.85	1.89	3.79	4.96
Coefficient of Variation	42.76	32.25	37.35	38.22	40.54
Price & Yield Insurance[3]					
Average Gross Income (JDs/Du)	4.93	2.65	5.05	9.91	12.22
Standard Deviation (JDs)	2.24	0.88	2.00	3.93	5.12
Coefficient of Variation	45.34	33.39	39.55	39.62	41.85

[1]Crop Code Key: W/F, W/L, B/F represent two-year rotations of Wheat/Fallow, Wheat/Lentils and Barley/Fallow, respectively. W/B/F and W/B/L represent three-year rotations of Wheat/Barley/Fallow and Wheat/Barley/Lentils, respectively.

[2]Coverage rate is assumed equal to 80% of the historical average of the gross income over the period 1975 - 1985.

[3]Coverage rate is assumed equal to 80% of the historical yield and 80% of the historical price respectively over the period 1975 - 1985.

Note: The value of fallow is assumed to equal zero for all models.

It should be noted that because of price fluctuations, an actuarially fair plan that insures only yield will not necessarily maintain the average gross margin for each crop insured.

Revenue insurance with an 80 percent coverage rate reduces the standard deviation significantly more than yield price insurance with an 80 percent coverage rate for the crops insured -- wheat and barley. This type of insurance also reduces the variability of gross revenues, as measured by the coefficient of variation, by 15 percent for wheat and by 33 percent for barley (Table 7.1).

With revenue insurance, the total indemnities received and the premiums paid during the period under analysis altered the stream of the deviation of the gross revenue from the mean. Indemnities for both crops were mandated in four out of eleven years. The average indemnity was JD 0.786/dunum for wheat and JD 0.502/dunum for barley (see Table 7.2).

Yield/price insurance at an 80 percent coverage rate preserves the level of the average gross revenue at the same level as without insurance. The variance and the coefficient of variation are reduced significantly. The coefficient of variation of the gross revenue per dunum is reduced by 6 percent for wheat and by 29 percent for barley (Table 7.1).

Under the yield/price insurance model, price indemnities for wheat occurred in one out of eleven years for wheat, and in three out of eleven years for barley. Yield indemnities, on the other hand, were mandated in three out of eleven years for wheat, and in four out of eleven years for barley.

The annual premiums for wheat and barley, under the 80 percent coverage rate for yield/price insurance, were JD 0.4[illegible]4/dunum and JD 0.461 dunum respectively. Yield/price insurance provided relatively more protection for barley than for wheat (Table 7.3).

Table 7. . Revenue Insurance with 70 Coverage Rate for Wheat and Barley Premiums, Indemnities and Insured Income Streams

	Wheat Gross Revenues w/o Insurance	Wheat Indemnity	Wheat Gross Revenue w Insurance	Barley Revenue w/o Insurance	Barley Indemnity	Barley Gross Revenue w/Insurance
1975	[illegible]	0.000	8.7[illegible]	7.[illegible]	0.000	7.00[illegible]
1976	8.516	0.000	7.761	5.[illegible]	0.000	[illegible]
1977	8.30[illegible]	0.000	7.[illegible]	[illegible]	0.000	[illegible].117
1978	7.417	0.11[illegible]	7.10[illegible]	[illegible].201	0.392	3.[illegible]
1979	4.429	[illegible].[illegible]67	7.10[illegible]	1.[illegible]	2.950	[illegible]
1980	18.050	0.000	17.[illegible]	9.[illegible]	0.000	8.986
1981	11.258	0.000	10.171	[illegible].067	0.000	1.56[illegible]
1982	5.016	2.830	7.109	[illegible].90[illegible]	1.29[illegible]	[illegible]
1983	20.[illegible]	0.000	19.717	7.519	0.000	7.017
1984	[illegible].012	1.88[illegible]	7.109	[illegible].906	0.289	[illegible]
1985	9.[illegible]	0.000	8.575	5.590	0.000	5.076
Average	9.870	0.786	9.870	5.215	0.502	5.215

Table 7.3. YIELD/PRICE INSURANCE with 80 Coverage Rate, Wheat and Barley Premiums, Indemnities, and Insured Income Streams

Year	Wheat Gross Revenues w/o Insurance	Wheat Price Indemnity JD/du	Wheat Yield Indemnity JD/du	Wheat Gross Revenue w/Insurance	Barley Gross Revenues w/o Insurance	Barley Price Indemnity	Barley Gross Revenue w/Insurance
1975	9.573	0.000	0.000	7.007	7.575	0.000	0.000
1976	8.518	0.000	0.000	0.000	5.669	7.7[illegible]	0.000
1977	8.509	0.000	0.000	0.000	5.668	7.52[illegible]	0.[illegible]
1978	7.117	0.000	1.2[illegible]1	0.647	[illegible]	7.109	0.000
1979	1.1[illegible]	5.379	0.000	0.169	1.257	7.109	1.676
1980	18.0[illegible]0	0.000	0.000	0.000	9.571	17.[illegible]	0.000
1981	1[illegible].258	0.000	1.521	0.000	5.111	10.171	0.000
1982	[illegible]016	0.000	0.538	0.000	2.928	7.10[illegible]	1.2[illegible]
1983	20.[illegible]	0.000	0.000	0.000	7.616	[illegible]717	0.000
1984	[illegible]012	0.000	0.000	0.000	[illegible]911	7.10[illegible]	0.000
1985	9.[illegible]61	0.000	0.000	0.000	5.[illegible]	[illegible]	[illegible]
Average	[illegible]70	0.198	0.[illegible]	0.102	5.[illegible]	[illegible]70	[illegible]

C. Whole-Farm Planning and Insurance

In this section the impact of the two insurance options, revenue and price/yield, is discussed in the context of a whole-farm planning approach using MOTAD procedure. The results of MOTAD procedures, with and without the two insurance options, will be presented and analyzed in terms of the objective function, crop mix and income stability. The results are presented in tabular form similar to that in Chapter V.

Risk Aversion and Expected Net Income

Revenue Insurance vs. Yield/Price Insurance. A comparison of the values of the gross margins under different RAPS (Tables 7.4 and 7.5) clearly illustrates that revenue insurance is more effective in stabilizing net income than price/yield insurance.

Table 7.4: Expected Gross Margin (JD) for the Optimal Farm Plans Under Risk Aversion[a]

		Risk Aversion Parameter		
	Unit	0.0	0.15	0.3
Revenue Insurance	JD	224	210	195
Yield/Price Insurance	JD	224	210	80
Initial Model	JD	224	210	80

[a]Entries in this table represent expected gross margin (JDs).

The 95 percent confidence interval reveals that net income with revenue insurance is more stable than with yield/price insurance or with no insurance (initial model). The coefficient of variation of the gross margin for optimal farm plans is also more stable in the case of revenue insurance (Table 7.5) than for the no insurance or yield/price insurance cases.

With revenue insurance, the total negative deviation has decreased relatively more for each level of expected gross margin in each farm plan than for the initial model or for the farm plan with yield/price insurance. The ratio of risk to the corresponding expected gross margin in each farm plan is also lower with revenue insurance than with yield/price insurance for all farm plans (Table 7.5).

Table 7.5: Coefficient of Variation and Ratio of Risk of the Expected Gross Margin (JD) for Optimal Farm Plans

	Expected Gross Margin[a]			Ratio of Risk[b]		
	224	208	82	224	208	82
Revenue Insurance	84	78	80	3.52	3.29	3.38
Yield/Price Insurance	89	84	87	3.75	3.53	3.67
Initial Model	97	92	97	4.05	3.84	4.07

[a]Coefficient of variation (standard deviation/expected gross margin).
[b]As measured by the total negative deviation divided by the expected gross margin.

The objective of both revenue insurance and yield/price insurance is to reduce the cost of risk to small farmers. The reduction in the cost of risk depends on two parameters: total negative deviation and RAP. The effectiveness of each insurance scheme in reducing the cost of risk is measured by the inverse of the absolute value of the dual in the average gross margin constraint multiplied by total negative deviation. The smaller this value at a specific RAP (the larger the certainty equivalent), the more effective the insurance scheme. Revenue insurance is more effective than price/yield insurance in reducing the cost of risk. Effectiveness increases as risk aversion increases (Table 7.6).

Table 7.6: Insurance and the Cost of Risk As a Percentage Decrease of the Cost of Risk in the Initial Model[1]

Unit	Risk-Aversion Parameter		
	0.1	0.2	0.3
Revenue Insurance	10	48	342
Yield/price Insurance	5	28	201

[1]Figures calculated as: (cost of risk with insurance - cost of risk without insurance)/(cost of risk without insurance) x 100.

Resource Allocation and Insurance

Land Use and Crop Mix. Land use under high risk aversion is significantly improved with both insurance options, as compared to the initial model. At RAP = 0.3, the 43 dunums that are unused in the initial model become fully utilized with revenue insurance. In relative terms, land use with revenue insurance has more than doubled at the highest RAP (Table 7.7). However, at the same RAP, yield/price insurance has no significant impact on land utilization.

Both insurance options have no significant effect on the crop mix at low-risk aversion and risk-neutral levels. At these levels, crop mix is characterized by a large proportion of land devoted to wheat in rotation with fallow.

With revenue insurance, as RAP increases the percentage of fallow to cropped land also increases because when the wheat/barley/fallow rotation leaves the optimal farm plan, the barley/fallow rotation enters it, causing an overall higher fallow percentage (Table 7.8).

Table 7.7 Summary of Risk Efficient Farm Plan under Labor-Intensive Practices Revenue Insurance and Yield/Price Insurance

	UNIT	REVENUE INSURANCE						PRICE/YIELD INSURANCE				
1 RAP[a]	-	0.00	0.09	0.15	0.15	0.30	0.53	0.00	0.10	0.15	0.20	0 [illegible]
2. EGM[b]	JDs	224.09	224.09	224.09	208.12	195.34	82.00	224.10	224.10	210.00	208.12	40.15
3 CEGM[c]	JDs	224.09	145.97	105.73	103.53	3.38	-10.40	224.10	140.01	96.81	61.03	-7.86
ENTERPRISE[d]												
4 LENTILS	Dunum						1.90					
5 WHEAT/FALLOW	Dunum	56.08	56.08	56.08	56.08	60.82	22.61	56.08	56.08	56.07	56.08	[illegible]
6 BARLEY/FALLOW	Dunum					9.47	13.28					
7 WHEAT/BARLEY/FALLOW	Dunum	1.53	1.53	1.53	14.21			1.54	1.54	12.79	11.21	[illegible]
8 WHEAT/BARLEY LENTILS	Dunum	18.39	18.39	18.39	5.71	5.71		18.38	18.38	7.11	5.71	5.71
9 WHEAT/LENTILS	Dunum											
10. UNUSED	Dunum	0.00	0.00	0.00	0.00	0.00	40.11	0.00	0.00	0.00	0.00	[illegible]
11 TOTAL NEGATIVE DEVIATION[e]	JD	789.91	789.12	789.12	685.65	639.88	277.28	840.95	840.95	[illegible]	735.15	[illegible]
12 STD[f]	JD	188.79	188.59	188.59	163.39	152.95	66.26	200.98	200.98	176.61	175.77	70.35
13 CV[g]	%	84.21	84.16	84.15	78.50	78.28	80.81	89.68	89.68	85.05	84.45	[illegible]
14 LENTILS[h]	Dunum	6.15	6.15	6.13	1.90	1.90	1.90	6.12	6.12	[illegible]	1.90	[illegible]
15 WHEAT[h]	Dunum	34.68	34.68	34.68	31.68	32.31	11.30	34.68	34.68	34.67	[illegible]	[illegible]
16 BARLEY	Dunum	6.64	6.61	6.61	6.61	6.63	6.64	6.64	6.61	6.64	[illegible]	[illegible]
17 FALLOW	Dunum	28.55	28.55	28.55	32.77	35.14	17.94	28.55	28.55	32.29	[illegible]	[illegible]
18 UNCROPPED[h]	Dunum	0.00	0.00	0.00	0.00	0.00	38.21	0.00	0.00	0.00	0.00	[illegible]
19 FALLOW IN TWO	Dunum	28.01	28.04	28.04	28.04	35.14	17.94	28.04	28.04	28.03	[illegible]	[illegible]
20 FALLOW IN THREE		0.51	0.51	0.51	4.75	0.00	0.00	0.51	0.51	4.26	[illegible]	[illegible]
21 FALLOW IN CROPPED LAND[k]		60.16	60.16	60.16	75.85	86.02	90.42	60.18	60.18	73.90	[illegible]	[illegible]
22 FALLOW IN TOTAL FALLOW[l]		98.21	98.21	98.21	85.51	100.00	100.00	98.20	98.20	86.50	[illegible]	[illegible]
23 FALLOW IN TOTAL FALLOW[m]		1.78	1.78	1.78	[illegible]	0.00	0.00	1.79	1.79	13.20	[illegible]	[illegible]

