A MICRO-ECONOMIC ANALYSIS OF IRRIGATION IN THE MORDEN-WINKLER AREA OF MANITOBA

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by

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ABSTRACT

The main purpose of this study was to determine what effect irrigation would have on a farm in the Morden-Winkler area of southern Manitoba. A budgetary analysis as well as linear programming were used to determine optimum farm organization under dryland and irrigation conditions. Using the two methods provided an opportunity to compare them and to indicate how the two methods could be used in analyzing a farm organizational problem such as this. Several levels of operating capital were used to show how these farms plans could be most profitably expanded as additional operating capital became available. The analysis was designed to show also how well irrigation programs could compete with dryland programs for the various factors of production.

Two surveys were made in the proposed irrigation area to gain information on land-use, farm organization, capital structure, income and expenses. On the basis of this information farms were selected for analysis and were used to develop a case farm. These fourteen farms were of similar size and nature and located on similar soil type. The case farm was 240 acres in size with 200 acres improved. It was estimated that 153 acres on this farm were suitable for irrigation. Only surface ifrigation was considered in the analysis.

Some of the more important results of this research study were as follows:

1. The returns to labor were higher under irrigation if operating capital was sufficient for a full cropping program. This required approximately $7,000 of operating capital.

2. The difference in returns between dryland and irrigation programs was less when the alfalfa could not be sold.

3. A dairy enterprise was important at lower levels of capital when no market existed for alfalfa hay. As capital was increased the dairy was replaced with a hog program in which hogs were farrowed and fed to market on the farm and a feeder steer enterprise.

4. When the alfalfa could be sold the main livestock program consisted of farrow and feed hogs and feeder steers. Feeder hogs were also included in the program at higher levels of capital when spring labor was exhausted.

5. The results of linear programming and budgeting were similar in many respects but linear programming provided a clearer insight into the various aspects of the problem because of the greater number of alternatives which could be considered.

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CHAPTER I

INTRODUCTION

Consideration is being given to the feasibility of building a dam on the Pembina River in South-central Manitoba. If the dam is constructed water would become available to irrigate approximately 20,000 acres in that area if it appeared practical. The Economics Divisions of the Canada Department of Agriculture and the Manitoba Department of Agriculture have agreed to study the problem and determine what net benefits might result from irrigation. The study is concerned with the area as a whole and considers three aspects:

1. the present crop and livestock programs
2. the optimum crop and livestock programs under dryland conditions
3. the optimum farm organization with irrigation.

Benefits can then be determined by making a comparison of incomes to the area from optimum dryland and irrigation programs.

In addition to this, it would be important to know what changes would be likely to take place on the individual farm level and how farmers might best adapt themselves to these changes. This has been done by selecting what was considered a typical farm in this area. Rather than relying on cost and yield data for one farm, consideration was also given to other farms of similar size and nature. Developing a case farm in this manner would make some generalization possible and could also be useful as a benchmark with which incomes from other farms could be

estimated by making the proper adjustments.

This research report is concerned only with the micro-economic aspects of the problem and limits itself therefore to analyzing the production problems of the firm. The first chapter presents the problem, scope, description of the area and the methodology employed. The second chapter establishes the conceptual framework with a discussion on the theory of the firm. The budgetary analysis is presented in the third chapter. The balance of the report is devoted to analysis of the problem by linear programming. The last section of the thesis presents the various alternatives considered, the results and the conclusions.

Description of the Area

The area studied lies approximately seventy miles south-west of Winnipeg in a relatively fertile part of the province in Townships one and two of Range Four. The major soil type is a fine sandy clay loam with good surface and sub-surface drainage. A detailed soil survey made of the area indicated that approximately fifty-five per cent would come under Class I for irrigation forty-five per cent of the remainder in Class II, III and VI. There were small areas of class III and lower because of poor drainage, salts, or other factors which soil specialists considered undesirable for irrigation[1]. A topographical survey made by engineers (Prairie Farm Rehabilitation Administration) showed that approximately

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[1]This soil survey was made by the Soils Department, University of Manitoba.

two-thirds of the Class I soils would require less than 200 cubic yards per acre to be moved to level them sufficiently to allow surface irrigation. On this basis soils falling into this classification could be levelled for a cost of $40.00 or less, using twenty cents per yard for cost of earch moving.

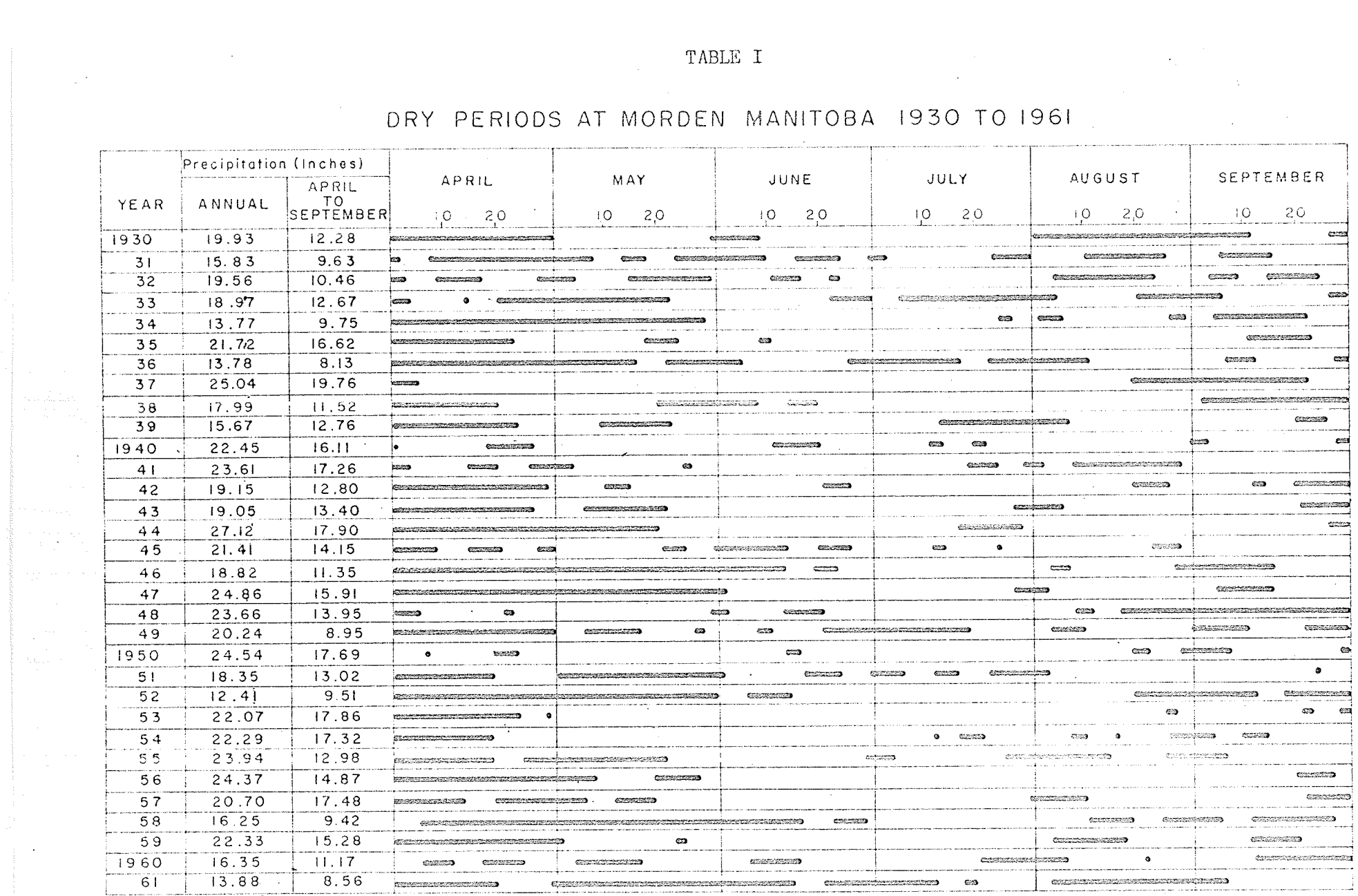
Climatic conditions are favorable for growing a large variety of crops. The average frost-free period is 122 days with a range of 93 days to 146 days. The average annual precipitation over the last thirty years has varied from a low of 12.41 inches to a high of 27.12 inches, averaging 20.10 inches. While the area does receive an average of 13.45 inches of rain during the growing season, April to September, records such as shown in Table I indicate that periods of deficient moisture have occurred during the growing season. On the basis of this and from information on yields collected during the survey it seems reasonable to expect, that supplemental water during these periods would increase both yield and quality of most of the crops grown.

A large variety of crops are being grown in the area at the present time. Oats and flax occupy apporximately forty per cent of the acreage and wheat and barley about sixteen per cent. More recently, the cropping pattern has become more diversified with such crops as peas, beans, corn, sunflowers, potatoes, sugar-beets, carrots and onions. Two canneries established at Morden and Winkler, an oil processing plant at Altona and a sugar-beet factory in Winnipeg provide a market for many of these special crops.

TABLE I

DRY PERIODS AT MORDEN MANITOBA 1930 TO 1961

YEAR	Precipitation (Inches) ANNUAL	APRIL TO SEPTEMBER
1930	19.93	12.28
31	15.83	9.63
32	19.56	10.46
33	18.97	12.67
34	13.77	9.75
35	21.72	16.62
36	13.78	8.13
37	25.04	19.76
38	17.99	11.52
39	15.67	12.76
1940	22.45	16.11
41	23.61	17.26
42	19.15	12.80
43	19.05	13.40
44	27.12	17.90
45	21.41	14.15
46	18.82	11.35
47	24.86	15.91
48	23.66	13.95
49	20.24	8.95
1950	24.54	17.69
51	18.35	13.02
52	12.41	9.51
53	22.07	17.86
54	22.29	17.32
55	23.94	12.98
56	24.37	14.87
57	20.70	17.48
58	16.25	9.42
59	22.33	15.28
1960	16.35	11.17
61	13.88	8.56
MEAN	20.10	13.45



PERIODS OF PROBABLE SOIL MOISTURE DEFICIENCY FOR PLANT GROWTH, MEASURED BY PLOTTING DAYS WITH LESS THAN 0.25" RAIN BEGINNING 5 DAYS AFTER A RAIN OF 0.25 TO 0.49", 10 DAYS AFTER A RAIN OF 0.50 TO 0.99, 15 DAYS AFTER A RAIN OF 1.00 TO 1.99, OR 20 DAYS AFTER A RAIN OF 2.00" OR MORE. DAYS AFTER RAINS ARE ACCUMULATIVE TO A MAXIMUM OF 20 DAYS FOR ANY ONE PERIOD AFTER THE LAST RAIN OF 0.25" OR MORE

Research Procedure

A reconnaisance survey covering all farms in the area provided information on distribution of farm size, farm organization, and livestock numbers. The results are presented in Table II. The 368 farms included in the survey ranged in size from less than three acres to over 2800 acres. The average size was 215 acres with 183.7 acres improved. This information is presented in Table III.

On the basis of the information received in the initial survey, a representative sample of various size farms was studied in detail. This additional information included capital investment, operating costs, farm receipts, tillage practices, yields, farm practices adopted and family labor supply.

The information which was provided by these two surveys was used as a basis for developing a case farm. The information on farm size shown in Table II indicated that over 44 per cent of the farms in the area were less than 150 acres in size but these occupied only 10.4 per cent of the total acreage. They were therefore considered to be of relatively minor economic importance and since many of these could not be considered as full time commercial farms they were not used in the analysis. On the other hand, farms over 400 acres in size were not used in this study because many of these were considerably larger in terms of acreage and capitalization and should be included in a separate study. Therefore, the case farm to be studied was selected from those ranging in size from 150 acres to 399 acres. This group represented almost 43

TABLE II

DISTRIBUTION OF FARM SIZE IN SURVEY AREA - 1961

	No. of farms	% of total number	% land managed
0 - 3 acres	9	2.40	0.02
4 - 9 "	23	6.30	0.20
10 - 69 "	77	20.90	3.28
70 - 149 "	54	14.70	6.70
150 - 239 "	87	23.60	21.00
240 - 399 "	71	19.30	27.60
400 - 559 "	28	7.60	16.50
560 - 759 "	12	3.30	10.40
760 -1119 "	4	1.10	4.30
1120 -1599 "	1	0.20	1.30
1600 -2239 "	0	-	-
2240 -2879 "	1	0.30	3.30
2880 + "	1	0.30	5.40
	368	100.00	100.00

TABLE III

LAND-USE FOR 368 FARMS IN SURVEY AREA - 1961

Crop	Average all farms (acres)	% of improved land	Number of farms with item	% with item
Wheat-fallow	21.6	12	177	52
-stubble	2.1	1	27	8
Oats	37.0	20	240	70
Barley	5.5	3	27	8
Flax	35.2	19	208	61
Corn-grain	0.9	-	15	4
-silage	2.1	1	31	9
Sunflower	10.2	6	76	22
Sugar-beets	2.6	2	30	9
Millet	3.1	2	61	18
Buckwheat	3.8	2	42	12
Potatoes	4.5	2	10	3
Rye	0.3	-	9	3
Dry peas	0.1	-	2	1
Rapeseed	0.1	-	1	-
Mixed grains	1.3	-	15	4
Mustard	0.1	-	1	-
Alfalfa hay	4.7	3	100	29
Alfalfa and grass	2.5	1	45	13
Timothy seed	3.2	2	72	21
Improved pasture	0.1	-	1	0
Summer fallow	39.3	21	207	60
Special crops				
Beans	0.3	0.2	13	4
Cucumbers	-	-	2	1
Corn	1.0	0.6	23	7
Onions	1.0	0.6	2	1
Peas	1.0	0.5	14	4
Tomatoes	-	-	2	1
Carrots	0.1	0.1	2	1
Celery	-	-	1	4
	183.7	100.		

percent of the farmers and they controlled over 48 per cent of the land. On this basis a farm which had a total of 240 acres and 200 improved acres was chosen. Fourteen other farms of similar size and nature were also used to determine the machinery requirements and costs, tillage and other farm practices used, and other farm costs which could not readily be estimated from a single farm.