[a] Risk aversion parameter
[b] Expected gross margin
[c] Certainty equivalent expected gross margin
[d] Crop rotations
[e] Risk as measured by total negative deviation
[f] Standard deviation of the expected gross margin
[g] Coefficient of variation of expected gross margin
[h] Actual crops grown on the farm
[i] Total fallow results from two-year crop rotation
[j] Total fallow results from three-year crop rotation
[k] Percentage of fallow land in total cropped land
[l] Two year fallow as a percentage of total fallow
[m] Three year fallow as a percentage of total fallow

Notes [illegible]

Table 7.8: Share of Fallow as Percentage of Cropped Land

	Risk Neutral RAP = 0.00	Risk-Averse RAP = 0.250
Initial Model	60	75
Revenue Insurance	60	76
Yield/Price Insurance	60	85

Least-Risk-Efficiency Frontiers

The least-risk-efficiency frontiers for the initial model and for models with revenue and yield/price insurance at an 80 percent coverage level were drawn by tracing the loci of the alternative optimal farm plans, with the expected gross margin on the Y-axis and the total negative deviations on the X-axis (after necessary scaling). The data for the models are summarized in Tables 7.8 and 7.9 and shown in Figure 7.1. The initial model is the same as described in Chapter V.

The least-risk-efficiency frontiers generated by the MOTAD procedure for revenue insurance lie above the contours of the initial model and the yield/price insurance model, suggesting that revenue insurance is more effective in reducing risk at every level of expected gross margin. Yield/price insurance completely dominates the initial model, showing that at each level of expected gross margin, the risk level could potentially be reduced in comparison to the plan without insurance. Both insurance schemes could, within a feasible range, potentially reduce the risk at every feasible level of expected gross margin.

LEAST RISK EFFICIENCY FRONTIERS fig:7.1

BASIC MODEL VS INSURANCE OPTIONS

LABOR INTENSIVE PRACTICES

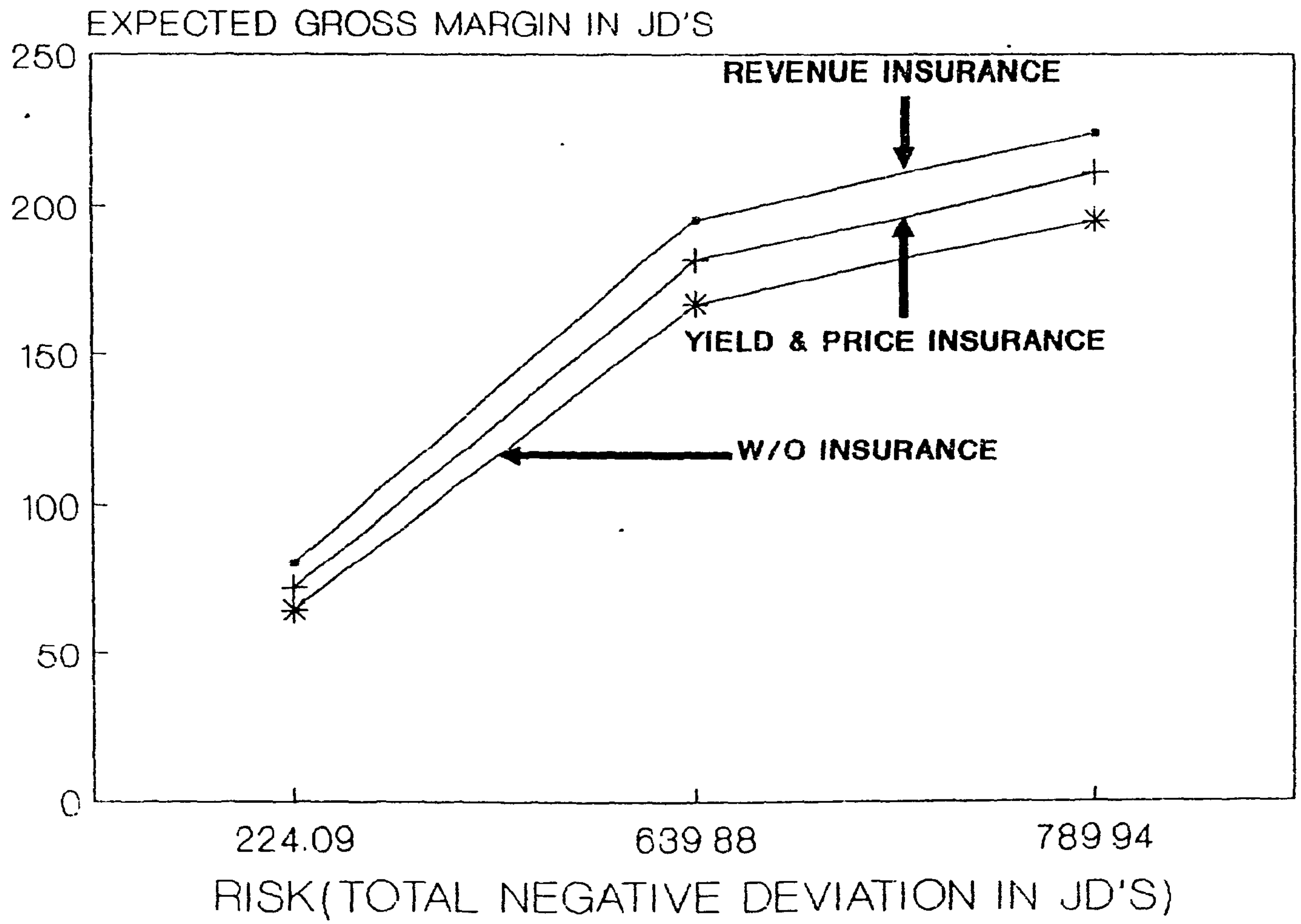


Table 7.9: Fallow Rotation for Different Levels of Risk Aversion Parameter (Fallow valued at JD 0.5 dunum)

	Risk Aversion Coefficient		
	0.1	0.2	0.3
Two Years Fallow Rotation			
Initial Model	86.0	97.6	100.0
Revenue Insurance	90.0	94.5	95.0
Price/Yield Insurance	86.0	98.0	100.0
Three Years Fallow Rotation			
Initial Model	14.0	2.4	0.0
Revenue Insurance	10.0	5.5	5.0
Price/Yield Insurance	14.0	2.4	0.0

[a]Figures are calculated by dividing fallow in two- and three-year rotation, respectively, by total fallow.

When insurance options are introduced at the same time that the value of fallow is parameterized, the structure of the crop mix remains basically the same. Revenue insurance increases the use of rotation, not including fallow (Table 7.9). This is due to the fact that reduction of the cost of risk induces farmers to plant relatively riskier crops so as to maximize the insured total gross margin. To explain this point further, at a RAP of 0.1, in both the initial model and the model with yield/price insurance, wheat and barley production is exclusively based on two-year rotations with fallow. This is expected because fallow is valued at JD 0.5/dunum. With revenue insurance, total land utilization increases by more than 100 percent and crop production includes a slight decrease in fallow (Tables 7.10). When the value of fallow is increased to JD 1.0/dunum no change is visible (Table 7.11).[1]

Table 7 10 Summary of Risk Efficient Farm Plan under Labor-Intensive Practices Revenue and Yield/Price Insurance When Value of Fallow is JD 0 5/du

	UNIT	-------REVENUE INSURANCE-------				-----PRICE/YIELD INSURANCE-----			
Dual Value		7 61	3 64	3.11	2 87	7.60	3 85	3 81	3 15
1 RAP[a]	-	0.13	0 27	0 32	0.35	0.13	0 26	0 26	0 32
2. EGM[b]	JDs	230 00	205 00	177.50	100 00	224.10	224 10	210 00	208.12
3. CEGM[c]	JDs	134 77	37.34	8 55	-5.31	224.10	110 01	96 81	61.03
ENTERPRISE[d]									
4 LENTILS	Dunum		1 63	1.90	1 90			1.65	1 90
5. WHEAT/FALLOW	Dunum	56.08	60 82	47.61	25.58	56 08	59 99	60 81	36 69
6. BARLEY/FALLOW	Dunum		12.72	26.49	13.28		7 85	12 75	15 28
7. WHEAT/BARLEY/FALLOW	Dunum	9.25	0.83			13.83	2.47		
8 WHEAT/BARLEY/LENTILS	Dunum	10 67				6.09	5 71	0 85	
9. WHEAT/LENTILS	Dunum								
10 UNUSED	Dunum	0.00	0.00	0.00	35.24	0 00	0 00	0 00	24 15
11. TOTAL NEGATIVE DEVIATION[e]	JD	724.94	610 81	524.68	302.20	758 65	698 55	660 08	427.20
12. STD[f]	JD	173 26	145.98	125 40	72 23	176.54	166.95	157 76	102 10
13. CV[g]		75.33	71.21	70 65	72.23	78.46	77.65	76.96	77 06
14. LENTILS[i]	Dunum	3.56	1 63	1.90	1.90	2.03	1.90	1 91	1 90
15. WHEAT[h]	Dunum	34.68	30.69	23.81	12.79	34.68	32.72	30.68	18.35
16. BARLEY[i]	Dunum	6.64	6.64	13 25	6.64	6.64	6.64	6.64	6 64
17. FALLOW[h]	Dunum	31.12	37.05	37 05	19.43	32 65	34 73	36.77	24.99
18 UNCROPPED[h]	Dunum	0.00	0 00	0.00	35.24	0.00	0.00	0.00	24 13
19 FALLOW IN TWO[i]	Dunum	28.04	36.77	37.05	19.43	28.04	33 91	36.77	24 99
20. FALLOW IN THREE[j]	%	3.08	0.28	0.00	0.00	4.61	0.82	0.00	0 00
21. FALLOW % IN CROPPED LAND[k]	%	69.35	95.11	95.12	91.09	75 32	84 17	93.73	92 95
22. FALLOW2 % IN TOTAL FALLOW[l]	%	90.09	99.25	100.00	100.00	85.88	97 63	100 00	100 00
23. FALLOW3 IN TOTAL FALLOW[m]	%	9.91	0.75	0 00	0.00	14 12	2 37	0 00	0 00

[a]Risk aversion parameter
[b]Expected gross margin
[c]Certainty equivalent expected gross margin
[d]Crop rotations
[e]Risk as measured by total negative deviation
[f]Standard deviation of the expected gross margin
[g]Coefficient of variation of expected gross margin
[h]Actual crops grown on the farm
[i]Total fallow results from two-year crop rotation
[j]Total fallow results from three-year crop rotation
[k]Percentage of fallow land in total cropped land
[l]Two year fallow as a percentage of total fallow
[m]Three year fallow as a percentage of total fallow

Notes Rows 14 - 23 are derived from rows 4 - 10.

Table 7.11: Summary of Risk Efficient Farm Plan under Labor-Intensive Practices Revenue and Yield/Price Insurance When Value of Fallow is JD 1.0/du

	UNIT	-------REVENUE INSURANCE-------				-----PRICE/YIELD INSURANCE-----			
Dual Value		8.99	4.06	3.11	2.58	8.97	4.28	3.49	2.82
1. RAP[a]	-	0.11	0.25	0.32	0.38	0.11	0.23	0.28	0.36
2. EGM[b]	JDs	242.50	222.50	197.50	110.00	242.50	222.50	210.00	100.00
3. CEGM[c]	JDs	164.88	72.83	27.08	-7.46	159.02	69.13	34.75	-6.48
ENTERPRISE[d]									
4. LENTILS	Dunum		1.83	1.90	1.90		1.83	1.90	1.90
5. WHEAT/FALLOW	Dunum	56.08	60.82	48.35	25.63	56.08	60.82	54.67	22.05
6. BARLEY/FALLOW	Dunum		13.12	25.75	13.28		13.13	19.43	14.83
7. WHEAT/BARLEY/FALLOW	Dunum	12.56				12.57			
8. WHEAT/BARLEY/LENTILS	Dunum	7.36	0.23			7.35	0.22		
9. WHEAT/LENTILS	Dunum								
10. UNUSED	Dunum	0.00	0.00	0.00	35.19	0.00	0.00	0.90	37.24
11. TOTAL NEGATIVE DEVIATION[e]	JD	697.41	607.22	529.26	302.76	749.16	656.28	612.35	299.71
12. STD[f]	JD	57.96	145.12	126.49	72.36	179.05	156.85	146.35	71.65
13. CV[g]	%		73.48	114.99	65.78	73.83	70.50	69.69	71.6[illegible]
14. LENTILS[h]	Dunum	2.45	1.91	1.90	1.90	2.45	1.90	1.90	1.90
15. WHEAT[h]	Dunum	34.68	30.49	24.18	12.82	34.68	30.48	27.34	11.02
16. BARLEY[h]	Dunum	6.64	6.64	12.86	6.64	6.64	6.64	9.72	7.42
17. FALLOW[h]	Dunum	32.23	36.97	37.05	19.46	32.23	36.98	37.05	18.43
18. UNCROPPED[h]	Dunum	0.00	0.00	0.00	35.19	0.00	0.00	0.00	37.24
19. FALLOW IN TWO	Dunum	28.04	36.97	37.05	19.46	28.04	36.98	37.05	18.43
20. FALLOW IN THREE	%	4.19	0.00	0.00	0.00	4.19	0.00	0.00	0.00
21. FALLOW IN CROPPED LAND[k]	%	75.62	94.72	95.12	91.03	73.64	94.75	95.12	90.65
22. FALLOW₂ IN TOTAL FALLOW[l]	%	87.01	100.00	100.00	100.00	87.00	100.00	100.00	100.00
23. FALLOW₃ IN TOTAL FALLOW[m]		12.99	0.00	0.00	0.00	13.00	0.00	0.00	0.00

[a]Risk aversion parameter
[b]Expected gross margin
[c]Certainty equivalent expected gross margin
[d]Crop rotations
[e]Risk as measured by total negative deviation
[f]Standard deviation of the expected gross margin
[g]Coefficient of variation of expected gross margin
[h]Actual crops grown on the farm
[i]Total fallow results from two-year crop rotation
[j]Total fallow results from three-year crop rotation
[k]Percentage of fallow land in total cropped land
[l]Two year fallow as a percentage of total fallow
[m]Three year fallow as a percentage of total fallow

Notes: Rows 14 - 23 are derived from rows 4 - 10

D. Premium Rate Making

A growing number of studies are producing evidence against the assumption of symmetry and the use of normal distribution in calculating crop-insurance price premiums.' Yeh et al. (1980) found that the wheat probability distribution in ten out of fourteen districts in Manitoba appeared to be asymmetrical. In four out of ten districts the distribution of wheat yield was skewed to the right, and in the remaining six districts it was skewed to the left. Nelson (1987) found similar results in eleven corn-growing counties in Illinois.

Pure premium calculation when annual yield data appear to be skewed to the right will underestimate the real pure premium; when annual yield data appear to be skewed to the left the pure premium will be overestimated. The bias will be aggravated if annual yield data appear to be less heavily concentrated than the normal distribution (Day, 1972).

In this section, an all-risk yield insurance scheme is designed, whereby the pure premium is calculated using the normal probability density function. Assumptions of coverage rates of 50 percent, 65 percent and 80 percent of the eleven years' historical average are made.

MOTAD procedure is applied to derive the least-risk-efficiency frontier for the plans with and without insurance. Other variations are also examined, including elimination of price effect and parametrization of the premium rate.

Wheat and Barley Yield Distribution

Examination of the yield data for wheat and barley for the period 1967-1984 (Table 7.12) summarizes the estimated values for the coefficient, skewness, kurtosis and Kolmogorov-Smirnov parameter. Both coefficients of skewness and kurtosis indicate that the normality assumption for wheat and barley is not valid. In fact, it was rejected at 5 percent significance using the Kolmogorov-Smirnov parameter.

Table 7.12: Statistical Parameters for Wheat and Barley Yield Data

	Skewness (n_1)	Kurtosis (KS) (n_2)	Kolmogorov-Smirnov (KS)[a]
Wheat	0.033	1.432	0.221
Barley	0.317	2.143	0.168

[a]The Kolmogorov-Smirnov parameter is a distance test based on the maximum discrepancy between the numerical distribution of the sample and some hypothesized distribution (in this case normal) (Shapiro et al., 1981).

Premium Rate Under Normality Assumption of Yields

Premium costs are calculated by the expression:

$$P = (R.GY.PG) \tag{7.1}$$

where P is the premium, GY is the guaranteed yield (a percentage of the historical average), PG is the elected price and R is the rate charged. R is calculated by the expression:

$$R = (EL/GY.100) \tag{7.2}$$

where EL[3] is the expected loss which is derived by the expression

$$EL = \int_{-\infty}^{GY} (GY - Y).f(Y)\, dy \tag{7.3}$$

using the 1985 price level at 50 percent, 65 percent and 80 percent of the historical average as guaranteed yields (coverage rate).

Table 7 13. Premium vs. Indemity for All Risk Yield Crop Insurance Under Normal Distribution, WHEAT and BARLEY

Year	WHEAT Crop Insurance Coverage Rate						BARLEY Crop Insurance Coverage Rate					
	50%		65%		80%		50%		65		80	
	Indemnity	Premium	Indemnity	Premium	Indemnity	Premium	Indemnity	Premium	Indemnity	Premium	Indemnity	Premium
1975	0.000	2.066	0.000	3.978	0.000	7.044	0.000	5.999	0.000	8.649	0.000	12.072
1976	0.000	2.066	0.000	3.978	0.009	7.044	0.000	5.999	0.000	8.649	0.000	12.072
1977	0.000	2.066	0.000	3.978	0.000	7.044	0.000	5.999	0.000	8.649	1.75[illegible]	12.072
1978	0.000	2.066	0.000	3.978	0.000	7.044	0.000	5.999	0.000	8.649	0.000	12.072
1979	0.000	2.066	2.250	3.978	15.117	7.044	9.942	5.999	19.450	8.649	28.917	12.072
1980	0.000	2.066	0.000	3.978	0.000	7.044	0.000	5.999	0.000	8.649	0.000	12.072
1981	0.000	2.066	0.000	3.978	0.000	7.044	0.000	5.999	0.000	8.649	0.000	12.072
1982	0.000	2.066	3.129	3.978	15.995	7.044	0.000	5.999	0.000	8.649	15.0[illegible]	12.072
1983	0.000	2.066	0.000	3.978	0.000	7.044	0.000	5.999	0.000	8.649	0.000	12.072
1984	0.000	2.066	3.139	3.978	16.006	7.044	0.000	5.999	0.000	8.649	8.845	12.072
1985	0.000	2.066	0.000	3.978	0.000	7.044	0.000	5.999	0.000	8.649	0.000	12.072
Avg	0.000	2.066	0.774	3.978	4.284	7.044	0.904	5.999	2.271	8.649	4.959	12.072

The expected loss (theoretical premium), as calculated using the procedure of Botts and Boles (1954) (equation 7.3), is presented in Tables 7.13 and 7.14 (quantity equivalent kgs/dunum). Table 7.13 shows that at a coverage rate of 50 percent during the period 1975-1985, the annual premium paid for wheat was 2.066 kgs of wheat and no indemnity was mandated. When the coverage rate was increased from 50 to 65 percent, the annual premium was 3.978 kgs of wheat, while the average indemnity over the same period averaged only 0.774 kgs. With an 80 percent coverage rate, the average premium and indemnity were 7.044 and 4.28 (kg), respectively.

Table 7.14: All-Risk Crop-Yield Insurance: Theoretical Premium Structure for Wheat and Barley in the Study Area

	Theoretical Premium[a] (kg)		Theoretical Premium[b] (JD)	
Coverage	Wheat	Barley	Wheat	Barley
50	2.066	5.999	0.227	0.480
55	2.595	6.802	0.285	0.544
60	3.228	7.684	0.355	0.615
65	3.978	8.649	0.438	0.692
70	4.856	9.700	0.534	0.776
75	5.875	10.840	0.646	0.867
80	7.044	12.072	0.775	0.966
85	8.375	13.399	0.921	1.072
90	9.873	14.822	1.086	1.186
95	11.544	16.341	1.270	1.307
100	13.393	17.960	1.473	1.437

[a]As a percentage of the average yield in Irbid area for 1961-1984.
[b]Theoretical premium is equivalent to the expected loss in kgs.

Source: Calculated by the author using Botts and Boles procedure.

These rates are similar for barley, with the exception that at the 50 percent coverage rate an average indemnity of 0.904 was received (see Table 7.14). The ratios of premium to indemnity for wheat and barley for the three coverage rates are presented in Table 7.15.

Depending on the crop mix, the ratio of weighted average of the premium and indemnity would be slightly lower than that for wheat alone. This suggests that the calculated premium for barley is relatively more actuarially fair than that for wheat. Consequently, in the short term, it can be concluded that expected loss, as estimated using Botts and Boles' procedure, renders the premium/indemnity structure "unfair".

Table 7.15: Indemnity Premium Ratio Under Normality Assumption of the Yields[1]

Crop Coverage Rate	50%	65%	80%
Wheat	0	19	61
Barley	30	47	82

[1]Calculated by summing indemnities from 1975-1985, and dividing by the sum of the premium multiplied by 100.

Actuarially Unfair Yield Insurance

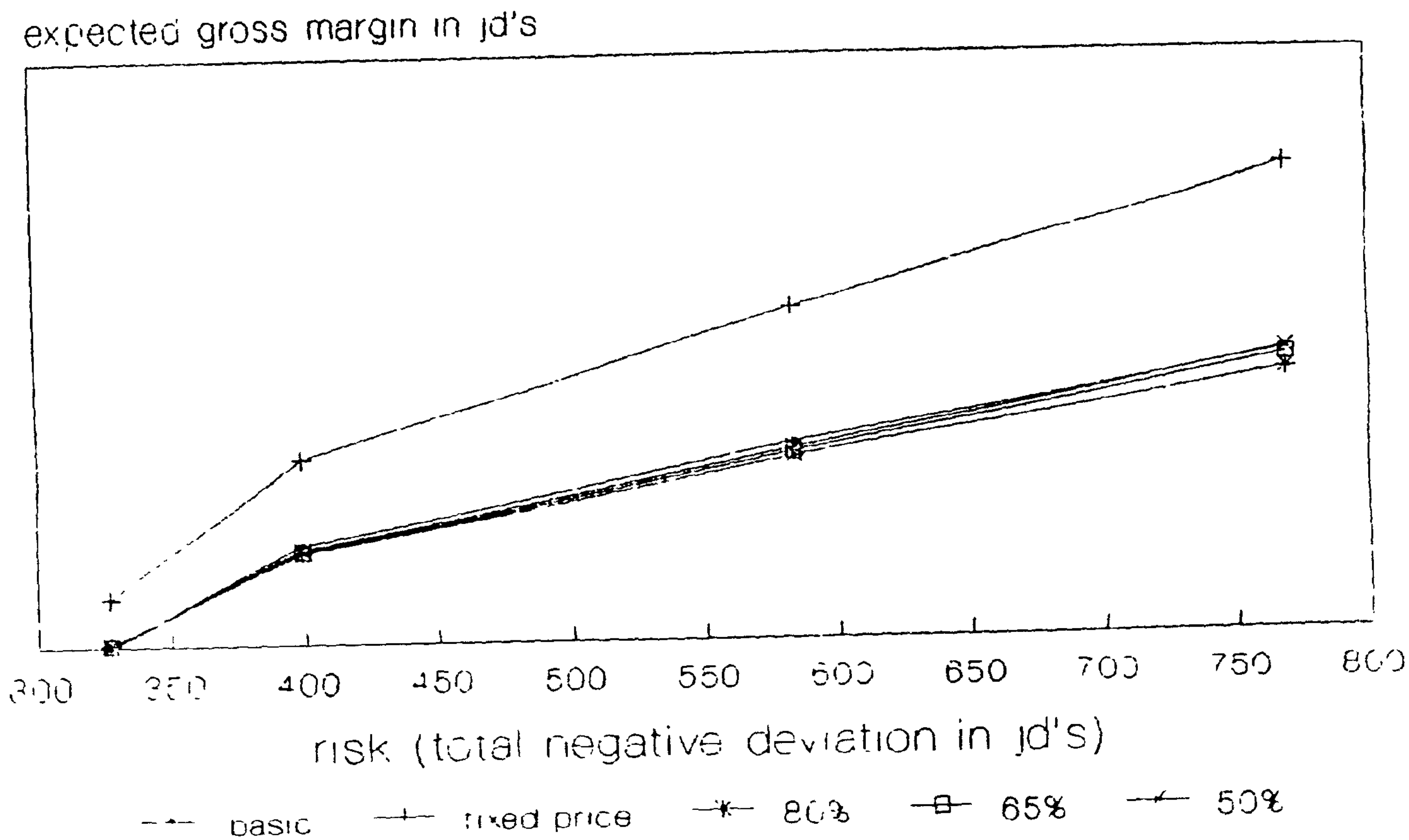
The yield insurance model uses the premium structure as derived from the normal distribution expected-loss relation and includes 50 percent, 65 percent and 80 percent coverage rates. The results show that the least-risk-efficiency frontier without insurance dominates completely the least-risk-efficiency frontier generated with insurance over all ranges of feasible income (Figure 7.2).