Scope and Objectives

The basic purpose of this thesis was to determine what effects irrigation would have on a particular farm in the Morden-Winkler area of Manitoba. The various crop and livestock alternatives which this farm would have under dryland conditions were explored as well as the ways in which the farm might be organized under irrigation.

Specific objectives were:

1. to study the effects of varying the level of operating capital. It was hypothesized that at high capital levels irrigation farming would be more profitable than dryland but not at lower levels of capital. Operating costs are considerably higher under irrigation and with capital limited the producer could put more dryland acres into production.

2. to show how well irrigation could compete with dryland at different levels of capital. It was hypothesised that dryland plans would be more profitable at low levels of capital.

3. to determine the income at various stages of irrigation development. It was hypothesized that incomes would increase as more acres were developed for irrigation.

4. to determine the importance of not having an established market for forage. It was hypothesized that profits would be lower when livestock enterprises had to be established to utilize the forage produced on the farm. It also seemed reasonable to expect that rotations with a minimum amount of forage would enter the program when there was no market.

5. to determine which livestock enterprises could most profitably be integrated with dryland and irrigation programs. It was hypothesized that if the alfalfa could be sold then hogs would be an important part of the program. If none could be sold then a livestock enterprise utilizing relatively large amounts of forage, such as dairy, would be a part of the program.

6. to compare linear programming and budgeting as tools for analyzing farm organization problems.

Method

Four programs were used to test these hypotheses. They were:

1. program in which only rotations suitable for dryland conditions were considered. Nine livestock enterprises were also allowed to compete for the available resources.

2. program in which only irrigation rotations were considered as well as the nine livestock enterprises.

3. program in which the dryland and irrigation rotations were competing for land.

4. program in which various levels of irrigation and dryland were considered. The purpose was to estimate the effect on income as a farm was gradually developed for irrigation.

In the four programs capital was allowed to vary and comparisons were made between having a cash market for forage and not having one.

CHAPTER II

THEORETICAL BACKGROUND FOR ALLOCATING RESOURCES BETWEEN DRYLAND AND IRRIGATION

There are four general types of production studies. These four are micro-static, macro-static, micro-dynamic and macro-dynamic. Micro-static analysis is concerned with one firm during one period of time. Macro-static is an analysis of the general economy during a specified period. The dynamic is introduced in the third and fourth categories to indicate that this analysis is concerned with a firm or an economy over several periods of time. More knowledge is available on micro-static analysis than the other three and is the category with which this particular study is concerned.

Micro-static analysis is a study of an individual firm. In their discussions on the theory of the firm Henderson and Quandt say:[1]

> A firm is a technical unit in which commodities are produced. Its entrepreneur (owner and operator) decides how much of and how one or more commodities will be produced, and gains the profit or bears the loss, which results from his decision. An entrepreneur transforms inputs into outputs, subject to the technical rules specified by his production function. The difference between his revenue from the sale of outputs and the cost of his inputs is his profit, if positive, or his loss if negative.

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[1] Henderson, James, M., and Richard E. Quandt, Micro-economic Theory (McGraw-Hill Book Company, Inc. New York, 1958), p.42.

Analysis may proceed either by means of budgetary analysis or by programming. The two approaches are not competitive but rather complementary. Marginal analysis provides a good method of exposition but cannot produce all the answers to questions on the behaviour of the firm. It draws its examples largely from agriculture and tends to over simplify many of the problems facing the larger and more complex firms of today. Linear programming is supplementary as the technology is more specific and the production is more detailed than that of marginal analysis.

There are three basic principles underlying production economics. They are the factor-product relationship, the factor-factor relationship, and the product-product relationship[2]. Since these principles are essentially the same for marginal analysis and linear programming they can be illustrated in terms of the classical marginal analysis using calculus. It is then possible to show how linear programming uses these to solve the resource allocation problems of the firm.

The Factor-Product Relationship (Production Function)

The factor-product relationship may be explained by varying one input and holding other variable inputs as well as the fixed inputs constant and noting the effect on output[3]. The function then takes the

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[2]Heady, E.O., Economics of Agricultural Production and Resource Use. (Prentice-Hall, Inc. Englewood Cliffs, N.J. 1961), Chapters II-VI

[3]Inputs refer to factors such as land, labor, and capital which the entrepreneur uses in the production process. They may be fixed or variable.

following form:

Wheat = f(capital/labor, water, machinery, land)

In this particular function, capital is allowed to vary and labor, water and machinery are held constant. This principle is illustrated in Figure 1 and shows the effect on wheat yields as capital is increased. The lower production function in this diagram (TPP_{DL}) shows the relationship under dryland conditions where 13.4 inches of water are applied. The upper function shows what could occur when an additional 18 inches of water are applied. The production function has shifted upward. Under dryland conditions wheat yields would be OH when ON units of capital are used whereas under irrigation this same capital level would result in higher wheat yields, OD.

The firm knowing its production function is aware of the possibilities open to it. The prices of capital and wheat are given on the market and the entrepreneur undertakes production if the value of the additional increment of wheat produced is greater than the additional unit of capital required. Further, the producer, if he wishes to maximize profits will increase production until these are equal[4].

In order to do this he must satisfy two conditions:

1. he must use a minimum cost combination of resources to produce a given quantity of output.

2. the marginal factor cost must be equal to the marginal value product or

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[4]Hicks, J.R., Value and Capital, (Oxford University Press, London, 1961), p.79.

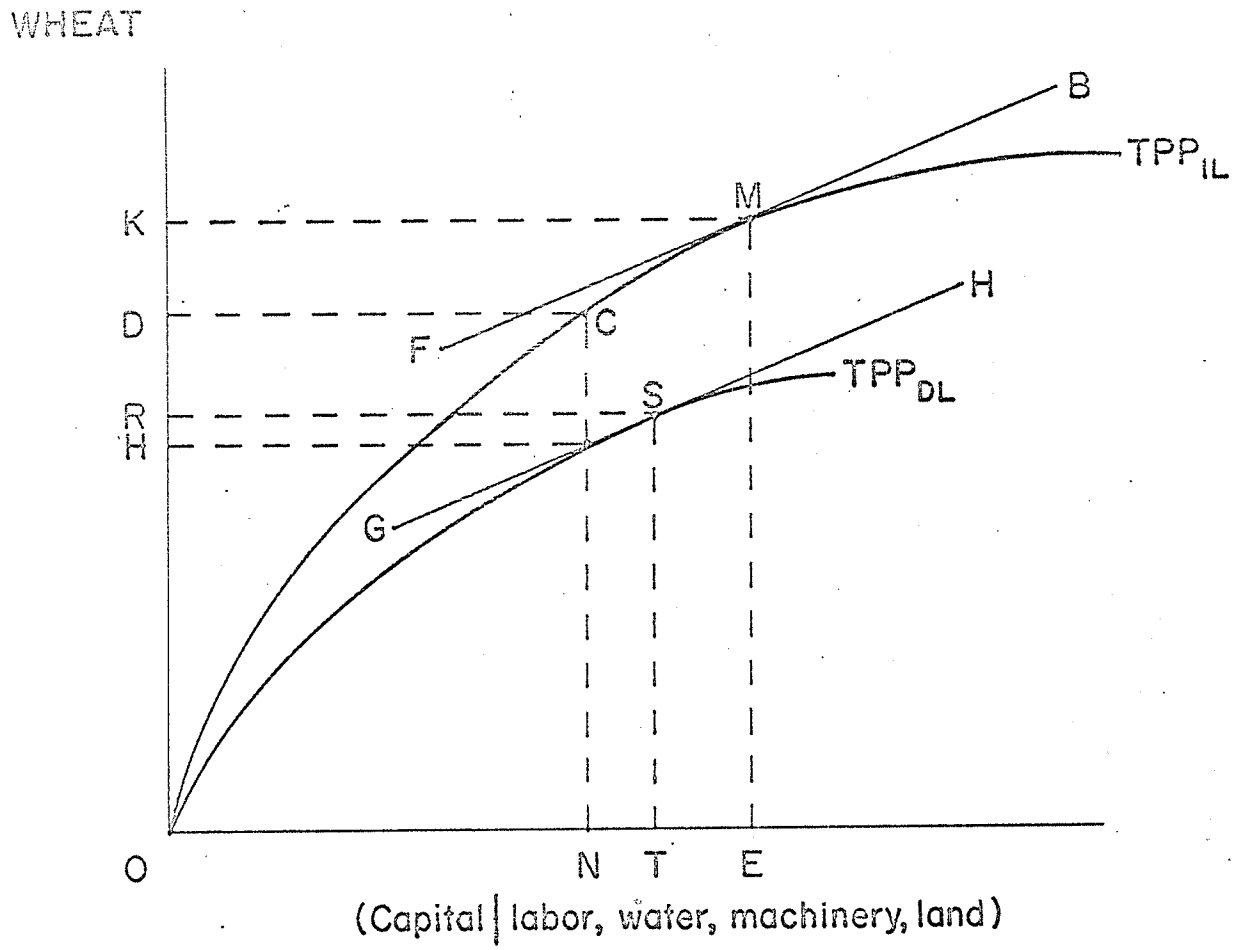

FIGURE I - THE FACTOR-PRODUCT RELATIONSHIP (PRODUCTION FUNCTION)

marginal cost must equal marginal revenue when the firm is at equilibrium. If the producer were to go beyond this point the value of the additional product forthcoming would not be enough to pay for the additional increment of input used.

The equilibrium point on TPP_{DL} is at point S while on TPP_{IL} it is at point M. The lines FB and GH are parallel lines and are the ratio of the price of wheat and the price of capital. At points S and M the slope of the price line is equal to the slope of the respective production function. The producer will therefore maximize his profits when he employs OT units of capital under dryland conditions producing OR of wheat and OE units under irrigation and producing OK bushels of wheat. At these equilibrium points the following equality holds:

$$\frac{dW}{dC} = \frac{Pc}{P_w}$$

where W is wheat and C is capital.

The Factor-Factor Relationship (The Isoquant)

Figure 2 shows the continuous isoquant of the factor-factor relationship. In practice the producer would have a choice of many factors to produce a certain amount of a commodity. Land and water were used in the example. The producer is interested in finding the least-cost combination of these two factors to produce a specified level of output of wheat. The isoquant does show all the combinations of land and water which can be used to produce twenty or thirty bushels of wheat and may be represented by the following equation:

$$\text{wheat} = f(\text{land}, \text{water})$$

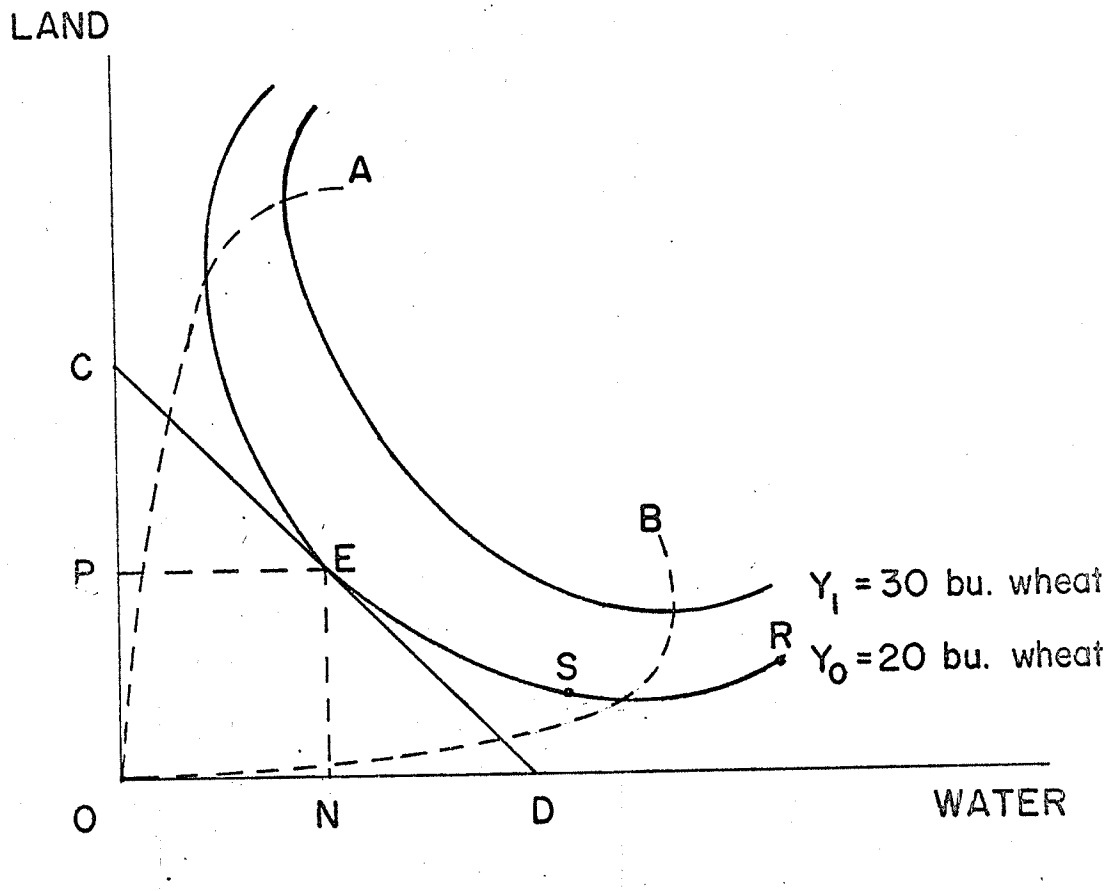

FIGURE 2 - THE FACTOR-FACTOR RELATIONSHIP (THE ISOQUANT).

In this case wheat yield is held constant and land and water allowed to vary. Two factors, such as land and water would have a family of isoquants with each isoquant representing a certain level of output. In Figure 2, two of these are shown with Y_o being an output of twenty bushels and Y_1 thirty bushels. Within the relevant range of operation an increase of both inputs will result in increased output.