LEAST RISK EFFICIENCY FRONTIERS

YIELD INSURANCE

LABOR INTENSIVE PRACTICES

fig: 7.2



PREMIUM IS CALCULATED ASSUMING
WHEAT AND BARLEY YIELDS TO BE NORMALLY
DISTRIBUTED NO SUBSIDY

When the effect of price was eliminated, the least-risk-efficiency frontier with insurance at a 50 percent coverage rate dominated the original least-risk-efficiency frontier and the frontiers generated by the 65 and 80 percent coverage rate alternatives. In spite of this slight advantage, provision of price support by fixing the price level at the crops' 11-year average is more effective. The least-risk-efficiency frontiers with fixed prices dominate those generated by all three insurance alternatives. When the premiums are reduced by 50 percent and guaranteed prices are offered, the insurance option with the 80 percent coverage rate outperforms the other two options, but is still dominated by the least-risk-efficiency frontier generated by guaranteed prices only (Figures 7.3, 7.4 and 7.5). The least-risk-efficiency frontiers for all insurance schemes using the premium/indemnity structure of Botts and Boles shows that this type of crop insurance is unlikely to provide the protection necessary to stabilize farmers' income in the study area.

In conclusion, premium calculation using the normal density function appears to generate unfair premiums because the total indemnity paid during the 11 years was substantially lower than total premium paid. It should also be noted that no administrative reinsurance-loading factors are dealt with in this study, that is, the study deals only with public or semi-public insurance schemes.

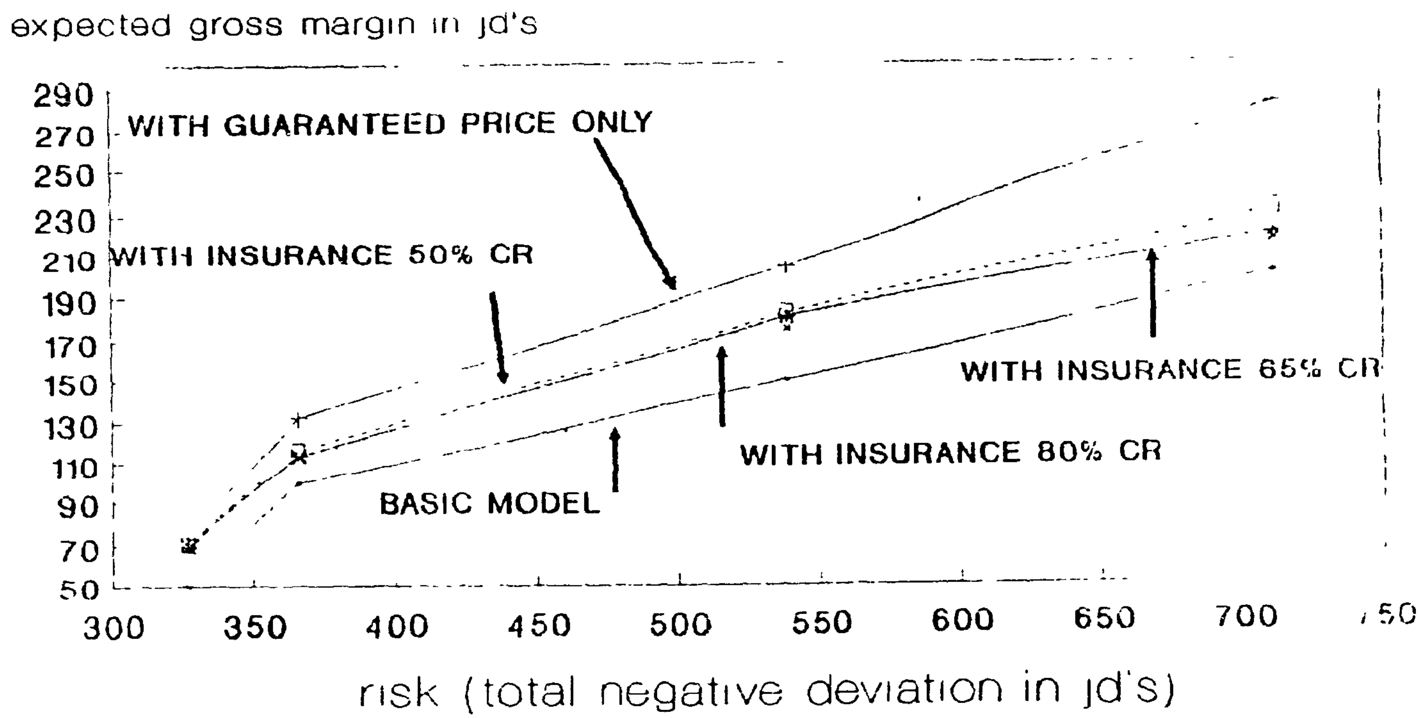
E. Revenue Insurance and Capital-Intensive Agricultural Practices

This section deals with the impact of revenue insurance on the adoption of capital-intensive practices. Revenue insurance is offered for