The producer is only concerned with operations within the relevant range. The ridge lines OA and OB enclose the area of rational operation in Figure 2. Outside of these ridge lines the producer would be applying more inputs to get the same output. For example, at R his inputs of both land and water are greater than at S and output is the same in both cases as they lie on the same isoquant. Within the rational area the operator is concerned with the optimum combination of inputs.

The slope of the tangent to a point on an isoquant is the rate at which one factor substitutes for the other in order to maintain the level of output. In the example being used water can be substituted for land so that it would be possible in practice that twenty bushels of wheat could be produced with one acre of land and two inches of irrigation water or with one-half acre of land and eighteen inches of water. The rate at which these two factors will substitute for each other is called the marginal rate of substitution (MRS). On a continuous isoquant such as shown in Figure 2 this would be:

$$MRS = -\frac{dL}{dW_I}$$

where L is land and W_I is irrigation water. This is really a ratio of

the marginal productivity of water to the marginal productivity of land.

The producer must then know the price he must pay for land and water and the amount of capital he has available to him in order to determine the point of equilibrium. His total cost of production (C) may be given by the linear equation:

$$C = P_1(\text{land}) + P_2(\text{water}) + F$$

where P_1 and P_2 are the respective prices of land and water and F is the fixed cost. The iso-cost line (CD) can then be defined as the locus of input combinations that can be purchased for a specified total cost:

$$C^{o} = P_1(\text{land}) + P_2(\text{water}) + F$$

where C is now a parameter.

The point at which the iso-cost line intercepts the Y-axis is the amount of land which could be purchased if the entire outlay, exclusive of fixed costs, were spent on land. Similarly, the intercept of the iso-cost line on the X-axis indicates the amount of water that could be purchased were it all spent on water. The point at which the iso-cost line is tangent to the isoquant is the point of equilibrium. This is shown in Figure 2 as point E and at this point:

$$\frac{dL}{dW_I} = \frac{Pw_I}{P_L}$$

At this point the ratio of the marginal productivities of land and water are equal to their inverse price ratio. The optimum combination of the two factors would be when OP units of land and ON units of water are used to produce twenty bushels of wheat. A restriction on capital, represented by the cost-line CD, limits production to twenty bushels.

In the linear programming analysis which is presented later the problem is much more complex than the one used in this example. Other factors of production, such as spring labor, summer labor, building space and others are considered. The principle, however, is the same and linear programming provides a method by which the best combination of these various factors can be determined.

The Product-Product Relationship (The Transformation Function)

"A product-transformation curve is defined as the locus of output that can be secured from a given input of X"[5]. This principle is illustrated in Figure 3 and is simplified by assuming that the entrepreneur has one input, which could be land, available for the production of two outputs, forage and grain. For example, if a producer were faced with a production possibility curve such as RS (Figure 3) then he could produce OR of grain if all the land were used for grain production or OS if the land were used for production of forage. The producer could also produce any combination of forage and grain within the limits set by the transformation curve. Each curve such as RS represents the production which can be attained with one level of input. If, for example, more land was obtained a higher level of production would be possible and would be represented by a higher transformation curve.

The rate at which one product will substitute for another without varying input of land is the rate of product transformation (RPT).

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[5]Henderson and Quandt, op.cit., p.68.

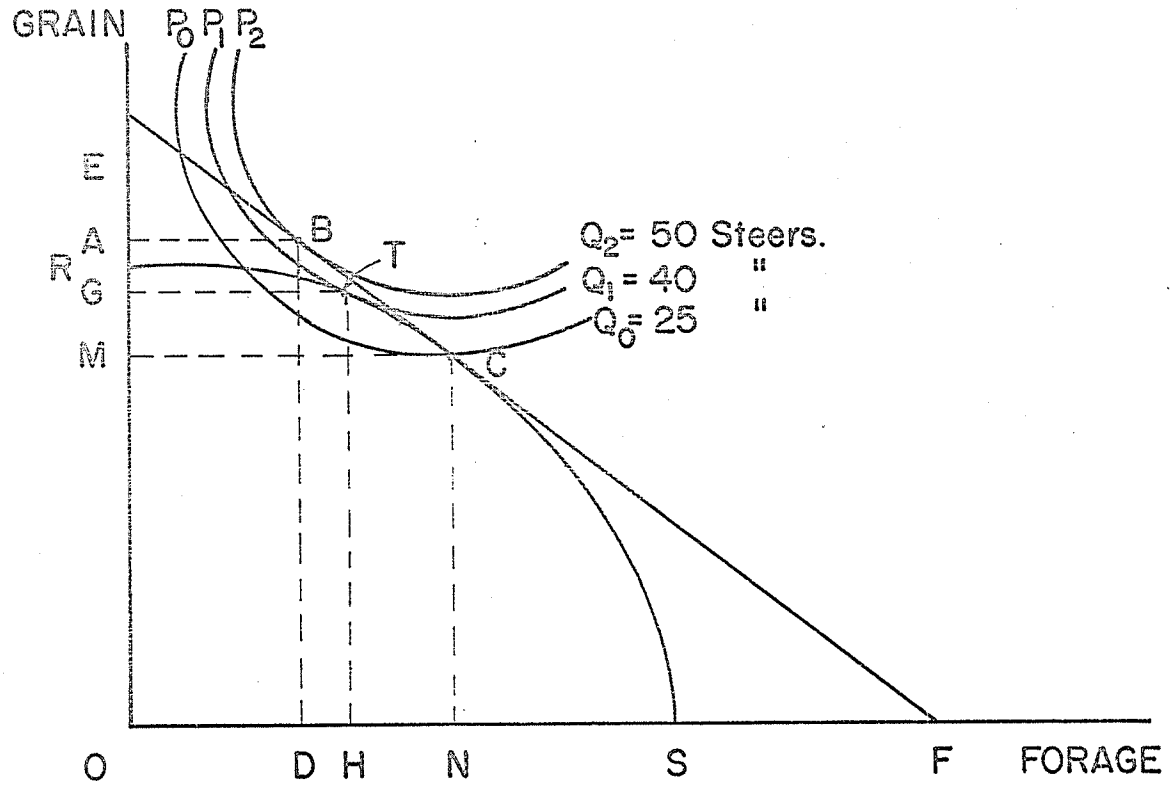

FIGURE 3 - THE PRODUCT-PRODUCT RELATIONSHIP (THE TRANSFORMATION FUNCTION)

This is determined by the slope of the tangent to a point on the curve and because there are derivatives along the curve it may be shown as:

$$RPT = -\frac{dG}{dF}$$

where G is grain and F is forage.

In a perfect market the entrepreneur will sell his products at fixed prices and in the example being used his total revenue (R) would be given by the linear equation:

$$R = P_1(\text{grain}) + P_2(\text{forage})$$

where P_1 is the price of grain and P_2 is the price of forage. The relative price of the two products determine the slope of the iso-revenue line EF.

The point of equilibrium is where the iso-revenue line is tangent to the transformation curve. At this point the rate at which one product substitutes for the other is equal to the inverse ratio of their prices of the two products.

This may be shown in the following form:

$$-\frac{dG}{dF} = \frac{P_F}{P_G}$$

In Figure 3 point C is the point of equilibrium and indicates the optimum combination of grain and forage to be produced on the land. In this case the operator should produce OM of grain and ON of forage. This would apply if both the grain and hay were being sold but not if consideration is given to disposing of these products through livestock.

If a livestock program is introduced into the analysis and it is assumed that the two commodities can be bought and sold outside the

farm the optimum combination for feeding livestock is not likely to be at point C. In Figure 3 an isoquant P_2Q_2 (fifty steers) is shown. Under these conditions the optimum point is at B where OA of grain and OD of forage fed to livestock. This means that there would be AM units of grain sold and DN units of forage purchased. This is so because only OM units of grain are produced but OA are fed. In the case of forage ON units are produced but a smaller quantity OA is fed.

If there is no market for alfalfa and a livestock enterprise such as steers is combined with the cropping program then point T represents the optimum point of production. This would be the maximum output (in term of steers) attainable from the given land area as shown by the product transformation curve RS. This is represented by the isoquant P_1Q_1 and in this case production has decreased to forty steers. At this point the marginal rate of substitution (MRS) of grain for hay in the crop rotations is equal to the MRS of grain for hay in the steer rations. OG of grain and OH of forage are intermediate products and are fed to produce 40 steers if conditions are as illustrated in Figure 3.

If the same ratio of forage and grain had been maintained as in the first case when there was a market for both commodities and no livestock program then only 25 steers could be produced as shown by isoquant P_oQ_o. There are therefore four situations illustrated in Figure 3.

Linear Programming - Definition and Assumptions

Linear programming may be defined as maximization of a linear function subject to a system of linear inequalities[6]. This definition

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[6] Ibid., p.83.

would apply to a production problem where the objective was to maximize profits. Linear programming may also be applied to problems where the production level was fixed and the objective was to minimize costs. Because technical conditions in the real world are so complex any formulation of them for analysis involves some simplification and that assumptions be made.

In most problems involving production analysis three simplifications are made initially[7]:

1. a single production period is used

2. prices and production coefficients or yields are known with certainty before production begins

3. the analysis concerns itself only with returns forthcoming from the physical production process and the sale of commodities. There is no concern with gains or losses arising out of changes in market value of durable resources.

In addition to these linear programming makes four major assumptions:

(1) Linearity - within each process the inputs bear a certain ratio to each other and to the quantities of each of the outputs. These ratios are constant for each process regardless of the extent to which they are used. The factor-product relationship is expressed as a linear function $Y = f(x)$. The factor-factor is expressed as $X_1 = f(X_2)$ and the product-product relationship as a linear function $Y_1 = f(Y_2)$.

(2) Divisibility - this means that any process can be used to

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[7]Heady, op.cit., p.25

any positive extent so long as resources are available. The solution could thus specify 14.8 hogs which can be adjusted by the researcher without any serious effects.

(3) Additivity - several processes can be used simultaneously and the quantities of outputs and inputs used will be the sums of the quantities which would result if the several processes were used individually. This can involve difficulties in giving the proper amount of credit to processes which are complementary. This could be overcome to a large extent by anticipating these and increasing the number of processes over the complementary range.

(4) Finiteness - the assumption is that there is a finite number of processes available to the entrepreneur.

The number of alternative processes available to an individual producer will depend on his particular circumstances. Processes, as generally used in farm management, would refer to the material or commodity being produced such as hogs, beef or poultry. In linear programming, however a process is more restrictive and is one particular combination of inputs to produce a commodity such as beef. For example, one feeding program for a steer may include a ration high in grain but low in forage while another ration could be relatively low in grain and high in forage. While the two processes are concerned with producing beef they are considered as two separate and distinct activities or processes. Such processes are illustrated in Figure 4 where P_1 could be one combination of hay and grain used in the production of beef, P_2 another and so on. The producer would have selected these as four

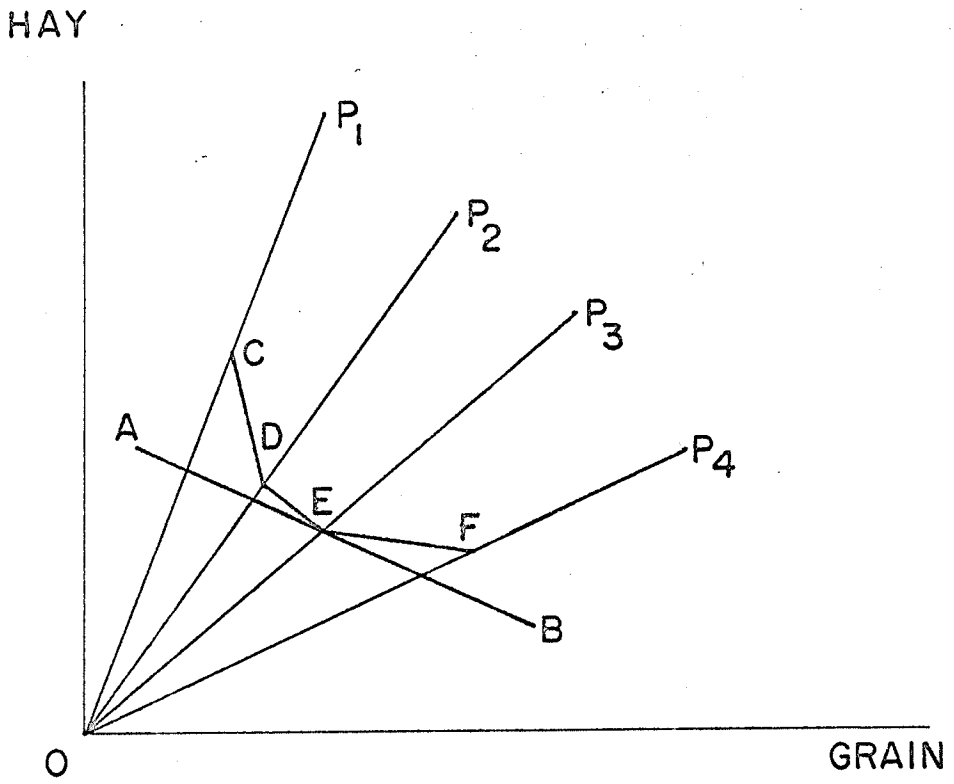

FIGURE 4 - THE DISCONTINUOUS ISOQUANT SHOWING FOUR PROCESSES

possible ways of feeding steers and wants to know which of these four would yield the highest profit.

As in marginal analysis discussed previously the optimum point or the point of equilibrium will be where the marginal rate of substitution between two inputs is equal to their inverse price ratio. In Figure 4 each point C,D, E and F may represent 100 pounds of beef using each of four different processes. This, CDEF is a discontinuous isoquant. If the ratio of the prices of hay and grain are represented by line AB then the optimum point will be at E. The producer would select P_3 as being most profitable.

In practice, the number of alternative processes and choice of inputs would be much greater than shown in Figure 4. A producer could have a certain amount of land, labor, capital and management and wants to know the combination of these, when 50 or 100 processes are available to him, will yield the highest profit. The operator's revenue (R) is a linear function of his activity levels:

$$R = p_1q_1 + p_2q_2 + - - - - p_nq_n$$

where p is the net price of a unit of output and q is the quantity of the respective output. The operator then tries to maximize R subject to limited inputs. This may be represented by the following equation:

$$a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + - - - - a_{1n}x_n \leq 855$$

where x_1, x_2- - - x_n are different processes and may be a rotation, a beef activity or a method of producing pork. The coefficient is the amount of that particular restriction required to produce a unit of the process. In the equation used 855 could, for example, be the number of spring

hours of labor available to the operator and all activities in the program could not use more than this 855 hours.

When the entrepreneur has outlined his restrictions, the various processes which are feasible alternatives for him, and determined the relevant coefficients for the processes a mathematical solution can be attained. An iterative process allows the determination of optimum output levels in a finite number of steps. In this method one process is selected and another is rejected. Flexibility is introduced by the possibility that any one process can be used at various levels and that different processes can be combined, or used together in various ways[8].

In this manner many production problems may be handled by linear programming. It is well adapted for application to decision-making at the level of the firm. Linear programming deals easily with large changes in inputs and outputs and limits on availability of production factors. Because of its emphasis on technology it does provide a link between the problems of interests to the economist and those which engage the attention of the entrepreneurs and the various sciences.

Linear programming does, however, require trained personnel and automatic high-speed computers. For these reasons it would seem reasonable to expect that the traditional budgeting approach will continue to be a useful tool for researchers, extension workers, and farmers in solving farm organizational problems. It was therefore con-

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[8]Allen, R.G.D., Mathematical Economics, (MacMillan and Co. Ltd., London, 1956), pp 618 ff.

sidered desirable to include a budgetary analysis as well as one which involved linear programming. The following chapter is devoted to a discussion on the budgeting technique and presentation of budgets and results.

CHAPTER III

A BUDGETARY ANALYSIS OF ALTERNATIVE FARM PLANS

The farm budget is an orderly and systematic approach to farm planning. It is a written plan outlining the acres of crops, the numbers of livestock, estimated receipts and expenses for each of several alternative farming systems. Comparison of net farm income for several different plans provides a basis for choosing the most profitable plans. Through budgeting one can develop a combination of enterprises and production methods that permits the fullest use of available resources and achieves the highest possible production efficiency. In practice, however, budgeting may only approach this optimum for the particular production relationships, prices, costs and restrictions as there is a limit to the number of alternatives being considered.

In the budgeting process one is primarily concerned with two figures. One of these is total receipts and the other total expenses. Bradford and Johnson use the following formula to illustrate the procedure.[1]

$$(Qy_1Py_1 + - - - + Qy_nPy_n) - (Qx_1Px_1 + - - - + Qx_nPx_n - FC) = II$$

Where Q = quantity

P = price

II = profit

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[1]Bradford, Laurence A. and Glenn L. Johnson, Farm Management Analysis (John Wiley and Sons, Inc., New York and Chapman and Hall, Limited, London, 1953) p.329.

$y_1 - y_n$ = different products sold or added to inventory.

$x_1 - x_n$ = different products used or taken from inventory.

FC = fixed costs.

Bradford and Johnson summarize their formula by saying, "essentially, a budget is the summation of all expected products (or increased inventories) times their respective prices less the summation of all items used in production times their prices for a given time period"[2].

In this study the budgeting procedure will proceed through five basic steps.

1. A complete inventory of resources:

These include such things as size of farm, building space available, machinery, labor, capital, management skills and preferences. The type of soil, topography and climate restrict the crops which can be grown.

2. The production relationships:

These should represent the physical input-output relationships and the production practices used. The production relationships also include such information as yields of the various crops, milk and beef production per cow and the costs associated with the different enterprises.

3. The level of prices and costs:

This list should include the cost of all materials used in production and the price of all products produced on the farm. These prices

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[2] Ibid.

and costs should take into consideration apparent future trends in production and demand.

4. The alternative systems to consider:

These indicate the combination of enterprises and the production practices used.

5. Estimating costs and returns:

This is done for each of the alternatives being considered and can be used as a basis for choosing the most profitable system.

Inventory of Resources

(a) Land - the size of farm used for this study was 240 acres. An indication of the type of farm considered is given in the following table.

TABLE IV

IMPROVED AND UNIMPROVED ACRES UNDER DRYLAND AND IRRIGATION

	Dryland (acres)		Irrigation (acres)
Improved	200	Irrigable land	153
Pasture	35	Canals, ditches etc.	12
Farmstead	5	Dryland: improved	35
		Pasture	35
		Farmstead	5
	240		240

Climatic conditions in the area allow the production of wheat, oats, barley, rye, buckwheat, sunflowers, corn, peas, sugar-beets alfalfa and sweet clover. Because of more limited markets other crops can be grown on a smaller scale. These include tomatoes, carrots, onions, field beans, turnips, cucumbers and asparagus. Because of these market limitations these crops in the latter groups were not included in this study as the results could be meaningless on an area basis. A farm plan including these crops would be realistic only for a few farms but for the rest of the farms would have little use because the products could not be sold.

The soils and crops specialists[3] were consulted regarding land use under dryland and irrigation conditions. Taking into consideration markets, soil type and fertility, and erosion problems, rotations were developed and are shown in Table V. The information on present dryland use was obtained from the survey taken of farms in the area.

(b) Buildings - those which existed on the case farm and could be considered useful for productive livestock was one stanchion barn 26 x 30 (780 sq.ft) and a hog barn 18 x 22 (396 sq.ft.) The stanchion barn could be renovated and used for hogs. In this study it was estimated that for $2,000.00 this barn could be converted into a unit satisfactory for farrowing and $1,000.00 for feeder hogs. This conversion made 1176 sq.ft

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[3]Crop rotations and recommended fertilizer rates were developed by J. Peters and R.A. Wallace, Soils and Crops Branch, Manitoba Department of Agriculture and A.O. Ridley, Soils Department, University of Manitoba.

TABLE V

LAND USE UNDER DRYLAND AND IRRIGATION

Crops	Present dryland	Optimum dryland	Irrigation
Wheat	-	50	20
Oats	55	25	20
Flax	54	25	20
Sunflowers	30	25	-
Corn silage	17	-	-
Sweet corn	-	15	35
Canning peas	-	10	-
Sweet clover	15	-	-
Alfalfa	20	50	30
Sugar beets	-	-	28
Pasture, waste	40	40	52
W-O-F-SF(dryland)	-	-	35[a]
Rye	9	-	-
	240 ac.	240 ac.	240 ac.

[a]35 acres were unsuitable for surface irrigation and were utilized by a wheat-oats-flax-summer-fallow rotation.

of space available for hogs. On the basis of space requirements used the existing facilities would allow a maximum production of livestock shown in Table VI.

In addition to buildings used for livestock there was adequate granary-space for grain storage and also a building for housing machinery.

TABLE VI

MAXIMUM PRODUCTION PERMITTED BY BUILDING SPACE

Type of livestock	Space available	Space required	Maximum animals
Dairy (cream)	780	78 sq.ft/ head	10 head
Beef	780	56 "	14 "
Feeder hogs	1176	6.6 "	175 x 3 = 525 head
Weanlings	1176	2.9 "	405 head
Farrow and feed	1176	5.2 "	226 "
Steers - these were not restricted by building space because of good shelter-belt and facilities available.			

(c) Machinery - Table 6 of Appendix lists the machinery used in the operation of the unit. Under dryland conditions this machinery complement was considered adequate for all necessary operations except spraying and baling. These two operations were custom-hired. It was estimated that $2,000.00 would be required to equip the farm for irrigation. This included such items as a two-way plow, ditcher, leveller, and siphons, tubes, etc whose values are also shown in Table 6 of Appendix.

(d) Labor - this was almost entirely supplied by the family with the operator himself supplying 2560 hours and the family 1815 hours for a total of 4375 hours for the year. The breakdown of hours by season is given in Table 1 of Appendix. The seasons were separated to conform to different operations on the farm. The Spring season, April 15 to June 15, would be the time for pre-seeding tillage, planting of crops and spring calving or farrowing if these were in the program. Crop-spraying,

cultivation of row-crops, haying would be done in the summer season, June 16 to August 15. During the fall season, August 16 to October 31, the harvesting, post-harvest tillage and some preparation for winter would take place. During the winter season, November 1 to April 14, the time would then largely be occupied with livestock, machinery repairs and some marketing of crops.

Labor is much more critical under irrigation than dryland farming. The amount of labor required is greater and the quality of labor needed is higher. In most cases it would probably require a full season for a newly hired man to acquire the techniques of irrigation to the point where he becomes useful to the employer. Under such circumstances it is important that family labor is available or reliable help can be hired on a year-round basis.

(e) Capital - this resource would very likely be more limited in some individual cases than the amount used in this study. It was felt, however, that it would be useful to utilize the resources available as fully as possible and see what the results might be. Fixed capital under dryland and irrigation conditions are shown in the following table. The 165 acres which were developed for irrigation increased from $100.00 per acre to $160.00 per acre. This increase, and the $2,000.00 invested in additional machinery explains the change in fixed capital. Additional capital would be required for building renovations or livestock purchases.

Operating capital is assumed to be adequate for putting all acres into crop and to fully utilize existing building space.

TABLE VII

FIXED CAPITAL - DRYLAND AND IRRIGATION

Item	Dryland	Irrigation
Land	$24,000.00	$33,650.00
Buildings	3,600.00	3,600.00
Machinery	6,728.00	8,728.00
	$34,328.00	$45,978.00

(f) Management skills and preferences - the level of management is difficult to measure but was taken into consideration whenever possible. When the survey was taken in the area farmers were asked what practices were used in crop and livestock production and the level of expenses, yields, and feed-conversion ratios were adjusted accordingly. The over-all level of management assumed in this study is probably slightly higher than that generally prevailing in the area at the present time.

Individual skills and preferences were not considered because it was felt that the results should be useful to a large number of farmers in the area. If only the preferences of the operator whose farm was selected for the study were being considered there would be no need to include a dairy program. However, since this enterprise is a common one in the area and it is expected that many will continue to include it in their farm plans, dairying was included in some of the budgets.

Production Relationships or Coefficients

One of the more difficult aspects of a study such as this is to establish realistic production relationships. If the results are to be meaningful to a policy maker or individual farm operators they must portray conditions as they exist in practice. Coefficients will vary because of area, soil type, size of farm, quality of livestock, type of operator and many other reasons. Some of these can be specified such as area, soil type and size of farm. Others must be assumed or established subjectively. This is where available information and judgement play an important part.

There were two general sources of information used to determine the coefficients used. One source was the farmers themselves. They were able to supply information on tillage practices, size of machinery and other crop requirements and costs. To a lesser extent, they were able to indicate what their livestock inputs might be. The second source was University and extension personnel and various research organizations in the United States and Canada. These were especially important when developing coefficients for irrigation-farming. Results of other studies were taken into consideration and adapted to local conditions as much as possible. Yields of the various crops grown were established on the basis of long-time average yields and adjusted by soil and crops specialists to take into account soil type and climate of the area, improved varieties, and production practices likely to be used. Most of the coefficients used in this study are listed in the appropriate tables of the Appendix.

Farm Prices and Production Costs

The prices of farm products and the cost of the various items used in farm production were established on the basis of those prevailing in the period 1959 - 1961[4]. Because of drought conditions in 1961 the prices of some commodities were considered to be unrealistic for planning purposes and were not included in the average. Prices and costs were all adjusted to take into account freight differentials and trading practices of the area so that those used were very similar to prices which farmers would receive for their products or pay for items required in their production plans.

While the level of prices is important, it is even more important to select a period in which cost-price relationships are realistic. The profit per hog may change only by a small amount if the price of barley and hogs both go up. If however, the price of barley goes up and hog prices are constant or lower, profits would then be reduced considerably.

The Livestock Systems Considered.

The type of livestock programs and the size of the enterprises were established by taking into consideration the pasture, buildings and labor available. No attempt was made to balance these with the grain produced on the farm as a ready market existed for these products and they could also be purchased if necessary. In one of the programs all

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[4]Dominion Bureau of Statistics, Agriculture Division, "Quarterly Bulletin of Agricultural Statistics", Catalogue No. 21-003.

the forage was used for a feeder-steer enterprise. The other programs assumed there was a market for baled alfalfa hay. Capital varied with each program and was assumed to be adequate.

There were four livestock programs considered under both dry-land and irrigation farming:

1. 10 dairy cows and 56 feeder-hogs

This is essentially the program being carried on at the present time on the case farm selected as the basis for this study. The production was 250 lbs. of butterfat (B.F.) per cow so it was estimated that 2500 lbs of B.F. in the form of cream would be sold annually. Calves were sold as veal at a weight of 175 lbs. Bred heifers were purchased to maintain the herd at the desired level. An artificial breeding service in the area was used to service the cows.

The 56 feeder-hogs was considered an off-season type of enterprise and did not utilize all the building space available at any time of the year. In other respects it is much the same as the program described in the following section.

2. 400 feeder-hogs

This was the only livestock enterprise on the farm and was housed in the existing hog-barn and the converted dairy-barn. This barn space could accommodate 175 hogs if the proper number of hogs in each size group could be maintained. 160 hogs was felt to be more practical and was the level used in the study. The hogs were purchased at six weeks of age weighing 20 pounds for a price of $9.00. A twenty-week feeding period was required to reach a market weight of 190 pounds. This program

would then permit two and one-half lots or four hundred hogs to be fed annually.

3. Farrowing and feeding program

Sixteen sows farrow twice a year and each produce fifteen pigs or a total of 240 hogs. The enterprise is planned as a continuous operation with five sows farrowing every two months. One boar is used to service the sows.