LEAST RISK EFFICIENCY FRONTIERS fig: 7.3

YIELD INSURANCE AND GUARANTEED PRICE

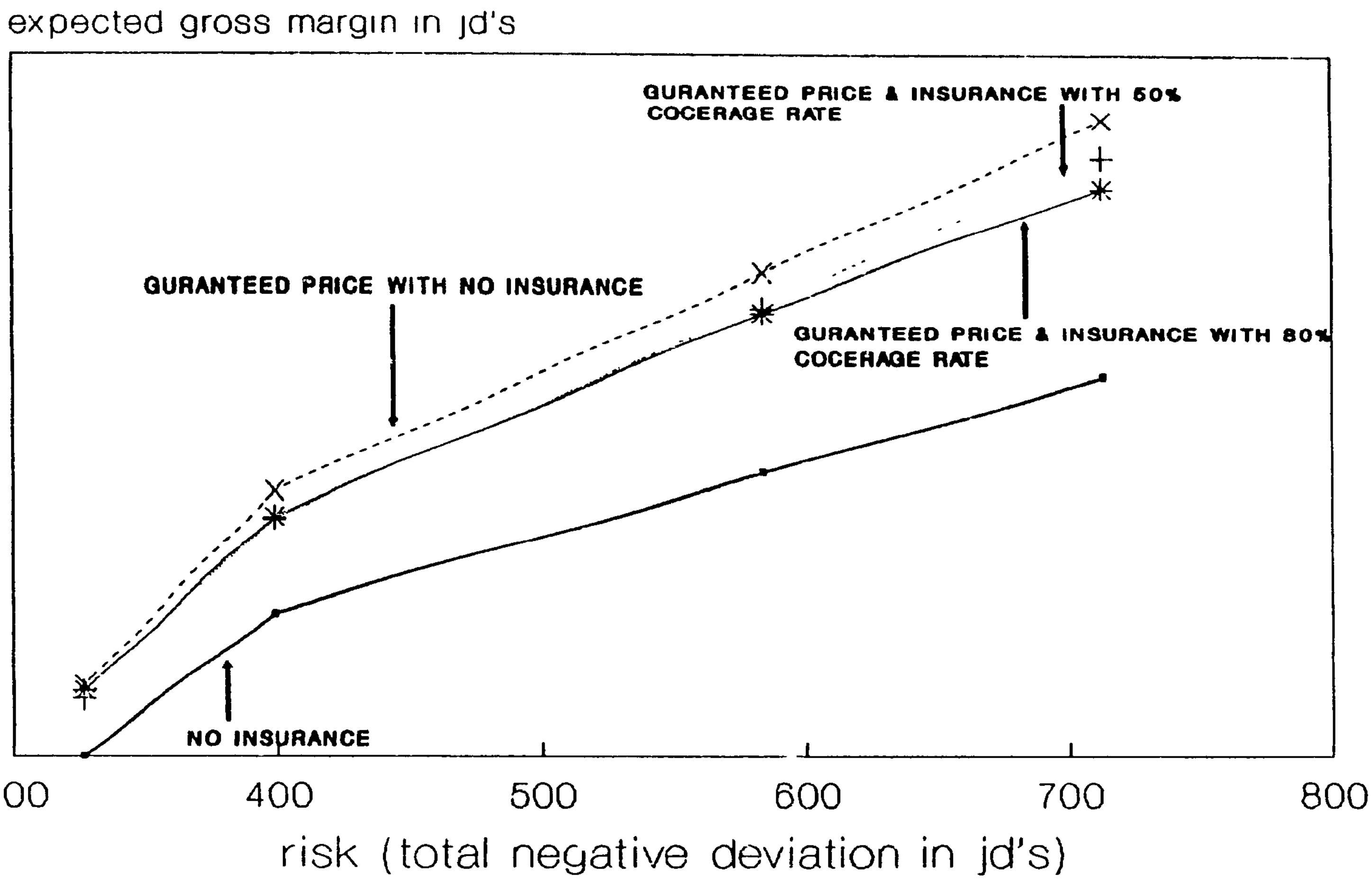
LABOR INTENSIVE PRACTICES



PREMIUM IS CALCULATED ASSUMING
WHEAT AND BARLEY YIELDS TO BE NORMALLY
DISTRIBUTEC NO SUBSIDY

LEAST RISK EFFICIENCY FRONTIERS
YIELD INSURANCE AND GUARANTEED PRICE
LABOR INTENSIVE PRACTICES

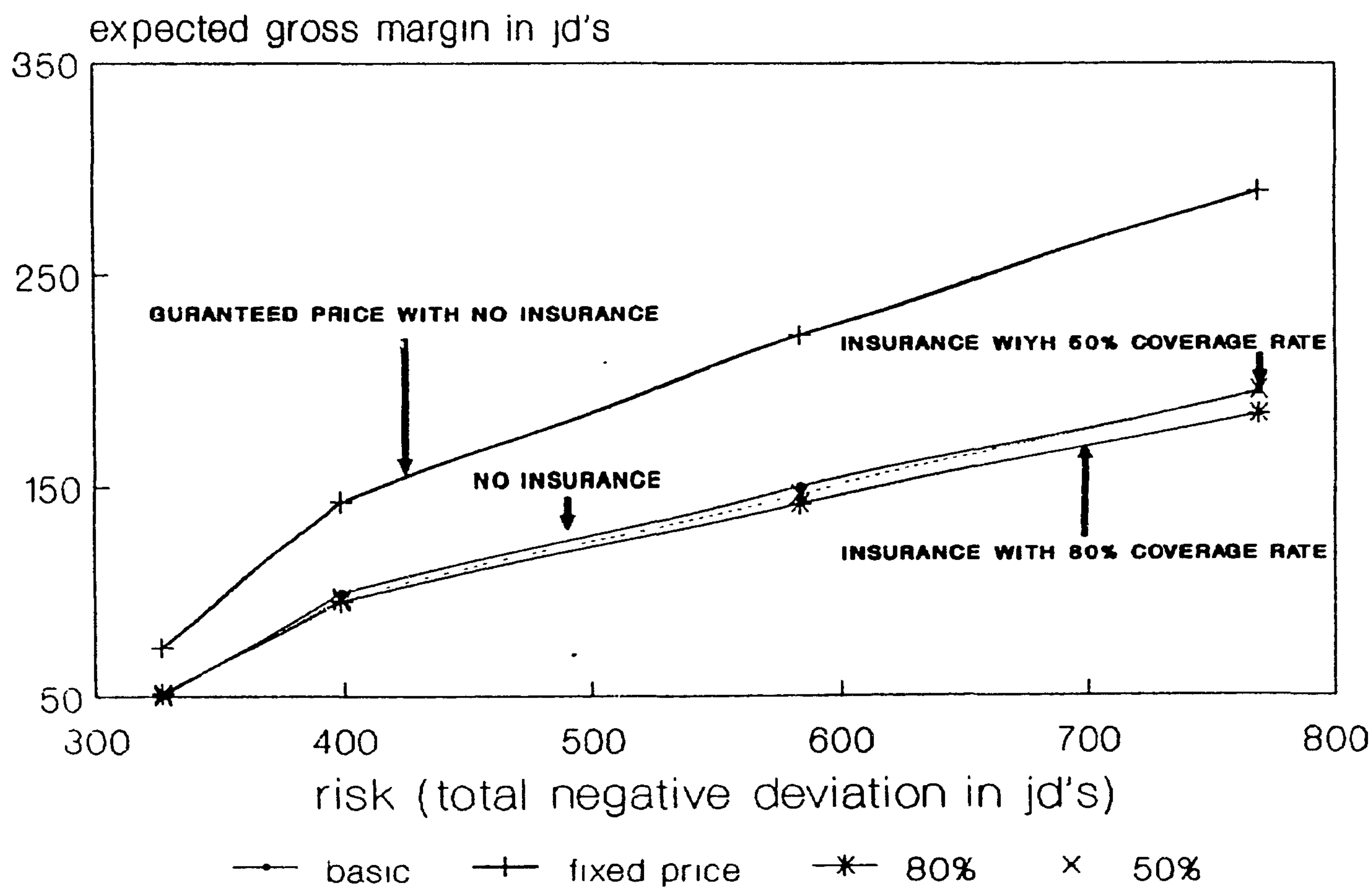
fig:7.4



PREMIUM ARE CALCULATED ASSUMING
WHEAT AND BARLEY YIELDS TO BE NORMALLY
DISTRIBUTED AND SUBSIDISED BY 50%

LEAST RISK EFFICIENCY FRONTIERS
YIELD INSURANCE
LABOR INTENSIVE PRACTICES

fig: 7.5



PREMIUM 'S CALCULATED ASSUMING
WHEAT AND BARLEY YIELDS TO BE NORMALLY
DISTRIBUTED AND SUBSIDISED BY 50%

each crop separately and then jointly. Capital-intensive practices are assumed to have been adopted by small farmers, as discussed in Chapters II and V. In this section the credit and landholding limits have been relaxed. The credit limit has been raised by 100 percent and the land-renting activity has been increased to 60 additional dunums.

Revenue Insurance for Wheat

Crop mix with and without insurance did not change for RAPs below 0.2; however, for RAPs above 0.2 a significant change in the crop mix was observed (Table 7.16). At a high RAP, production of all crops was barely sufficient to meet subsistence constraints. At a risk-neutral level, 60 dunums of additional land was rented in and a 200 percent increase in borrowed funds was observed.

Revenue insurance at RAP of 0.2 induced farmers to rent additional land; with a very slight increase in the coefficient of variation the farmer increased his income by about 35 percent. At a RAP of 0.3, with revenue insurance for wheat, the land was fully utilized. Net farm income increased sixfold and the coefficient of variation of the farm plan crop mix was substantially reduced, from 98 to 50 percent. Barley and lentil production remained at the subsistence level (Table 7.17).

Revenue Insurance for Barley

When revenue insurance for barley only was offered to farmers who adopted the capital-intensive practices, no significant effect on crop mix or on expected income was observed. The variance of the expected income for each alternative farm plan was reduced insignificantly. Land allocated to barley remained at the same level as in the case without

Table 7.16: Summary of Risk Efficient Farm Plan Under Capital-Intensive Practices with 70% Yield Increase over Labor-Intensive Practices REVENUE INSURANCE: WHEAT AND BARLEY Separately

	UNIT	WHEAT					BARLEY				
1 DUAL VALUE	-		10 00	5 00	3.33	2 50		10 00	5 00	3.[illegible]	2 50
2 RAP	-	0 00	0.10	0.20	0.30	0.40	0 00	0.10	0.20	0 30	0 40
3 EGM	JDs	1057 00	1057.46	1057 45	675 38	105.08	1057 45	1057.45	675 38	105 08	105 08
4 CEGM	JDs	1057 00	654 08	250.70	12 34	-41 18	1057.45	654 08	180 37	-12 911	-52 24
ENTERPRISE											
5 WHEAT	Dunum	129 32	129 32	129 32	69 32	8.41	129 32	129 32	69.32	8 41	8 11
6 BARLEY	Dunum	5 10	5 10	5.10	5 10	5 10	5 10	5.10	5 10	5.10	5 10
8 LENTILS	Dunum	1 58	1.58	1.58	1 58	1 58	1.58	1.58	1 58	1 58	1 58
9. UNUSED	Dunum	0 00	0.00	0.00	0.00	60.88	0.00	0 00	0 00	60 88	60.88
10 RENTED LAND	Dunum	60 00	60 00	60.00	0 00	0 00	60 00	60 00	0 00	0 00	0 00
TOTAL NEGATIVE DEVIATION	JDs	10[illegible].76	4033.76	4033 76	2210 12	365.66	4539.32	4539 32	2475.0[illegible]	393 [illegible]0	[illegible]
11. STD	JDs	964 06	964 06	964 06	528 21	87 39	1084 89	1084 89	591 53	91 00	[illegible] 00
12 CV		91 21	91 17	91 17	49 95	12 94	102 59	102 59	87 58	89 45	89 15
13 BORROWED FUNDS	JDs	883 82	883.82	883.82	468 02	46 14	883 82	883 82	468 02	46 14	46 11

insurance. The optimal farm plans were dominated by wheat in spite of revenue insurance for barley. Barley and lentil production at every level of risk aversion remained equal to the family's needs (Table 7.16).

Table 7.17: Wheat Revenue: Insurance vs No Insurance

	Risk Aversion Parameter	
	0.2	0.3
With Wheat Revenue Insurance		
Land Use (dunum)[a]	136.00	76.00
Expected Net Income (JD)	1,057.45	675.38
Variance of Net Income (JD)	946.06	528.30
Coefficient of Variation (%)	91.17	49.95
Without Wheat Revenue Insurance		
Land Use (dunum)	76.00	9.20
Expected Net Income (JD)	675.38	109.00
Variance of Net Income (JD)	594.67	98.22
Coefficient of Variation (%)	88.05	90.00

[a]Above 76 dunum indicates land renting activity.

Revenue Insurance for Lentils

When revenue insurance was offered for lentils only, no change was observed (Table 7.18). This was explained by the fact that lentils are a labor-intensive crop and current wages are relatively high. Although revenue insurance reduces the variance, the net gross revenues remained unchanged on a per dunum basis; when hired labor was used the net margin was reduced substantially below that of wheat.

Revenue Insurance for Wheat and Barley

When revenue insurance was offered for both wheat and barley, certain significant changes were noticed from the no insurance case and the case where insurance was offered for wheat only. These changes occurred for RAPs equal to or higher than 0.2. At a RAP of 0.2, revenue insurance induced the rental of additional land and the borrowing of additional funds. At a RAP of 0.3, although no renting of land or additional borrowing was observed, a significant change in crop mix occurred, including a substantial increase in barley acreage (see Table 7.19 and Table 7.20).

Table 7.18: Summary of Risk Efficient Farm Plan Under Capital-Intensive Practices with 70% Yield Increase over Labor-Intensive Practices - REVENUE INSURANCE: LENTILS

	UNIT					
1. DUAL VALUE	-		10.00	5.00	3.33	2.50
2. RAP	-	0.00	0.10	0.20	0.30	0.40
3. EGM	JD	1057.45	1057.45	1057.45	514.38	100.61
4. CEGM	JD	1057.45	656.55	255.64	24.78	-29.56
Enterprise						
5. WHEAT	Dunum	129.32	129.32	129.32	46.57	8.44
6. BARLEY	Dunum	5.10	5.10	5.10	27.85	5.10
8. LENTILS	Dunum	1.58	1.58	1.58	1.58	1.58
9. UNUSED	Dunum	0.00	0.00	0.00	0.00	60.88
10. RENTED LAND	Dunum	60.00	60.00	60.00	0.00	0.00
TOTAL NEGATIVE DEVIATION	JD	4547.41	4547.41	2483.12	404.08	404.08
11. STD	JD	1086.82	1086.82	593.46	96.57	96.57
12. CV		102.78	102.78	87.87	91.90	91.90
13. BORROWED FUND	JD	883.82	883.82	468.02	46.14	46.14

The results show that barley insurance alone is unlikely to affect barley production at any RAP. Barley acreage may be increased if revenue insurance is offered jointly for wheat and barley. For low risk-averse and risk-neutral farmers, the crop mix will be dominated by wheat.

Table 7.19: Case With and Without Insurance: Wheat and Barley

	Revenue Insurance for Wheat Only	Revenue Insurance for Wheat & Barley	No Insurance
Wheat Acreage (dunum)	69.30	46.57	8.44
Barley Acreage (dunum)	5.10	27.85	5.10
Lentils Acreage (dunum)	1.58	1.58	1.58
Net Income (JD)	514.38	675.38	109.00
Variance of Net Income (JD)	390.04	528.21	98.22

[a]Risk aversion parameter = 0.3.

Revenue Insurance for Wheat, Barley and Lentils

When revenue insurance was offered for the three crops jointly, no change in the optimal farm organizations was observed at lower RAPs (0.0-0.2). At a higher level, the optimal farm plan and crop mix was similar to the case where insurance is offered for wheat and barley, i.e. considerable increase in barley acreage. Lentils always remained at a subsistence level.

F. Summary and Conclusions

The insurance options analyzed in this chapter include actuarially fair revenue insurance and yield/price insurance. The hypothetical insurance options were designed so that total indemnities were equal to total premiums. This way, both the revenue insurance and the yield/price insurance options maintained the average farm income with and without insurance at the same level. Since fluctuations in the gross margin are reduced, the variance and the coefficient of variation for the stream of yearly gross margin are also reduced.

Table 7.20: Summary of Risk Efficient Farm Plan Under Capital-Intensive Practices with 70% Yield Increase over Labor-intensive Practices - REVENUE INSURANCE

	UNIT					
Wheat and Barley						
1. DUAL VALUE	–		10.00	5.00	3.33	2.50
2. RAP	–	0.00	0.10	0.20	0.30	0.40
3. EGM	JD	1057.45	1057.46	1057.45	514.38	100.61
4. CEGM	JD	1057.45	656.55	255.64	24.78	-29.56
ENTERPRISE						
5. WHEAT	Dunum	129.30	129.32	129.32	46.57	8.44
6. BARLEY	Dunum	5.10	5.10	5.10	27.85	5.10
8. LENTILS	Dunum	1.58	1.58	1.58	1.58	1.58
9. UNUSED	Dunum	0.00	0.00	0.00	0.00	60.88
10. RENTED LAND	Dunum	60.00	60.00	60.00	0.00	0.00
TOTAL NEGATIVE DEV.	JD	4009.07	4009.07	4009.07	1632.00	325.43
11. STD	JD	958.16	958.16	958.16	390.04	77.78
12. CV		90.61	90.61	90.61	75.83	77.30
13. BORROWED FUND	JD	883.82	883.82	883.82	452.77	46.14
Wheat, Barley and Lentils						
1. DUAL VALUE	–		10.00	5.00	3.33	2.50
2. RAP	–	0.00	0.10	0.20	0.30	0.40
3. EGM	JD	1057.46	1057.44	1057.45	510.33	105.09
4. CEGM	JD	1057.46	657.04	256.65	24.78	-26.93
ENTERPRISE						
5. WHEAT	Dunum	129.32	129.32	129.32	46.23	8.44
6. BARLEY	Dunum	5.10	5.10	5.10	28.19	5.10
8. LENTILS	Dunum	1.58	1.58	1.58	1.58	1.58
9. UNUSED	Dunum	0.00	0.00	0.00	0.000	60.88
10. RENTED LAND	Dunum	60.00	60.00	60.00	0.000	0.00
TOTAL NEGATIVE DEV.	JD	4003.99	4003.99	4003.99	1618.49	330.04
11. STD	JD	956.94	956.94	956.94	386.82	78.88
12. CV		90.50	90.45	90.50	75.80	75.06
13. BORROWED FUND	JD	883.82	883.82	883.82	452.54	46.14

Actuarially fair insurance is motivated by the theoretical work of Ahsan et al. (1982) and Nelson et al. (1987) (see Chapter III), who have shown that under actuarially fair insurance schemes, farmers will opt for full coverage. These researchers have also shown that risk-averse farmers will behave as if they are risk-neutral when they purchase actuarially fair insurance. The analysis was carried out by choosing one coverage rate only, that is, 80 percent of the historical average for wheat and barley. Since lentils are not a priority crop in Jordan, neither revenue nor yield/price insurance was offered for this crop under labor-intensive practices.

Revenue insurance outperformed price/yield insurance, in that farm income exhibited less variability, and the level of risk was uniformally lower at each level of expected gross margin. At higher risk-aversion levels, revenue insurance reduced the risk/gross margin ratio substantially more than price/yield insurance. Land use at high risk-aversion levels was more efficient with revenue insurance than with price/yield insurance.

The least-risk-efficiency frontier for revenue insurance always dominated the frontiers for yield/price insurance and the initial model, showing that revenue insurance generates optimum, more risk-efficient farm plans.

Examination of barley and wheat yields over the period of 1962-1984 (a longer period than that used in the study) shows that the assumption of normality does not hold. Yields are skewed to the right, with the mode on the lower yield side. This suggests that unadjusted normal distribution is not recommended to derive insurance pure premiums for all risk crop insurance on the basis of historical yield data.

An insurance scheme using the normal density function for calculating pure premium was analyzed using the MOTAD procedure. The results show that since this scheme is actuarially unfair, the optimal farm plans without insurance are more risk-efficient than those with this type of insurance. When price effect was eliminated and the pure premium was reduced by 50 percent, although the scheme became more attractive, it was still less efficient than price support on its own.

Revenue insurance was tested in situations where capital-intensive agricultural practices are adopted. A number of scenarios were tested, including revenue insurance for one crop at a time, for two crops at a time and for all crops. No fundamental change occurred in crop mix in all cases where insurance was offered for one crop only. The crop mix was dominated uniformly by wheat. Barley and lentils were grown only for subsistence purposes.

When revenue insurance was offered for two and three crops, an important change was noticed: farmers with RAP around 0.3 will devote over 30 percent of their land holdings to barley, which is not the case with revenue insurance under labor-intensive practices (see Chapter VI).

Finally, at all risk aversion levels at which the land holding was fully utilized, the need for additional credit is substantial. It is safe to conclude that if revenue insurance and capital-intensive practices were adopted a vast expansion in rural credit in the study areas would have to be mobilized.

Notes

[1]The least-efficiency-frontier associated with the case when fallow was valued proportionally to barley (with and without variability) dominated the rest of the frontiers. This conclusion is consistent with the results obtained in Chapter VI. Since the value of fallow on a per dunum basis was set at 60% of that of barley and its variability was assumed to be 50% lower than that of barley, the LEF associated with optimal farm plans dominates the basic model and the models which follow were set at an arbitrary value of JD 0.5/du and JD 1.00/du. The important point is that no matter what the value of fallow is, once it is incorporated into the MOTAD model it renders optimal farm plans involving fallow more risk efficient than when fallow is valued at zero. Furthermore, comparing capital-intensive practices to labor-intensive practices without incorporating a value for fallow tends to underestimate the farm income, and overestimate its variability.

[2]The evidence must be interpreted with caution, because data for the specific area are not necessarily representative of the probability distribution of the yield data countrywide.

[3]To estimate EL, assuming that f(y) is normal density function, is explained in Skees and Reed (1986). The procedure involves numerical integration of a truncated normal distribution (see M. Abramowitz et al., 1968).

This implies that, given farmers' iso-utility curves, farmers purchasing revenue insurance will at equilibrium be better off since they will be at higher iso-utility curves.

CHAPTER VIII: SUMMARY AND CONCLUSIONS

A. Introduction

Small farmers in the dryland areas in Jordan, like most farmers in the Near East and North Africa region, practice cultivation methods which are dominated by <u>bour</u>, or weedy fallow, with very limited application of chemical fertilizers or chemical weed control. Government policies in Jordan, aiming among other things at increasing food supply, have constantly attempted to induce small as well as medium-scale farmers to adopt capital-intensive practices and reduce weedy fallow acreage and introduce instead clean summer fallow. These measures include the establishment of a number of relatively well equipped agricultural machinery stations, including seed cleaning units and a significant expansion in agricultural credit has taken place. The extension service of the Ministry of Agriculture as well as those of the Jordanian Cooperative Organization have promoted a package of modern capital-intensive practices which involve basically minimum tillage, chemical fertilizers and weed control, in addition to combine harvesting. Appropriate crop rotations including clean fallow are also promoted. While these policy measures have been instituted for the past 10 years, very few small farmers have adopted the improved practices.

In this study, the agricultural sector in Jordan and the characteristics of dryland farming and cereal production as practiced by small faremrs were breifly reviewed. The results and methodology of past agricultural research experiences were critically analysed in terms of their adaptability by the small-scale farmers. An attempt was also made to address some gaps left by the previous research. The role of risk in the decision-making process of small farmers in the dryland areas in evaluating existing labor-intensive practices *vis-a-vis* the capital-intensive agricultural practices was explored. The impact of yield and price variability on farm income was also assessed. Recognizing the importance of traditional fallow, an attempt was made to integrate fallow as a crop in the risk analysis undertaken in this study.

The procedure for risk analysis used in this study is known as Minimization of Total Negative Deviation (MOTAD). As opposed to quadratic risk programming, MOTAD is a linear risk programming technique. The structure of MOTAD procedure is similar to quadratic programming it establishes the trade-offs between gross margins and risk. Risk is measured by the total negative deviations about the expected gross margin. The MOTAD version used for this study is slightly different from procedures used elsewhere. This method minimizes the total negative deviation of the gross margin from the mean gross margin by parametrizing the latter without converting the problem into its maximization equivalent, it is possible to derive the risk aversion parameter which corresponds to the optimal level of total negative deviation by simply inverting the shadow value of the constraint of the gross margin constraint. This was tested and an outline of the proof of this relationship is provided in Chapter V.

Analysis of the data available on the results of various research programs on agricultural practices in Jordan which took place during the sixties and the seventies reveal the following:

a) the improved capital-intensive cultural methods have demonstrated the possibility of increasing cereal yields significantly, ranging from 40 to 60 percent;

b) while these improved practices could potentially increase yield, their scope in reducing the variability of yields is limited; and

c) the economic valuation of these improved packages using the ruling input and output prices was carried out for medium and large-scale farming. Output from weedy fallow was ignored and farmers assumed to be risk neutral.

This chapter is divided into four sections. The first summarizes the scope of this study and highlights certain methodological and data problems. Section two summarizes findings relating to yield and price variability and their effect on farm income; trade-offs between risk and income and associated optimal farm plans, crop mix and resource allocation; and comparison between labor- and capital-intensive agricultural practices in terms of risk efficiency, farm income and resource allocation. Section three provides a summary of the impact and role of hypothetical and actuarially fair revenue insurance, as well as yield/price insurance schemes as policy instruments for stabilizing farm income and improving resource allocation. Certain aspects relating to premium rate-making are also discussed. Section four presents the major limitations of this study and some recommendations for further research.

Data Problems

Althoguh the results of this study are fairly robust, inherent data deficiency cannot be ingored. Yield data was collected by the Ministry of Agriculture or by the National Bureau of Statistics through the usual crop cutting surveys. Crop cutting surveys provide aggregate data by crop and by governorate. Such data ignores the possible differences within the same area in terms of soil, precipitation, etc. It also ignores possible differences among farmers in terms of the size of the landholding, tenurial arrangement, agricultural practices, etc. Similarly, data from research institutions in the country has been collected with different objectives in mind and thus could not be utilized for this study.

B. Summary of Yield and Price Variability

The statistical analysis of the three major crops grown in the study area namely wheat, barley and lentils show that the yields and the prices of these crops over the period 1975-1985 have experienced significant variability. By breaking down per dunum gross income variablity into its components, yield and price variability as well as the interaction between the two, barley yield exhibits the highest variability followed by wheat and then lentils. Price variability for lentils is the highest followed by barley and wheat. The variability of gross income caused by the interaction of yields and prices appeared to be the highest in wheat followed by lentils and barley.

Further analysis using the whole farm planning approach showed that the price and yield risks are evident. By stabilizing the yields of the three crops at a pre-determined level, the level of risk at any level of expected gross margin is reduced substantially. Similarly by stabilizing the price of the same crops at a pre-determined level, the level of risk at any level of expected gross margin is also reduced significantly. However, yield risk is substantially higher than price risk. Based on these results it can be asserted that the presence of yield and price risks were evident in the study area, thus producing risk averse farmers.

Analysis of optimal farm plans appear to substantiate the assumption that a relationship between the practice of traditional fallow in the crop rotation and risk exists. It appears that high risk aversion is associated with a higher percentage of traditional fallow in the optimal farm plan. The analysis also shows that wheat crops grow principally in rotation with fallow. When other crops are grown to meet the family needs they are grown in either two or three year crop rotations. As gross margins increases, diversification increasingly restricts wheat and fallow.

The analysis in Chapter VI includes a comparison of risk and gross margin trade-offs among the optimal farm plans for the basic model and in the situations where price and yield variabilities were removed. The analysis revealed that yield variability is a substantial source of farm-income variability. The assumption of 100% reduction in yield variability results in about JD 464 reduction in the total negative deviation for the same level of gross margin of about JD 207. Further analysis shows that yield stability brings about very few changes in optimal farm plans, in terms of acreage of fallow and crop rotations, for a wide range of risk-aversion coefficients.

The price variability analysis shows that price variability is also a significant source of farm income variability. Price variability, however, appears to be relatively less important than yield variability. Approximately 61% variability in the gross margin for different optimal plans is caused by yield variability and about 39% is covered by price variability. The assumption of 100% reduction in price variability results in a decrease in risk by about JD 307 at the same level of gross margin of JD 207.

As pointed out in Chapter VI, the impact of price variability appears to be less important than yield variability for two reasons. Firstly, all crop prices have been adjusted to 1985 price levels thereby reducing their variability. Secondly, the Government has instituted support price for wheat since 1979. However, the analysis indicates that price variability has not been entirely eliminated.

The analysis was also extended to explore the relationship between risk aversion and adoption of improved agricultural practices. Statistical analysis demonstrates that the gains in yields, from proper tilling of the land, using seed drills, chemical weed control, fertilizers and combine harvesting, is substantial reaching up to 40% of the yields recorded. Where labor-intensive methods are used, however, time series data from various cereal improvement projects also show that though capital-intensive techniques consistently outperform labor-intensive practices, they have not managed to reduc· yield variability.

Further analysis using Motad procedure substantiates this point further. If the yields of the three crops are not increased by at least

70%, the labor-intensive practices are more risk efficient than capital-intensive practices. If it is further assumed that inclusion of traditional fallow in crop rotation generates additional imputed income by providing grazing land for small ruminants, the assumed minimum 70% increase in yields resulting from adoption of capital-intensive techniques will not improve risk efficiently when compared to the labor-intensive practices.