4. 120 feeder steers

This program plans for two lots of sixty steers but is flexible as more steers may be fed during the slack winter season and less in summer if labor is limited. The steers are purchased at 710 pounds and fed to 1010 pounds in approximately 160 days. An important feature of this program is that it balances the forage produced under dryland condition and very nearly so under irrigation.

5. The costs and returns of the nine alternative plans are shown in Table VIII. The present program is included so that it may be compared with those proposed. The livestock production alternatives include the following enterprises:

Plan I - Present cropping program with 10 dairy cows and 56 hogs.

II - Revised cropping program with 10 dairy cows and 56 hogs.

III - Revised cropping program with 400 feeder hogs

IV - Revised cropping program with 120 feeder steers.

V - Revised cropping program with 240 hogs farrowed and fed to market.

Irrigation Programs - cropping program same for all.

VI - 10 dairy cows and 56 hogs.

VII - 120 feeder steers.

VIII - 240 hogs farrowed and fed to market

IX - 400 feeder hog program.

Summary of Results

1. Capital investments

This represented fixed capital and included land, buildings, machinery and breeding stock. Building renovations to accomodate feeder steers, feeder-hogs and sows resulted in a higher investment in real estate in Plans III, IV and V. Land suitable for irrigation increased in value from $110.00 to $160.00 per acre. This increase in price represents the cost of development and restoration of the land to its original fertility. An additional $2,000.00 worth of machinery was required for the farm under irrigation.

2. Receipts

The crop receipts shown in Table VIII were the total value of crops produced on the farm for each plan. All plans assumed a market for forage crops.

3. Expenses.

The cash expenses included home-grown grain and hay fed to livestock. Because of this the amount of cash actually spent during the year would be considerably less than the amount shown. The machinery depreciation was $865.00 for dryland farming and increased to $1065.00 under irrigation. The building depreciation took into account the renovations made for various livestock enterprises.

TABLE VIII

COMPARISON OF NINE DRYLAND AND IRRIGATION PLANS

Capital Investment	Plan I	Plan II	Plan III	Plan IV	Plan V	Plan VI	Plan VII	Plan VIII	Plan IX
	- dollars -		- dollars -		- dollars -		- dollars -		
Real estate	27,600.00	27,600.00	28,600.00	28,600.00	29,600.00	37,450.00	38,450.00	39,450.00	38,450.00
Livestock	2,250.00	2,250.00	-	-	870.00	2,250.00	-	870.00	-
Machinery	6,728.00	6,728.00	6,728.00	6,728.00	6,728.00	8,728.00	8,728.00	8,728.00	8,728.00
Total	36,578.00	36,578.00	35,328.00	35,328.00	36,598.00	48,228.00	47,178.00	49,048.00	47,178.00
Receipts									
Crops	5,161.56	8,037.80	8,277.80	8,277.80	8,277.80	14,829.80	14,829.80	14,829.80	14,829.80
Cattle	2,241.00	2,241.00	-	27,144.00	-	2,294.51	27,117.60	-	-
Hogs	1,210.00	1,859.76	13,284.00	-	7,977.40	1,859.76	-	7,977.40	13,284.00
Total	8,612,56	12,138.56	21,561.80	35,421.80	16,288.20	18,984.07	41,947.40	22,807.20	28,113.80
Expenses									
Cash	3,846.40	6,121.75	13,841.87	27,953.00	9,077.89	9,120.79	31,085.50	12,185.63	17,241.61
Depreciation	1,107.00	1,107.00	1,167.00	1,137.00	1,167.00	1,319.00	1,369.00	1,399.00	1,369.00
Total	4,953.40	7,228.75	15,008.87	29,190.00	10,244.89	10,439.79	32,454.50	13,584.63	18,610.61
Return to capital and labor	3,659.16	4,909.81	6,552.93	6,231.80	6,010.31	8,544.28	9,492.90	9,222.57	9,503.19
Imputed return to capital	1,918.68	1,918.68	1,833.68	1,833.68	1,935.88	2,471.18	2,446.18	2,548.38	2,446.18

TABLE VIII (CONTINUED)

Capital Investment	Plan I	Plan II	Plan III	Plan IV	Plan V	Plan VI	Plan VII	Plan VIII	Plan IX
	- dollars -		- dollars -		- dollars -		- dollars -		
Return to labor	1,740.48	2,991.13	4,719.25	4,398.12	4,074.43	6,073.10	7,046.72	6,674.19	7,057.01
Return per hour	.40	.68	1.08	1.00	.93	1.39	1.61	1.52	1.61
Imputed return to labor	2,800.00	2,800.00	2,800.00	2,800.00	2,800.00	2,800.00	2,800.00	2,800.00	2,800.00
Return to capital	859.16	2,109.81	3,752.93	3,431.80	3,210.31	5,744.28	6,692.00	6,422.57	6,703.19
	- per cent -		- per cent -		- per cent -		- per cent -		
Interest on capital	2.34	5.76	10.62	9.71	8.77	11.91	14.18	13.09	14.20

4. The return to capital and labor was determined by the difference between total receipts from all sources and total expenses, including depreciation. It was felt that it would be useful if the return to capital and the return to labor were estimated, despite the inherent weaknesses of trying to do so. This was done by imputing a value of one factor and the residual would then be the value of the other. The return to labor was estimated by imputing a charge of five per cent on real estate and six per cent on livestock and machinery and subtracting this from return to capital and labor figure. The balance represented the return to family labor. An hourly rate was calculated by dividing this return by the number of hours available, or 4375 hours. This return per hour is therefore not for each hour worked but for each hour available for work.

The return to capital was estimated by placing a value on family labor. This was valued at $2800.00, or $1800.00 for the operator and $1000.00 for the rest of the family. The fixed capital was used to calculate the rate of interest earned.

Plans IV and IX, both including a hog-feeder enterprise, appear to be the most profitable. There are, however, two major assumptions made. They are:

(1) that a reliable source of feeder-hogs exists in the area.

(2) that a market exists for the forage produced on the farm.

If these assumptions cannot be accepted, plans including the feeder steers or farrow and feed hogs can be selected with a relatively small loss of income.

An examination of the budgets presented in Table VIII seems to show a considerable difference in income between dryland operations, Plans I to V, and irrigation, Plans V to IX. If this increase in income is ascribed to the 153 acres which were developed for irrigation the increase per acre would be as shown in Table IX.

TABLE IX

BENEFITS PER ACRE FROM IRRIGATION

Plan	Dryland income	Irrigation income	Increase	Increase per acre	Irrigation benefits per acre
	- dollars -		- dollars -		
Dairy and 56 hogs	2,991.13	6,073.10	3,081.97	30.14[a]	10.57
400 feeder hogs	4,719.23	7,057.01	2,337.78	15.28	5.55
240 farrow and feed hogs	4,074.43	6,674.19	2,599.76	16.99	7.38
120 feeder steers	4,398.12	7,046.72	2,649.60	17.32	7.70

[a]The dairy + 56 hog program is higher than the other three because of a slight improvement in the dairy enterprise.

It would, however, be unrealistic, to credit the irrigable acres with all the increased income as more capital and labor were employed in order to do this. Using coefficients which were developed for this study Plan III would require 1708 hours of actual work while Plan IX would need 2992 hours or 1284 hours more. There would also be $3081.97

more capital required. If the extra labor is valued at one dollar per hour and the increased operating capital at six per cent the balance left to irrigable acres would be $849.80. This reduces the benefits to $5.55 per acre. Using the same procedure with the other plans resulted in a range in benefits from $5.55 to $10.57 or an average of $7.80 as shown in Table IX.

A charge of $4.00 per acre has already been assessed against the irrigable acres. If this charge is included with the average benefits then $11.80 would be available to pay for operation and maintenance and amortization of irrigation structures outside the farm boundaries.

Debt Repayment Capacity

In order to determine the debt-repayment capacity of the nine plans considered it is necessary to take into account the operator's personal living costs. These are shown for the five size groups included in the survey.

In calculating the repayment capacity of the plans a living cost of $2,000.00 was used. The other items shown in Table XI may be defined as follows:

1. Cash net income: - income remaining after cash expenses have been paid.

2. Machinery repayment: - machinery was repaid over a 10-year period at an interest rate of 6 per cent. The amount shown in Table XI is the annual payment required to repay the money invested in machinery

TABLE X

PERSONAL LIVING EXPENSES BY SIZE OF FARM* - 1961

Size groups (ac)	Average Living costs	Range in living costs
10 - 69	$1,155.70	390 - 2299
70 - 149	1,502.60	576 - 4020
150 - 239	1,516.10	915 - 2344
240 - 399	1,816.40	647 - 5050
400 - 759	2,711.10	1318 - 7145
Average	$1,764.80	

*Living costs do not include farm perquisites, personal share of car or an estimated value for house.

in 10 years[5].

3. Livestock repayment: - this was calculated so that the amount of money invested in breeding stock would be repaid in ten years at 6 per cent rate of interest.

4. Living costs: - set at $2,000.00 to include a value for garden. This was necessary as a garden valued at $200.00 had previously been included in farm receipts.

5. Interest on operating cost: - this was charged at a rate of 6 per cent on current cash costs.

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[5]Gilson, J.C., The Cost of Credit, Agricultural Economics Bulletin No. 3, 1961, (University of Manitoba, Winnipeg), p.24.

6. Balance for land payment: - this is calculated by adding items 2 to 5 and subtracting this total from item 1. This amount is available for paying interest and principal on the land.

7. Land investment: - this is the amount of money invested in land and buildings and is the amount which the operator repays out of earnings.

8. Annual payment - 20 years: - this is the annual payment required to repay principal and interest on land investment over a period of 20 years.

9. Annual payment - 30 years: - same as number 8 except that repayment period has been extended to 30 years.

Items 6, 8 and 9 are important and have been underlined in Table VIII. Using these three figures Plan I would not seem to be able to repay the face value of the land in either the 20 or the 30 year repayment period. Plan II would seem to be profitable enough to do this but has only a small surplus if the 20-year period is used. All the other plans are profitable enough to allow repayment in either 20 or 30 years.

TABLE XI

DEBT REPAYMENT CAPACITY FOR DRYLAND AND IRRIGATION PLANS

	Plan I	Plan II	Plan III	Plan IV	Plan V	Plan VI	Plan VII	Plan VIII	Plan IX
		- dollars -			- dollars -			- dollars -	
1. Cash net income	4766.16	6016.81	7719.93	7468.80	7177.31	9863.28	10861.90	10621.57	10872.19
2. Machinery repayment	914.06	914.06	914.06	914.06	914.06	1185.87	1185.87	1185.87	1185.87
3. Livestock repayment	305.70	305.70	-	-	118.20	305.70	-	118.20	-
4. Living costs	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00
5. Interest on operating capital	230.78	482.27	830.51	1677.18	544.67	547.24	1865.13	731.14	1034.50
6. Balance for land payment	1315.62	2314.78	3975.36	2876.94	3600.38	5824.47	5810.90	6586.36	6651.82
7. Land investment	27600.00	27600.00	28600.00	28600.00	29600.00	37450.00	38450.00	39450.00	38450.00
8. Annual payment (20 years)	2214.62	2214.62	2294.86	2294.86	2375.10	3004.99	3085.23	3165.47	3085.23
9. Annual payment (30 years)	1795.38	1795.38	1860.43	1860.43	1925.48	2436.13	2501.17	2566.22	2501.17

CHAPTER IV

ANALYTICAL PROCEDURE FOR COMPARING DRYLAND AND IRRIGATION PLANS

Budgeting and linear programming are useful tools for evaluating new techniques or resources which are not already being used on farms. If these resources are being used surveys and farm record studies may be used in which a group of similar farms employing the new resource are compared with another group not using it. This method cannot be used until a sufficient number of farmers have adopted the new resource. Budgeting and linear programming do therefore provide some prior prediction of the outcome and the results can be used to give farmers guidance in its use[1]. These two techniques are therefore especially well suited for studying irrigation in areas where little or no irrigation has been done.

Budgeting and linear programming are similar in many other respects. They are both normative in the sense that they provide information on the course of action which ought to be taken. Regression analysis, on the other hand, is positive because it explains what has occurred in the past. The assumptions discussed earlier in Chapter II with respect to linear programming also apply to budgeting. Subjective knowledge, experience and judgement can be applied equally well to both methods.

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[1]Edited by Earl O. Heady, Glenn L. Johnson, Lowell S. Hardon, Resource Productivity, Returns to Scale, and Farm Size, (The Iowa State College Press - Ames, Iowa, U.S.A., 1956), p.71 f.

The risk factor can be considered in both by including enterprises which are less risky. Both methods are mathematical rather than statistical and their greatest application is to problems where coefficients, prices and restrictions are known or assumed to be known with certainty[2].

Linear programming does have advantages and differs from budgeting mainly in three ways:

1. The number of alternatives which can be considered are much greater with linear programming. Budgeting is time consuming and in complex problems where there are many restrictions and opportunities it is unlikely that all of them would be considered with this method.

2. The computational procedure is different. In budgeting the researcher uses pencil and calculator to determine receipts, expenses and profits. In linear programming the data is arranged in matrix form and uses high-speed computors which are capable of hnadling large quantities of data to obtain a solution.

3. The problem must be more precisely formulated with linear programming and everything must be specified before computation begins. For example, if a plan had no activity for buying oats then livestock feeding would be restricted to the amount produced on the farm. If it seemed desirable at a later stage of the analysis to include a buying activity for oats much of the program would have to be changed. With budgeting, however, this change could be made very easily. Budgeting

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[2]Heady, Earl O., and Wilfred Candler, Linear Programming Methods, The Iowa State University Press, Ames, Iowa, U.S.A. pp 18 ff.

permits the analyst to assess the plans as they develop, make changes when they seem desirable, and continue from there.