C. Summary of Agricultural Insurance Analysis

The main purpose of Chapter VII was to determine the effects which could be anticipated from a potential number of agricultural insurance schemes. specifically, two alternative agricultural insurance schemes were proposed and their potential impact on farm income resource allocation in a typical small landholding in the dryland in the study area were analyzed. The two insurance schemes which were proposed are revenue and joint yield/price insurance.

Revenue increase would cover the gross revenues received by small farmers. A minimum level of gross income would be insured whereby the small farmers would be indemnified if and when their gross farm income falls below the specified insured level. The indemnity would be equal to the difference between the actual gross income determined (yield times the area planted times the previous market price) and the insured income.

The second option is the joint yield/price insurance scheme. Under this scheme, insurance is offered to insure a specified percentage of a historical price and yield level. Yield indemnity is received whenever the actual yield of the small farmer is below that specified percentage of the historical yield level. This indemnity is calculated as the difference between the specified percentage of the average historical yield and the realized yield multiplied by the insured price level. In the same way, indemnities are paid to the small farmer when the prevailing market price falls below the insured level. The price indemnity is calculated as the difference between the insured price and the prevailing price multiplied by the insured yield level.

Based on yield and price data for the major crops grown in the study area, gross income series for 1975-1985 were calculated for a typical dryland holding of 76 dunums. Indemnities and premiums were then calculated as if these insurance schemes were offered to the small farmers. The per dunum premium rate was set equal to average indemnity so as to satisfy the condition of fairness. The per dunum premium rates for wheat and barley revenue insurance were JD 0.786 and JD 0.502 respectively. For joint price and yield insurance the premium rates per dunum were JD 0.454 for wheat and JD 0.461 for barley.

For comparison purposes, descriptive statistics for the insured and uninsured gross margins revenues for the years under consideration were calculated. The insurance schemes as proposed in this study were designed so as to maintain the average gross margin unchanged while reducing their variability.

The results of the small landholding suggest that typical risk averse small farmers would be willing to purchase revenue insurance even at premiums above the actuarially fair level. Several insurance options (revenue and yield/price insurance) were made available to the small farmers in cases where labor-intensive or capital-intensive agricultural practices are used. The efficient choice was to insure the two major crops, wheat and barley.

High risk aversion farmers (RAP 0.3) without insurance did not utilize all their land holdings for crop production. By taking acreage out of crop production, small farmers reduce risk but at the same time their expected gross margin was also reduced.

When insurance was offered, small farmers with the same risk aversion level increased land utilization. Since insurance reduced the gross margin variance it induces small farmers to increase land utilization by devoting larger proportions of their landholdings for crop production.

When revenue insurance was offered to small farmers adopting capital intensive agricultural practices, the expected gross margin, depending on the level of risk aversion, changed accordingly. The changes in the expected gross margin with insurance depended on the resulting variation in cropping portfolio brought about as a result of revenue insurance. If the variation in wheat revenue relative to barley or lentils was changed noticeably, small farmers would respond by increasing the crop mix in favor of the least risky crop. The profit margin of the crop to which production is shifted would determine whether the level of the optimal farm income was increased, decreased or remained unchanged.

The examination of yields for wheat and barely distribution over the period under analysis shows that the normality assumption cannot be sustained. Crop yield insurance schemes based on Botts and Boles were designed at various coverage levels. It was found that the situation without insurance outperforms, in terms of the trade-off between risk and expected margin, all the situations with insurance at all coverage rates.

When guaranteed prices were included in the analysis, the situation with guaranteed price only outperforms the insurance options at various coverage rates. When insurance options together with guarateed price and subsidized premium were introduced, it outperforms the situation without insurance but remains sub-optimal compared to situations with guaranteed prices only. This suggests that premiums under this type of insurance scheme need to be adjusted. This could be done by estimating an empirical probability density function for the crop yields.

D. Limitation of the Analysis and Recommendations for Further Research

The assumptions made for carrying out this study have no doubt a significant influence on the results, robustness of the results can only be validated by relaxing some of the assumptions made. Although some assumptions have imposed themselves due to the scarcity or inadequacy of necessary data to relax them. Other assumptions have to be made to render the objectives of the thesis manageable.

Formation of Expected Value

Simple expectation model was used to calculate the expected gross margin and deviation of the gross margin line from their mean. It is known that farmers do not rely simply on the past information to forumulate their decisions. It will therefore enrich the analysis if alternative expectation models are tested and compared. For this to be accomplished specific research is needed to indicate better the expectation formation process which produces expected values of gross margins.

Livestock and Diversification

Farmers in the dryland of Jordan are engaged in a number of farm management practices to diversify crop production including the production of cash crops such as tobacco and summer vegetables. Although livestock is not integrated in crop production as such, most small farmers hold a small number of animals mainly sheep and goats. Farmers also practice some form of rudimentary sequential marketing particularly livestock and to a limited extent cereal crops. Incorporation of livestock and crop diversification into a whole farm risk analysis model would be an important extension of this study.

Traditional Fallow

The imputed economic value of fallow in this study was parametrized in an arbitrary way relying on research findings carried out elsewhere in the region. This was unavoidable due to lack of data. From the author's experience, farmers' opinions surveys by themselves are unlikely to result in any significant improvement of the existing database. A crop cutting survey followed by some statistical analysis to link value of weedy fallow to a cereal crop would perhaps be more useful, especially if such a survey is carried out in different agro-climatic zones.

Institutional Set-up for Pilot Agricultural Insurance

No attempt has been made to discuss the institutional design nor the financial implication of establishing a pilot scheme of either revenue or yield/price all risk crop insurance. In 1985 a study, accomplished through the bilateral aid of the Federal Republic of Germany, recommended the institution of a pilot crop insurance scheme in the area of Madaba (see Map). This study has two major flaws. First, it used very short-term data to determine premium rates, using Botts and Boles procedures. As in this study, however, there was no evidence that wheat and barley yield data follow a normal probability density function. The second flaw is the proposed scheme did not address the problem of price insurance.

Premium rates need to be adjusted by attempting to derive an emperical density function of the yield time series as suggested by Nelson (1987) and Yeh (1981). This analysis would require additional research.

There are a good number of viable insitutions in Jordan who have the competence to design and implement a pilot agricultural insurance scheme, notably ACC, and regional institutions who could provide technical assistance. In order to make the schemes as simple and manageable as possible, it is recommended that such schemes be based on an area approach, be compulsory and applied, at the initital stages, to the two major cereal crops -- wheat and barley.

A P P E N D I X

JORDAN —— RAINFED AGRICULTURE

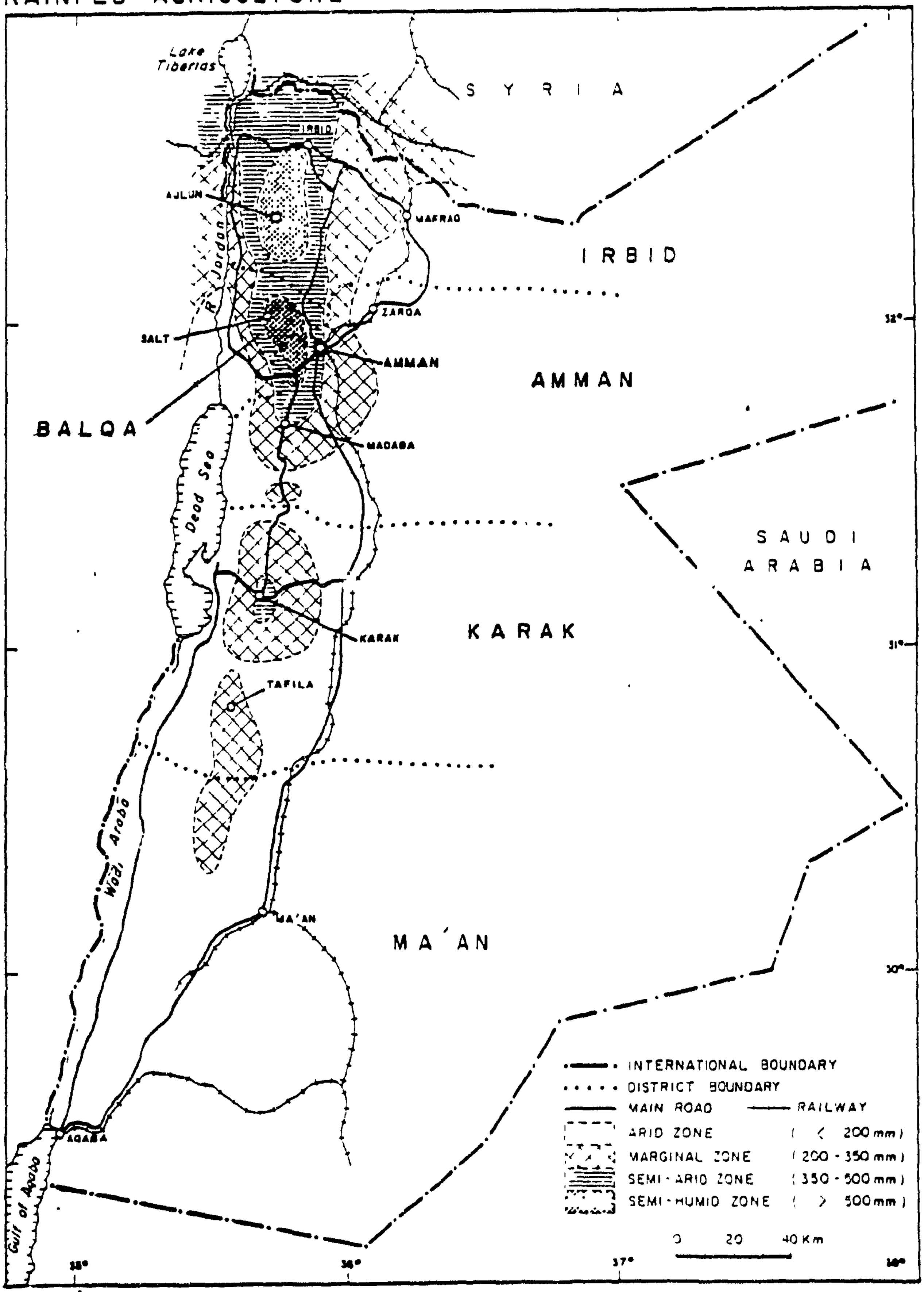


Table 1: Yields of Wheat and Barley (kgs/ha) in Dryland Areas in Selected Countries of the Near East and North Africa Region

	Wheat 1948/49 - 1952/53[a]	Barley 1948/49 - 1952/53[a]	Wheat 1982[b]	Barley 1982[b]
Algeria	620	690	600	765
Iran	900	1,010	1,083	857
Iraq	480	770	750	724
Jordan	700	840	200	400
Lebanon	730	1,230	1,278	1,200
Morocco	610	740	1,074	929
Syria	770	870	1,188	489
Tunisia	490	370	1,250	706
Turkey	1,000	1,150	1,908	2,034
Yemen (North)	-	-	1,021	946
Average	700	863	1,037	900
STD	164	244	455	457
CV	23	29	44	51