The nature of the problem would in most cases indicate which of the two methods should be used. Figure 5 illustrates a problem where there are two production alternatives (hogs and steers) and three restrictions, namely building space, labor and capital. A farmer faced with this situation could produce no more than OA of hogs because labor is restricted and only OD of steers because of restriction on capital. The relevant transformation function then becomes ABCD. If the relative prices of hogs and steers are represented by the price line PQ then the optimum point is C or there would be OR of hogs produced and OS of steers. If by budgeting only hogs were considered or only steers the implicit assumption is that the line AD is the production possibility curve. It would therefore be unlikely that an optimum point could be reached. It is possible, however, that with the limited number of restrictions and alternatives in this case a number of budgets, using various combinations of hogs and steers, would find the optimum point C.

The preceding discussion indicates that linear programming and budgeting are interchangeable to a point. They should therefore be substituted for each other on the basis of the relative cost of the two methods and the rate at which one replaces the other in terms of speed and accuracy[3]. In smaller problems budgeting could be more economical but as the problems become more complex and the opportunities more

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[3] Ibid., p.42.

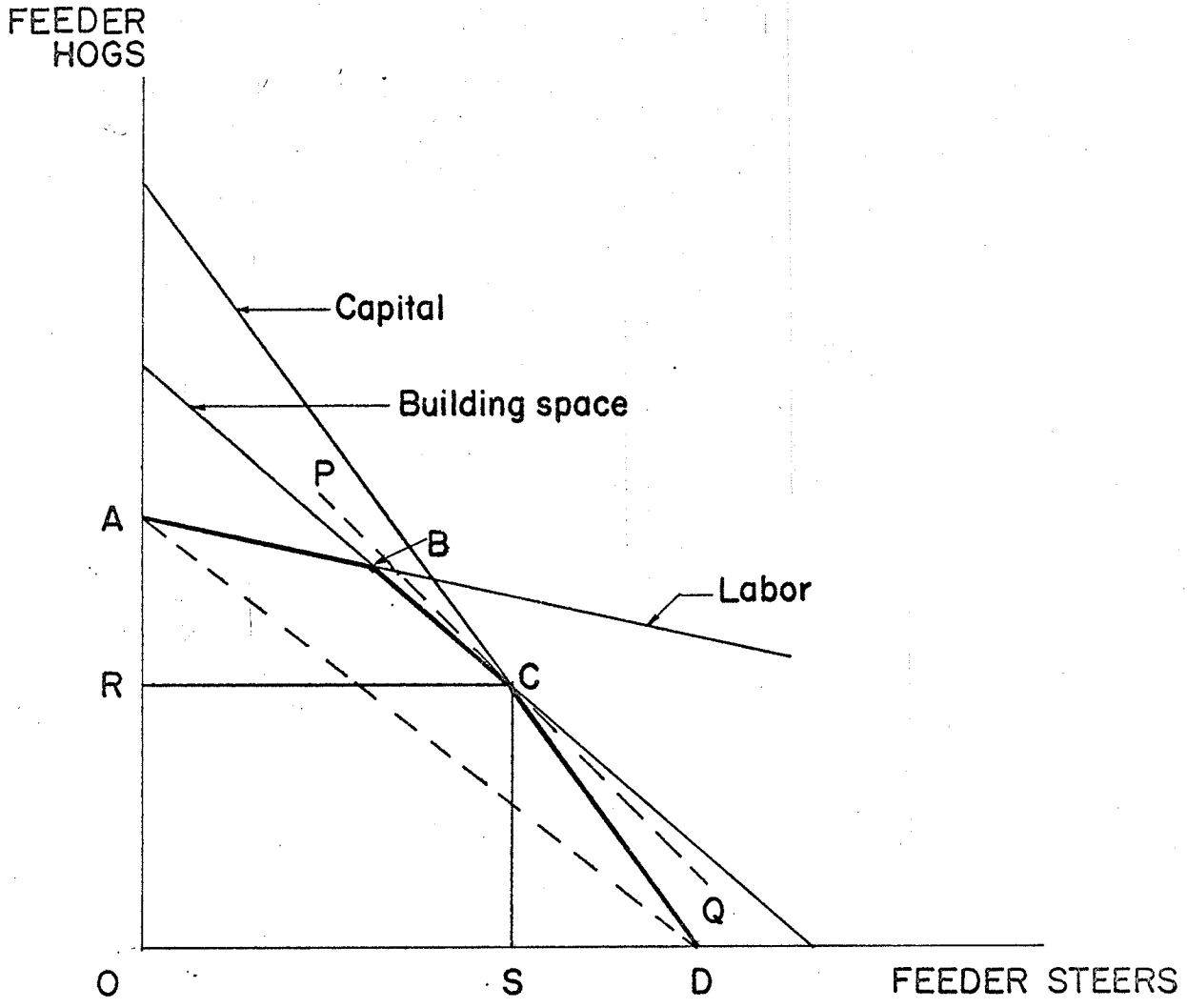

FIGURE 5 - THE RELEVANT TRANSFORMATION FUNCTION WHEN TWO PROGRAMS AND THREE RESTRICTIONS ARE CONSIDERED.

numerous linear programming would be more efficient. The problem with which this thesis is concerned involves the organization of a farm and is therefore one for which linear programming is well suited.

Description of Farm

Tables I and II of Chapter III indicate the acres available for crop production and the land-use program presently being carried out. The 35 acres used for pasture at the present could not be included in the rotation because of poor drainage. They have therefore no alternative use and are considered adequate pasture for approximately fifteen animal units of beef or ten of dairy.

A topographical survey of the farm showed that 153 acres could be used for surface irrigation. The remaining forty-seven acres would be taken up by twelve acres of canals and ditches and thirty-five acres remaining in dryland crop production. These thirty-five acres were considered too uneven, thus making the cost of levelling uneconomical for surface irrigation. Although it was not considered in this study, it is quite possible that a suitable arrangement could be made to irrigate these by a sprinkler system.

Cropping Program

Dryland - The present dryland program includes buckwheat and rye which were not considered important in the area and were omitted from other alternative rotations. The sweet clover is harvested for feed at the present time but in all other rotations was used only for green manure. Acres used for corn silage in the present program were used for

alfalfa in other programs. No canning crops are grown on this farm at the present time but, as many of these can be grown in the area, corn and peas were included in some of the rotations considered. The various cropping programs are described in detail later.

Irrigation

In the rotations considered for irrigation row crops occupied approximately one-third of the acreage, small grains one-third and forage crops one-third[4]. Canning peas were not included because research work in the area seemed to indicate that with an early crop such as peas natural rainfall would in most years be adequate[5]. Sugar beets and sweet corn were the main row crops used under irrigation.

Livestock Program

The present livestock program includes ten dairy cows and a small feeder-hog program. Many farmers in the area do have small dairy enterprises and as they are expected to continue to do so it was included as an alternative. A beef cow-calf enterprise was considered because a number of farmers indicated that they would prefer this enterprise as an alternative to dairy. Three beef feeder enterprises were also considered because this is an important part of the program in many irrigation areas

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[4]Larson, W.E., S.N. Brooks, T.S. Aashurn and A.H. Post, Irrigated Crop Rotations At The Huntley Branch Station (Montana Agricultural Experiment Station, Boseman, Montana, Bulletin Number 535, January 1956).

[5]This is based largely on discussions with Dr. Walkoff who has been doing research work with irrigation at the Dominion Research Station at Morden.

and would likely be so in this area because of relatively high land values and a limited amount of what would normally be considered grazing land. There were four hog programs included in the list of alternatives, namely : weanlings to be sold at six weeks, farrow and feed to market, a summer feeder-hog program and a winter feeder-hog. These nine livestock alternatives were considered to be feasible alternatives for farms under both dryland and irrigation.

Restrictions

The resource restrictions used in the various programs are shown in Table XII. Most of these have been discussed previously in Chapter III. Capital, however, was treated differently with linear programming than with the budgetary analysis. In this case it was allowed to vary and four levels were used: $4,000, $7,000, $10,000 and $15,000.

TABLE XII

RESOURCE RESTRICTIONS

Labor - see Appendix Table 1 for details

Spring (April 15 - June 15)	.	855 hours
Summer (June 16 - August 15)	.	1170 "
Fall (August 16 - October 31)	.	1035 "
Winter (November 1 - April 14)	.	1315 "
Winter space	.	1176 sq.ft.
Summer space	.	1165 "
Capital	.	$4,000-$15,000.
Land (dryland program)	.	200 acres
Land (irrigation program: irrigable		135 acres
dryland		35 "

The Alternative Enterprises

Crops - dryland (numbers in bracket indicate percentage)

1) Present rotation - oats (26.0) - flax (32.5) - sunflower (12.5) buckwheat (7.5) - corn silage (8.0) - clover fallow (5.0) - alfalfa (5.0) - rye (3.5). This rotation is low in forage.

2) Rotation 1 - wheat (12.5) - oats (12.5) - flax (25.0) - sunflowers (12.5) - sweet clover (12.5) - alfalfa (12.5) field peas (12.5)

3) Rotation 2 - wheat (16.5) - oats (17.0) - flax (16.5) - sunflowers (17.0) - sweet clover (16.5) - alfalfa (16.5)

4) Rotation 3 - wheat (12.5) - oats (25.0) - flax (12.5) - sunflowers (12.5) - alfalfa (25.0) - field peas (12.5)

5) Rotation 4 - wheat (12.5) - oats (12.5) - flax (25.0) - sunflowers (12.5) - canning peas (5.0) - sweet corn (7.5) sweet clover (12.5) - alfalfa (12.5)

6) Rotation 5 - wheat (25.0) - oats (12.5) - flax (12.5) - sunflowers (12.5) - canning peas (5.0) - sweet corn (7.5) alfalfa (25.0).

The order in which the crops are listed in these six rotations is not necessarily the sequence which would be used in practice. They indicate only the crops grown and the percentage of each.

The six rotations listed above were also considered using recommended levels of fertilizer as shown in Table XIII.

TABLE XIII

FERTILIZER APPLICATION USED ON DRYLAND AND IRRIGATION ROTATIONS

Crop	Dryland (rate/acre) (N-P-K	Irrigation (rate/acre)
Wheat 1st crop	40 lbs of 11 - 48 - 0	
2nd crop	96 lbs of 16-20 - 0	125 lbs of 11-48-0
Oats	96 lbs of 16 - 20 - 0	125 lbs of 16-20-0
Sunflowers	40 lbs of 11 - 48 - 0	
Sweet corn	100 lbs of 27 - 14 - 0	200 lbs of 14-14-0
Alfalfa	100 lbs of 11 - 48 - 0	150 lbs of 11-48-0
Flax	-	-
Canning peas	-	-
Sugar beets	-	400 lbs of 14-14-0

Crop Rotations Considered Under Irrigation

1) Rotation I_2 - Sweet clover (19.7) - sugar beets (19.7) - flax (20.2) - canning corn (20.2) - wheat (20.2)

2) Rotation I_4 - Alfalfa (33.3) - sugar beets (16.6) - canning corn (16.6) - wheat (16.6) - oats (16.6)

3) Rotation I_5 - Sweet clover (16.6) - alfalfa (16.6) - sugar beets (16.6) - wheat (16.6) - canning corn (16.6) - flax (17.0)

4) Rotation I_8 - Alfalfa (33.4) - canning corn (11.1) - sugar beets (22.2) - wheat (11.1) - oats (11.1) - flax (11.1).

Livestock Programs for Dryland and Irrigation[6]

1. Weanling pigs

Under this program each sow would farrow twice a year and wean fifteen pigs each. These pigs were weaned at six weeks at a weight of twenty pounds and sold for $9.00 each. Sows were purchased for $50.00 each and sold for $43.00 while boars were purchased for $70.00 and sold for $50.00. Since it was assumed that both boars and sows would be kept for two years on the average the total replacement cost for both was $.55 per weanling pig.

The maximum size of enterprise permitted by the 1176 square feet of barn space available would be 405 weanling pigs. This would mean 9 sows farrowing every two months or a total of 27 sows in the breeding herd. Two boars would be used for servicing.

To calculate building costs it was assumed that 405 pigs would be produced each year. Only repair costs were charged for the present barn but interest and depreciation as well as repairs, were charged on the improvements made. It was estimated that it would cost $2,000.00 to renovate the barn and make it suitable for farrowing. On this basis, the total building cost was $255.00 or $.63 per weanling pig.

2. Farrow and Feed Hogs to Market

This is essentially the same as the weanling pig program dis-

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[6]The budgets for these programs were developed largely from the "Farm Management Handbook", Department of Agricultural Economics, University of Manitoba. The steer rations were recommended by Prof. M.E. Seale of the Animal Science Department, University of Manitoba and hog budgets were checked by Dr. S.C. Stothers of the same department.

cussed in the preceding section to the age of six weeks or until the pigs have reached approximately twenty pounds. After weanling the hogs were fed to a market weight of 190 pounds live weight or 150 pounds dressed weight and sold for $33.21.

Fifteen sows and one boar was required for breeding stock for this plan if all barn space was to be utilized. This means that five sows would farrow every two months and since each one farrows twice a year this was a total of thirty farrowings per year. 225 hogs were marketed annually. The building cost per hog was higher as fewer hogs were produced and amounted to $1.13.

3. Winter feeder - hog program

The weanling pigs were purchased at twenty pounds for $9.00 and fed to 190 pounds. These hogs were purchased on November 1 and sold on March 15, a feeding period of almost 140 days. The building space available could house 160 hogs at one time.

4. Summer feeder - hog program

This was the same program as the feeder program previously described except that pigs were purchased on June 15 and sold on October 31. The building cost per hog for the feeder programs was $.73.

5. Beef cow-calf

The building space and pasture limited the size of beef herd which could be kept on this farm to fifteen cows. The cows were bred artificially at a cost of $6.00 each. Calves were born in spring and weaned

about October 1 at a weight of 405 pounds. Assuming a 90 per cent calf-crop it was estimated that each calf would be worth $79.13.

6. Long beef-feeder program

These steers were purchased at 405 pounds for $87.92 about October 1. They were fed for 305 days and sold at 1044 pounds for $227.07. The steers gained slightly over two pounds per day on the average. They were brought to full feed as soon as possible and kept there for the balance of the feeding period.

The daily ration for the first 150 days was 5 pounds of hay, 6 pounds of oats, 2.5 pounds of barley and .5 pounds of soybean oil meal and minerals free choice. The ration was increased during the last 150 days to 10 pounds of hay, 10 pounds of oats, 6 pounds of barley and no supplement.

7. Winter beef-feeder program

These steers were purchased about November 1 and sold early in March, a feeding period of 153 days. The feeders weighed 700 pounds when they went on feed and 1056 pounds when sold. They were purchased for $20.00 per hundred pounds or $140.00 each and sold for $21.75 per hundred pounds or $229.68 each. This was a positive margin of $1.75 per hundred pounds.

The daily ration consisted of 10 pounds of hay, 10 pounds of oats and 6 pounds of barley. Minerals were fed free choice but no protein supplement was fed during any part of the feeding period.

8. Summer beef-feeder program

This was the same as the winter program except that steers were purchased about June 1 and sold at the end of October.

9. Dairy program-selling cream

Dairy cows produced 250 pounds of butter fat worth $155.00. Skim-milk was valued at 15.00 per cow. Calves were sold as veal at a weight of 175 pounds for $40.93. 25 per cent of the herd was culled each year and replacement heifers were purchased.

Barn-space and carrying capacity of the pasture limited the dairy herd to ten cows.

The overall analysis was divided into four categories. These were:

1. Dryland program
2. Irrigation program
3. Four levels of irrigation development
4. Irrigation and dryland rotations competing

1. Dryland program

The purpose of this analysis was to determine the optimum program for present dryland conditions. There were twenty-one processes considered; six rotations fertilized and unfertilized, and nine livestock programs. In other words, there were twenty-one activities competing for the available resources listed in Table XII. The coefficients used are shown in Table 7 of Appendix.

It was considered desirable to give special consideration to forage. There was no established and reliable market for this crop and the analysis seemed incomplete if it were assumed that all of this crop could be sold. Therefore, one part of the analysis assumed a market for alfalfa hay and another part assumed no market was available. When the forage could not be sold directly it had to be fed to livestock or left unused.

In any production program such as this the amount of operating capital available is a critical factor. Four levels of capital were considered to determine the effect on profits and the various programs as it was increased from $4,000 to $7,000 and then to $10,000 and $15,000. There were eight plans considered for dryland conditions:

Plan I	No market for alfalfa - $4,000 capital
II	No market for alfalfa - $7,000 "
III	No market for alfalfa - $10,000 "
IV	No market for alfalfa - $15,000 "
V	Market for alfalfa - $4,000 capital
VI	Market for alfalfa - $7,000 "
VII	Market for alfalfa - $10,000 "
VIII	Market for alfalfa - $15,000 "

2. Irrigation program

The object of this part of the analysis was to determine what the most profitable combination of resources would be if irrigation water was available. The four rotations previously described and nine livestock enterprises were allowed to compete for the available resources.

The coefficients used are shown in Table 8 of the Appendix. It was more difficult to estimate these coefficients for irrigation farming than dryland because of the lack of information. It was therefore necessary to use results of studies made in other irrigation areas and adapt these, as much as possible to local conditions[7].

Similar consideration was given to forage and capital as was done under dryland farming. Three levels of capital were considered assuming a market for alfalfa and three levels without a market. This made six plans for the irrigation program:

Plan IX	No market for alfalfa	$ 4,000 capital
X	"	10,000 "
XI	"	15,000 "
XII	Market for alfalfa	4,000 "
XIII	"	10,000 "
XIV	"	15,000 "

3. Levels of irrigation development

The purpose of this section was to determine what the income and plans would be at various stages as the farm was developed for irrigation. It was considered desirable to do this as farmers in the area

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[7]There were three bulletins especially helpful in this regard: L.W. Schaffner, Bulletin No. 411 (1957)"Some Irrigation Guides for North Dakota" and Bulletin No. 404 (1956), "An Economic Analysis of Proposed Irrigation in Northern North Dakota", North Dakota Agricultural Experimental Station NDAC, Fargo, North Dakota; T.S. Thorfinnson, Meryl Hunt and A.W. Epp., Bulletin No. 432 (1955) "Cost of Distribution of Irrigation Water by Different Methods", University of Nebraska College of Agriculture, The Agricultural Experimental Station, Lincoln.

would be more likely to proceed in this manner than to develop the whole farm at one time. There is also the possibility that some farmers would develop only a portion of their farm for irrigation with the rest of their farm devoted to dryland agriculture as at present.

There were two intermediate stages of development considered; 50 acres irrigated, 138 acres dryland and 100 acres irrigated with 88 acres dryland. It was assumed that $10,000 of operating capital was available and that no market existed for alfalfa hay. Plans III and X were included in this analysis so that a program with no irrigation and one with full irrigation could be compared with the two intermediate stages. In this way the four plans may be considered as four stages of development as shown below:

Plan III	0	acres	irrigated	200	acres	dryland
XV	50	"	"	138	"	"
XVI	100	"	"	88	"	"
X	153	"	"	35	"	"

4. Irrigation and dryland competing

In this analysis four rotations suitable for dryland farming and four rotations suitable for irrigation were allowed to compete for the available land and labor. The nine livestock enterprises used previously were also included in the program. The purpose was to find out whether irrigation would be more profitable at all levels of operating capital or whether there were some levels at which a farmer would find it more profitable to continue with his dryland program. The irrigated

programs required more capital and labor per acre so if one or both of these were limiting factors it would be possible to put more dryland than irrigated acres into production.

The manner in which this program was organized would allow 153 acres of land to be used for dryland rotations if this was more profitable or for an irrigation program if profits could be increased by doing so. Any combination between these two extremes was also possible. There were four levels of capital used. It was assumed that no market existed for alfalfa.

Plans XVII to XX were used to show how well irrigation would compete with dryland at different levels of capital:

Plan	XVII	no alfalfa	market	$4,000	capital
	XVIII	"	"	7,000	"
	XIX	"	"	10,000	"
	XX	"	"	15,000	"

Summary

Many plans need to be considered when analyzing farm reorganization problems in a new irrigation area. A farmer in such an area would want to examine his present situation and compare this with his optimum under dryland and irrigation farming. To do this he must consider the resources which he owns or controls, the alternatives which are available to him and then determine what type of program would maximize profits for him.

In the problem which was analyzed the farmer had a total of

240 acres, of which 200 acres were improved. Of these 200 acres, 153 of them were considered potentially irrigable. The operator estimated that he and his family would have 4375 hours of labor for the year and that he had 1176 square feet of barn space on his farm. There were twenty plans used to determine what his optimum allocation of resources would be under different conditions. The results of these plans are discussed in the following chapter.

CHAPTER V

RESULTS OF ANALYSIS - DRYLAND AND IRRIGATION

Method of Presenting Results

The results of the analysis are presented in four sections as outlined in the previous chapter on Analytical Procedure For Comparing Dryland and Irrigation Plans. In each section several plans are included, each of which represent maximum profit for the amount of operating capital shown and the assumptions made with respect to prices, yields, markets and enterprise alternatives.

In each of the four sections two tables are used to give the results of the twenty plans which were considered. One of these tables shows the rotations and livestock enterprises in each plan and also the level of these activities. This table also shows the total receipts from sale of crops and livestock products, the current operating expenses and the return to the family for their labor and fixed factors. The second table is concerned with resource use and shows the amount of the various inputs available and the amount used, sold and left over. It also shows how much crop was produced and purchased and how much of this was fed and sold.

In addition to the two tables in each section there are two more general tables which are used to summarize results of all the plans. Table XXII shows the return to labor and fixed capital as well as the amount of these two resources used in each plan. Table XXIII shows the debt repayment capacity of sixteen dryland and

irrigation plans using two time periods. The information presented in these two tables should be used with caution because of the problems encountered when trying to impute a value to labor and capital. It is difficult to know what the opportunity cost of these factors would be. However, consideration was given to labor and capital because of the difference in the amount of these inputs used under dryland and irrigation.

Tables 7 and 8 of the Appendix present the matrices used to analyze dryland and irrigation plans. The irrigation matrix was altered, when analyzing the stages of development, by adding four dryland rotations and adjusting the number of dryland and irrigation acres to the level desired. These same eight rotations were also used when dryland plans were allowed to compete with irrigation. In this analysis, however, only 153 acres of land were available and these could be used for either dryland or irrigation rotations.

1. Dryland Plans - No market for alfalfa

Table XIV shows the eight plans which were most profitable for dryland conditions. In Plans I to IV it is assumed that no market is available for alfalfa hay so if this product is produced it must be fed to livestock or allowed to go to waste. All resource supplies except capital, were held constant for these plans. That is, the number of acres, hours of labor, barn space were unchanged as increased amounts of operating capital were assumed. This implies that changes in these farm plans was the result of changes in operating

TABLE XIV

DRYLAND PLANS AND FINANCIAL SUMMARY

Enterprises in Plan	Level of Enterprise	Receipts $	Expenses $	Return to Labor and Fixed Factors
I Capital at $4,000 with no alfalfa market				
Rotation 4	200.0 ac.	-	2390.00	$-2390.00
Dairy	9.7 cows	2047.71	758.80	1288.91
Light feeders	6.47 steers	1489.97	699.28	790.69
Buy barley	174.63 bu.	-	151.92	- 151.92
Sell oats	52.68 "	31.61	-	31.61
" wheat	475.0 "	693.50	-	693.50
" flax	440.0 "	1460.80	-	1460.80
" sunflowers	175.0 cwt	787.50	-	787.50
" canning peas	300.0 "	1410.00	-	1410.00
" sweet corn	900.0 "	900.00	-	900.00
Total	-	$8821.09	$4000.00	$ 4821.09
II Capital at $7,000 - No alfalfa market				
Rotation 4F	200 ac.	-	2964.40	-2964.00
Dairy	9.7 cows	3047.71	758.80	1288.91
Light feeders	22.23 feeders	5114.39	2400.15	2714.91
Buy barley	599.39 bu.	-	521.47	-521.47
Sell wheat	620.0 "	905.20	-	905.20
" flax	440.0 "	1460.80	-	1460.80
" sunflowers	200.0 cwt	900.00	-	900.00
" peas	300.0 "	1410.00	-	1410.00
" corn	1050.0 "	1050.00	-	1050.00
Buy oats	582.26 bu.	-	355.18	-355.18
Total		$12888.10	$7000.00	$5888.10

TABLE XIV (CONTINUED)

Enterprises in Plan	Level of Enterprise	Receipts $	Expenses $	Return to Labor and Fixed Factors
III Capital $10,000 - No alfalfa market				
Rotation 4F	142.89 ac.	-	2117.92	-2117.92
Rotation 5F	57.11 ac.	-	948.15	- 948.15
Dairy	9.7 cows	2047.71	758.80	1288.91
Light feeders	39.33steers	9024.25	4235.08	4789.17
Buy oats	1672.0 bu	-	1019.92	-1019.92
" barley	1057.0 "	-	920.13	- 920.13
Sell wheat	797.05 "	1163.69	-	1163.69
" flax	377.17 "	1252.20	-	1252.20
" sunflowers	200.00 cwt	900.00	-	900.00
" peas	300.00 "	1410.00	-	1410.00
" corn	1050.00 "	1050.00	-	1050.00
Total		$16847.85	$10000.00	$6847.85
IV Capital $15,000 - No alfalfa market				
Rotation 4F	81.0 ac.	-	1200.51	-1200.51
Rotation 5F	119.0 ac.	-	1975.71	-1975.71
Dairy	7.16cows	1511.74	560.18	951.56
Light feeders	61.6steers	14144.72	6638.09	7506.63
Farrow and Feed hogs	58.7 hogs	1949.86	684.29	1265.57
Buy oats	3395.71 bu.	-	2071.38	-2071.38
" barley	2149.22 "	-	1869.84	-1869.84
Sell wheat	961.36 "	1403.59	-	1403.59
" flax	309.10 "	1026.21	-	1026.21
" sunflowers	200.0 cwt	900.00	-	900.00
" peas	300.0 "	1410.00	-	1410.00
" corn	1050.0 "	1050.00	-	1050.00
Total		$23396.12	$1500.00	$8396.12

TABLE XIV (CONTINUED)

Enterprises in Plan	Level of Enterprise	Receipts	Expenses	Return to Labor and Fixed Factors
V Capital at $4,000 - with alfalfa market				
Rotation 5F	200.0 ac	-	3320.40	-3320.40
Dairy	8.7 cows	1834.04	679.60	1154.44
Sell oats	877.83 bu.	526.70	-	526.70
" wheat	1240.0 "	1810.40	-	1810.40
" flax	220.0 "	730.40	-	730.40
" sunflowers	200.0 cwt	900.00	-	900.00
" canning peas	300.0 "	1410.00	-	1410.00
" sweet corn	1050.0 "	1050.00	-	1050.00
" alfalfa	1778.30 "	1315.94	-	1315.94
Total		$9577.48	$4000.00	$5577.48
VI Capital at $7,000 - with alfalfa market				
Rotation 5F	200.0 ac.	-	3320.40	-3320.40
Hogs - fed & farrowed	184.25 hogs	6121.82	2148.32	3973.50
Dairy	1.73 cows	364.91	135.22	229.69
Sell wheat	1153.49 bu.	1684.10	-	1684.10
" flax	220.0 "	730.40	-	730.40
" sunflowers	200.0 cwt	900.00	-	900.00
" canning peas	300.0 "	1410.00	-	1410.00
" corn	1050.0 "	1050.00	-	1050.00
Buy oats	87.89 bu.	-	53.61	- 53.61
" barley	1543.04 "	-	1342.45	-1342.45
Sell alfalfa	2196.19 cwt	1625.18	-	1625.18
Total		$13886.41	$7000.00	$6886.41

TABLE XIV (CONTINUED)