[a] FAO Production Yearbook, 1965
[b] FAO Production Yearbook, 1982

Table 2: Irbid Rainfall and Wheat and Barley Yields, 1963 - 1982

Year	Yields (kg/du) Wheat	Barley	Rainfall (mm) November	December	January	February	March	April	Total Rainfall
1963	43.00	22.00	8.70	61.10	51.30	111.90	49.00	47.50	329.50
1964	86.00	79.00	59.00	100.90	78.40	125.30	87.40	9.10	460.10
1965	100.00	98.00	95.10	58.90	151.90	55.50	39.50	48.30	449.20
1966	44.00	23.00	66.90	65.80	38.90	64.30	105.40	2.00	343.30
1967	109.00	135.00	42.30	191.00	150.20	68.10	181.40	18.50	651.50
1968	68.00	65.00	78.30	65.70	155.90	35.50	17.60	27.40	380.40
1969	101.00	143.00	35.20	116.20	161.60	27.80	126.80	13.30	480.90
1970	42.00	22.00	55.00	20.90	116.00	34.00	143.60	18.20	387.70
1971	92.00	82.00	9.00	63.30	65.50	93.60	51.30	168.30	451.00
1972	93.00	66.00	40.10	135.10	63.40	78.70	63.70	29.90	410.90
1973	38.00	14.00	31.40	15.10	104.40	20.10	67.00	3.80	242.10
1974	113.00	114.00	70.80	36.80	251.40	93.90	42.50	37.10	532.50
1975	12.00	45.00	23.60	51.50	28.50	154.90	60.90	10.00	329.40
1976	18.00	43.00	54.10	92.60	61.40	103.50	83.30	31.60	426.50
1977	45.00	24.00	58.50	28.80	103.40	26.20	102.70	75.70	395.30
1978	[illegible]	34.00	11.90	131.50	61.00	66.30	121.[illegible]0	13.50	409.10
1979	27.00	5.00	3.40	46.60	63.00	21.70	73.60	6.90	216.20
1980	100.00	99.00	111.80	198.10	116.90	109.60	142.80	19.30	698.50
1981	61.00	39.00	10.00	117.10	121.10	82.30	93.10	18.40	47[illegible].[illegible]0
1982	52.00	24.00	55.30	28.10	111.40	71.60	47.20	18.80	3[illegible]2.10
1983	11[illegible].00	86.00	62.10	47.90	71.50	113.50	95.70	5.70	397.20
Average	67.00	58.00	47.17	78.69	103.95	73.10	85.80	29.19	411.[illegible]
STD	29.19	39.15	27.68	51.23	49.06	35.45	39.15	34.01	107.[illegible]
CV	[illegible].51	67.19	58.68	65.10	48.1[illegible]	17.81	46.72	116.61	26.01

Table 3: Intensity of Hail and Probability of Occurrence

Hail Intensity		Probability of Occurrence
$(x \leq 1)$	Light = less than or equal to one day/year	0.475
$1 < x \leq 2$	Moderate = more than one day and less than or equal to three days/year	0.127
$x > 3$	Heavy = more than or equal to 3 days/year	0.398

Source: Raw data from Meteorological Department, Amman. Calculations by author.

Table 4: Yields and Prices Adjusted for Trend, 1985 Price Level and TEC

Year	Yields			Prices		
	Wheat	Barley	Lentils	Wheat	Barley	Lentils
1975	74.545	68.091	77.436	111.664	96.734	199.370
1976	77.291	53.782	90.593	96.164	91.663	135.918
1977	71.036	42.473	86.749	101.712	116.045	132.506
1978	71.782	50.164	68.905	90.213	56.023	143.655
1979	46.527	18.855	30.062	82.766	57.972	127.299
1980	116.273	110.545	113.218	134.993	75.290	246.680
1981	76.018	48.236	83.375	128.777	92.145	228.023
1982	45.764	30.927	65.531	95.301	82.331	208.525
1983	121.509	90.618	111.687	146.945	73.079	194.787
1984	45.755	36.309	69.544	114.837	94.376	184.603
1985	74.000	55.000	70.000	110.000	89.000	174.000
Average	74.591	55.000	78.827	110.307	84.060	179.579
SD	24.157	25.205	21.958	19.013	16.800	38.744
CV	32.386	45.827	27.856	17.237	19.986	21.575

Table 5: CROP BUDGET 1: Labor-Intensive Agricultural Practices: BARLEY (1985)

Cost/Item	Unit	Quantity / du	Unit Cost	TOTAL JD
Means of Production			JD/du	
1. Fertilizers	kgs			
2. Chemicals	kgs	12	0.025	0.3
3. Bags	kgs	1.4	0.3	0.42
4. Seeds	kgs	10	0.08	0.8
Subtotal	kgs			1.52
Machinery Hire			JD	
1. Tillage	times	2	0.4	0.8
2. Seed Drilling	times			
3. Chemical Spraying	times			
4. Combine Harvesting	times			
5. Threshing/Winnowing	times	1	0.3	0.3
6. Transportation	times	1	0.48	0.5
Subtotal				1.6
Labor			JD/hour	
1. Family Labor				
Crop Residue Removal	man-hour	0.248	-	
Seed Cleaning	man-hour	0.056	-	
Weeding	man-hour	6.272	-	
Harvesting	man-hour	8.064	-	
Packing, etc.	man-hour	0.008	-	
Subtotal		14.648		
TOTAL VARIABLE COST (JD/ du)				3.12

Table 6: CROP BUDGET 2: Labor-Intensive Agricultural Practices: WHEAT (1985)

Cost/Item		Unit	Quantity /du	Unit Cost	TOTAL JD
Means of Production				JD/du	
1.	Fertilizers	kgs			
2.	Chemicals	kgs	12	0.025	0.3
3.	Bags	kgs	1.6	0.3	0.48
4.	Seeds	kgs	12	0.11	1.32
	Subtotal	kgs			2.10
Machinery Hire				JD	
1.	Tillage	times	2	0.4	0.8
2.	Seed Drilling	times			
3.	Chemical Spraying	times			
4.	Combine Harvesting	times			
5.	Threshing/Winnowing	times	1	0.3	0.3
6.	Transportation	times	1	0.48	0.48
	Subtotal				1.58
Labor				JD/hour	
1.	Family Labor				
	Crop Residue Removal	man-hour	0.32	-	
	Seed Cleaning	man-hour	0.08	-	
	Weeding	man-hour	8.00	-	
	Harvesting	man-hour	8.00	-	
	Packing, etc.	man-hour	0.008	-	
	Subtotal		16.408		
TOTAL VARIABLE COST (JD/ du)					3.68

Table 7: CROP BUDGET 3: Labor-Intensive Agricultural Practices: LENTILS (1985)

Cost/Item	Unit	Quantity /du	Unit Cost	TOTAL JD
Means of Production			JD/du	
1. Fertilizers	kgs			
2. Chemicals	kgs	11	0.025	0.275
3. Bags	kgs	3.5	0.3	1.05
4. Seeds	kgs	6.6	0.19	1.292
Subtotal	kgs			2.617
Machinery Hire			JD	
1. Tillage	times	2	0.4	0.8
2. Seed Drilling	times			
3. Chemical Spraying	times			
4. Combine Harvesting	times			
5. Threshing/Winnowing	times	1	0.8	0.8
6. Transportation	times	1	2.1	2.1
Subtotal				3.7
Labor			JD/hour	
1. Family Labor				
Crop Residue Removal	man-hour	0.042	-	
Seed Cleaning	man-hour	0.02	-	
Weeding	man-hour	8.00	-	
Harvesting	man-hour	11.82	-	
Packing, etc.	man-hour	0.025	-	
Subtotal		19.907		
2. Hired Labor				
Sowing	man-hour	8	0.625	5.00
TOTAL VARIABLE COST (JD/ du)				11.317

Table 8: CROP BUDGET 4: Capital-Intensive Agricultural Practices: BARLEY (1985)

Cost/Item		Unit	Quantity / du	Unit Cost	TOTAL JD
Means of Production				JD/du	
1.	Fertilizers	kgs	10	0.105	1.05
2.	Chemicals	kgs	11	0.03	0.33
3.	Bags	kgs	1.5	0.25	0.375
4.	Seeds	kgs	10	0.08	0.80
	Subtotal	kgs			2.555
Machinery Hire				JD	
1.	Tillage	times	2	0.4	0.8
2.	Seed Drilling	times	1	0.5	0.5
3.	Chemical Spraying	times	1	0.5	0.5
4.	Combine Harvesting	times	1	1.5	1.5
5.	Threshing/Winnowing	times			
6.	Transportation	times	1	0.5	0.5
	Subtotal				3.8
Labor				JD/hour	
1.	Family Labor				
	Crop Residue Removal	man-hour	0.248	-	
	Seed Cleaning	man-hour	0.056	-	
	Packing, etc.	man-hour	0.056	-	
	Subtotal		0.360		
TOTAL VARIABLE COST (JD/ du)					6.355

Table 9: CROP BUDGET 5: Capital-Intensive Agricultural Practices: WHEAT (1985)

Cost/Item		Unit	Quantity /du	Unit Cost	TOTAL JD
Means of Production				JD/du	
1.	Fertilizers	kgs	10	0.105	1.05
2.	Chemicals	kgs	12	0.025	0.2753.
	Bags	kgs	1.6	0.25	0.4
4.	Seeds	kgs	10	0.11	1.1
	Subtotal	kgs			2.825
Machinery Hire				JD	
1.	Tillage	times	2	0.4	0.80
2.	Seed Drilling	times	1	0.8	0.8
3.	Chemical Spraying	times	1	0.5	0.5
4.	Combine Harvesting	times	1	1.5	1.5
5.	Threshing/Winnowing	times			
6.	Transportation	times	1	0.5	0.5
	Subtotal				4.1
Labor				JD/hour	
1.	Family Labor				
	Crop Residue Removal	man-hour	0.08	-	
	Seed Cleaning	man-hour	0.01	-	
	Weeding	man-hour	1.0		
	Harveting	man-hour	1.0		
	Packing, etc.	man-hour	0.001	-	
	Subtotal		2.051		
TOTAL VARIABLE COST(JD/ du)					6.925

Table 10: CROP BUDGET 6: Capital-Intensive Agricultural Practices: LENTILS (1985)

Cost/Item		Unit	Quantity / du	Unit Cost	TOTAL JD
Means of Production				JD/du	
1.	Fertilizers	kgs	6	0.105	0.63
2.	Chemicals	kgs	11	0.025	0.275
3.	Bags	kgs	4	0.3	1.2
4.	Seeds	kgs	7	0.19	1.33
	Subtotal	kgs			3.435
Machinery Hire				JD	
1.	Tillage	times	2	0.4	0.8
2.	Seed Drilling	times	1	0.5	0.5
3.	Chemical Spraying	times			
4.	Combine Harvesting	times			
5.	Threshing/Winnowing	times	1	0.8	0.8
6.	Transportation	times	1	2.1	2.1
	Subtotal				4.2
Labor				JD/hour	
1.	Family Labor				
	Crop Residue Removal	man-hour	0.042	-	
	Seed Cleaning	man-hour	0.02	-	
	Weeding	man-hour	8.00	-	
	Harvesting	man-hour	11.82	-	
	Packing, etc.	man-hour	0.025	-	
	Subtotal		19.907		
2.	Hired Labor				
	Sowing	man-hour	8	0.625	5.00
TOTAL VARIABLE COST (JD /du)					12.635

Table 11: Premium vs Indemnity for Wheat Under Normal Distribution

Year	Crop Insurance Rate 50% Indemnity	50% Premium	65% Indemnity	65% Premium	80% Indemnity	80% Premium
1975	0.000	2.066	0.000	3.978	0.000	7.044
1976	0.000	2.066	0.000	3.978	0.000	7.044
1977	0.000	2.066	0.000	3.978	0.000	7.044
1978	0.000	2.066	0.000	3.978	0.000	7.044
1979	0.000	2.066	2.250	3.978	15.117	7.044
1980	0.000	2.066	0.000	3.978	0.000	7.044
1981	0.000	2.066	0.000	3.978	0.000	7.044
1982	0.000	2.066	0.000	3.978	15.995	7.044
1983	0.000	2.066	0.000	3.978	0.000	7.044
1984	0.000	2.066	0.000	3.978	16.006	7.044
1985	0.000	2.066	0.000	3.978	0.000	7.044
Average	0.904	2.066	2.271	3.978	4.284	7.044

Table 12: Premium vs Indemnity for Barley Under Normal Distribution

Year	Crop Insurance Rate 50% Indemnity	Premium	65% Indemnity	Premium	80% Indemnity	Premium
1975	0.000	5.999	0.000	8.649	0.000	12.072
1976	0.000	5.999	0.000	8.649	0.000	12.072
1977	0.000	5.999	0.000	8.649	1.756	12.072
1978	0.000	5.999	0.000	8.649	0.000	12.072
1979	9.942	5.999	19.430	8.649	28.917	12.072
1980	0.000	5.999	0.000	8.649	0.000	12.072
1981	0.000	5.999	0.000	8.649	0.000	12.072
1982	0.000	5.999	0.000	8.649	15.034	12.072
1983	0.000	5.999	0.000	8.649	0.000	12.072
1984	0.000	5.999	0.000	8.649	8.845	12.072
1985	0.000	5.999	0.000	8.649	0.000	12.072
Average	0.904	5.999	2.271	8.649	4.959	12.072

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