	Level of Enterprise	Receipts $	Expenses $	Return to Labor and Fixed Factors
VII Capital at $10,000 - with alfalfa market				
Rotation 5F	200.0 ac.	-	3320.40	-3320.40
Hogs farrowed and fed	224.21 hogs	7449.26	2614.19	4835.07
Winter hogs	1.67 "	56.13	29.73	26.40
Light Feeders	13.25 steers	2984.28	1400.56	1583.72
Sell wheat	1133.95 bu.	1655.57	-	1655.57
" flax	330.0 "	730.40	-	730.40
" sunflowers	200.0 cwt	900.00	-	900.00
" canning peas	300.0 "	1410.00	-	1410.00
" sweet corn	1050.0 "	1050.00	-	1050.00
" alfalfa	2003.72 "	1482.75	-	1482.75
Buy oats	1128.04 bu	-	688.11	-688.11
" barley	2237.95 "	-	1947.01	-1947.01
Total	-	$17718.39	$10000.00	$7718.39
VIII Capital at $15,000 - with alfalfa market				
Rotation 5F -	200.0 ac.	-	3320.40	-3320.40
Hogs farrowed and fed	224.21 hogs	7449.26	2614.19	4835.07
Winter hogs	1.67 "	56.13	29.73	26.40
Light feeders	43.21 steers	9729.51	4566.03	5163.48
Sell wheat	1133.95 bu.	1655.57	-	1655.57
" Flax	220.0 "	730.40	-	730.40
" sunflowers	200.0 cwt	900.00	-	900.00
" canning peas	300.0 "	1410.00	-	1410.00
" sweet corn	1050.0 "	1050.00	-	1050.00
" alfalfa	1334.08 "	987.22	-	987.22
Buy oats	3008.00 bu.	-	1834.88	-1834.88
" barley	3028.47 "	-	2634.77	-2634.77
Total		$23968.09	$15000.00	$8968.09

TABLE XV

RESOURCES AVAILABLE, USED AND LEFT OVER IN DRYLAND PLANS

	Spring Labor (hours)	Summer Labor (hours)	Fall Labor (hours)	Winter Labor (hours)	Winter Space (sq.ft)	Summer Space (sq.ft)	Land (ac)	Capital (dollars)	Alfalfa (cwt)	Oats (bu)	Barley (bu)	Wheat (bu)	Flax (bu)	Sun flowers (cwt)	Canning Peas (cwt)	Sweet corn (cwt)
Plan I Capital $4,000.																
Available	855	1170	1035	1315	1176	1165	200	4,000	750.0	800.0	174.63	475.0	440.0	175.0	300.0	300.0
Used	413.7	456.7	384.51	811.87	1165	1165	200	4,000	582.5	747.32	174.63	-	-	-	-	-
Sold	-	-	-	-	-	-	-	-	-	52.68	-	475.0	440.0	175.0	300.0	900.0
Left over	441.30	713.30	650.49	503.13	11.0	-	-	-	167.5	-	-	-	-	-	-	-
Plan II Capital - $7,000.																
Available	855	1170	1035	1315	1176	1165	200	7,000	1150.0	1757.46	599.39	620.0	440.0	200.0	300.0	1050.0
Used	483.05	538.25	400.5	990.69	1165	1165	200	7,000	1090.24	1757.46	599.39	-	-	-	-	-
Sold	-	-	-	-	-	-	-	-	-	-	-	620.0	440.0	200.0	300.0	1050.0
Left over	371.95	631.75	634.5	324.31	11.0	-	-	-	59.76	-	-	-	-	-	-	-
Plan III Capital $10,000.																
Available	855	1170	1035	1315	1176	1165	200	10,000	1478.40	2847.20	1057.62	797.05	377.17	200.0	300.0	1050.0
Used	554.32	650.13	414.55	1183.6	1165	1165	200	10,000	1478.40	2847.20	1057.62	-	-	-	-	-
Sold	-	-	-	-	-	-	-	-	-	-	-	797.05	377.17	200.0	300.0	1050.0
Left over	300.68	519.87	620.45	131.40	11	-	-	-	-	-	-	-	-	-	-	-
Plan IV Capital $15,000.																
Available	855	1170	1035	1315	1176	1165	200	15,000	1834.28	4570.90	2149.22	988.91	309.09	200.0	300.0	1050.0
Used	615.4	767.41	402.92	1196	1165	1165	200	15,000	1834.28	4570.90	2149.22	27.56	-	-	-	-
Sold	-	-	-	-	-	-	-	-	-	-	-	961.35	309.09	200.0	300.0	1050.0
Left over	239.60	402.59	632.08	119.00	11.0	-	-	-	-	-	-	-	-	-	-	-
Plan V Capital $4,000.																
Available	855	1170	1035	1315	1176	1165	200	4,000	2300.	1175.20	-	1240.0	220.0	200.0	300.0	1050.0
Used	376.14	578.41	345	671.47	1043.4	1043.4	200	4,000	521.7	297.37	-	-	-	-	-	-
Sold	-	-	-	-	-	-	-	-	1778.30	877.83	-	1240.0	220	200.0	300.0	1050.0
Left over	478.86	591.59	690.0	643.53	132.6	121.6	-	-	-	-	-	-	-	-	-	-

TABLE XV (CONTINUED)

	Spring Labor (hours)	Summer Labor (hours)	Fall Labor (hours)	Winter Labor (hours)	Winter Space (sq.ft)	Summer Space (sq.ft)	Land (ac)	Capital (dollars)	Alfalfa (cwt)	Oats (bu)	Barley (bu)	Wheat (bu)	Flax (bu)	Sun-flowers (cwt)	Canning Peas (cwt)	Sweet Corn (cwt)
Plan VI Capital $7,000.																
Available	855	1170	1035	1315	1176	1165	200	7,000.	2300.0	1263.09	1543.04	1240.0	220.0	200.0	300.0	1050.0
Used	295.21	530.9	268.95	357.72	1165	1165	200	7,000	103.8	1263.09	1543.04	86.51	-	-	-	-
Sold	-	-	-	-	-	-	-	-	2196.20	-	-	1153.49	220.0	200.0	300.0	1050.0
Left over	559.79	639.10	766.05	957.28	11.0	-	-	-	-	-	-	-	-	-	-	-
Plan VII Capital $10,000																
Available	855	1170	1035	1315	1176	1165	200	10,000	2300.0	2303.24	2237.95	1240.0	220.0	200.0	300.0	1050.0
Used	326.92	570.92	261.32	425.55	1176	1165	200	10,000	296.28	2303.24	2237.95	106.05	-	-	-	-
Sold	-	-	-	-	-	-	-	-	2003.72	-	-	1133.95	220.0	200.0	300.0	1050.0
Left over	528.08	599.08	773.68	889.45	-	-	-	-	-	-	-	-	-	-	-	-
Plan VIII Capital $15,000.																
Available	855	1170	1035	1315	1176	1165	200	15,000	2300.0	4183.20	3028.47	1240.0	220.0	200.0	300.0	1050.0
Used	447.8	691.8	291.46	758.35	1176	1165	200	15,000	965.92	4183.20	3028.47	106.05	-	-	-	-
Sold	-	-	-	-	-	-	-	-	1334.08	-	-	1133.95	220.0	200.0	300.0	1050.0
Left over	407.20	478.20	743.54	556.65	-	-	-	-	-	-	-	-	-	-	-	-

capital only. In Plans V to VIII it was assumed that there was a market for forage. In this case the alfalfa hay would be fed to livestock only if it was more profitable than selling it. Four levels of operating capital were assumed here also while other resources were held constant.

Plan I includes 200 acres of rotation 4 which includes wheat - oats - flax - sunflowers - canning peas - sweet corn, sweet clover (summer fallow) and alfalfa. This rotation was unfertilized and was more profitable at this low level of operating capital ($4,000). This is because profits were increased by seeding all acres to crop rather than seeding and fertilizing part of the available acreage and allowing remaining acres to lie idle. Rotation 4 had a low percentage of alfalfa and was more profitable at this level of capital when the alfalfa could not be sold.

The livestock program in Plan I consisted of ten dairy cows kept for cream and a small feeder enterprise of six steers. These ten cows and six steers consumed most of the alfalfa produced on the farm. Capital and barn space were the limiting resources.

In Plan II the level of operating capital was increased to $7,000. This plan included 200 acres of rotation 4F which was the same as that in Plan I except that wheat, oats, sunflowers, sweet corn and alfalfa were fertilized. Fertilizing these crops became profitable when capital was available to put all acres into production as well as a livestock program to make use of the forage.

The size of the livestock program was increased in this plan. There were still ten dairy cows but the feeding enterprise now consisted of twenty-two steers (305 day). These animals consumed all but three tons of the alfalfa produced on the farm. Capital and barn space were limiting resources in this plan. The barn space restricted the dairy enterprise but not the feeders.

In Plan III the operating capital was assumed to be $10,000 and includes 143 acres of rotation 4F and 57 acres of 5F. Rotation 5F was similar to 4F except the percentage of alfalfa was increased from 12.5% to 25 % and there was no sweet-clover summerfallow. With more operating capital available it was possible to buy more livestock to balance the larger amount of forage which was produced through rotation 5F.

The size of the dairy enterprise remained the same in this plan as the previous two but there were now 39 feeder steers (305-day). With this plan all the forage was consumed. Capital and barn-space were the limiting resources.

When the operating capital was increased to $15,000 as in Plan IV the acreage of rotation 5F was greater and acreage in rotation 4F was less. In this plan there were 119 acres of 5F and 81 acres of 4F.

The additional $5,000 of operating capital required caused another reorganization in the farm plan. In Plan IV the dairy enterprise was reduced to seven cows and the steer-feeding enterprise

increased to 62 steers. A third enterprise was also added which included fifty-eight hogs. Since these hogs were farrowed and fed to market on the farm, four sows would be required.

In the four plans which have been discussed the return to labor and fixed capital increased as more operating capital became available. It is however important to note that the return per added dollar decreased as capital was increased. In Plan I the marginal value productivity (MVP) per dollar was .46. This means that at this capital level each additional dollar of operating capital increased the return to labor and fixed factor by $.46. At the $7,000 level of operating capital the MVP per dollar decreased to $.35. The MVP per dollar was reduced to $.32 and $.31 respectively at the $10,000 and $15,000 levels of capital.

This decrease in the MVP per dollar may be explained by the fact that the first dollars were invested in the most profitable alternative which in this case was rotation 2 and dairy cows. As additional capital became available this was used to fertilize the crops but this meant a smaller return per dollar than bringing new acres into production. As these more profitable alternatives became restricted the opportunity to invest more money in them ceased and further capital increases had to be invested in other less profitable alternatives which were not restricted.

Dryland Plans with Market for Alfalfa

The same levels of resource was assumed in Plans V to VIII

as the first four plans decreased previously. The difference is that it was now assumed that alfalfa could be sold for $15.00 per ton.

In Plan V it was assumed that $4,000 of operating capital was available. This plan included 200 acres of rotation 5F which was high in forage and fertilized. The operating capital was first used to put all the available acres into production with the balance of the capital invested in dairy. There were approximately 89 tons of alfalfa sold.

The livestock program in this plan consisted of 9 dairy cows. This number of cows did not occupy all the barn space but the herd size was restricted by capital. Land and capital were the limiting resources in Plan V.

Plan VI assumed that $7,000 of operating capital was available and included 200 acres of rotation 5F. The additional $3,000 available for this plan was all used for expanding the livestock enterprises.

The livestock program in Plan VI consisted of two dairy cows and 185 hogs farrowed and fed to market. These results indicated a shift out of dairy and into hogs as the dairy enterprise was decreased from nine cows to two. Barn space and capital were the limiting resources.

With a further increase in capital to $10,000 as requested by Plan VII the cropping program remained the same but the farrow and feed hogs replaced the dairy and thirteen steers were added. 224 hogs

were marketed and fifteen sows were kept for breeding stock. In this plan the capital available for livestock was invested in hogs until the barn space was exhausted and the balance used for 305 day feeder steers.

In Plan VIII the operating capital was increased to $15,000 but no major reorganization occurred. The cropping program remained the same with 200 acres in rotation 5F and 224 hogs being marketed. The additional capital was therefore all used to increase the feeding enterprise from thirteen steers to forty-three steers. This was to be expected as the land and building space had been used up and the additional capital had to be invested in steers. It seems likely that further increases in capital would mean an increase in the feeder enterprise until labor or alfalfa hay become restricted.

In Plans V to VIII the return to labor and fixed factors decreased as the level of operating capital was increased. At the $4,000 level of capital the return per dollar invested was $.87 and decreased to $.36 when it was increased to $7,000. The return was $.25 at both the $10,000 and $15,000 levels. The reason for this was outlined for Plans I to IV. In this case farrow and feed hogs were more profitable than steers and operating capital was invested in hogs until barn space was exhausted. Capital was then invested in feeder steers. When the feeder steers were included in the program the return per dollar invested was lower and the MVP of capital dropped from $.36 to $.25.

2. Irrigation Program

Six plans were used to analyze the irrigation program. In Plans IX, X, and XI no market existed for alfalfa hay. Three levels of operating capital were assumed, $4,000, $10,000 and $15,000, but all other resource levels remained constant. In Plans XII, XIII and XIV the alfalfa hay could be sold for $15.00 per ton. These plans were the same as Plans IX, X and XI with respect to resource levels.

No market for alfalfa

In Plan IX the cropping program consisted of 85 acres in rotation I_2 and 35 acres in rotation 2. Rotation I_2 included sweet-clover, sugar beets, flax, sweet corn and wheat. Rotation 2 included 16.5% sweet clover and 16.5% alfalfa as well as wheat, oats, flax and sunflowers. There were 68 acres of irrigable land left unused.

The livestock program in Plan IX consisted of three dairy cows. These three cows used all the forage produced on 35 acres of rotation 2. Capital and land were the limiting resources at this lowest level of operating capital.

In Plan X the $10,000 of capital was sufficient to put all land into production. There were 153 acres of rotation I_2 and 35 acres of rotation 2F. At this higher capital level the fertilized dryland rotation entered the plan.

The livestock program in this plan concisted of four dairy cows and 129 hogs farrowed and fed to market. One more cow was added in this program to balance the additional forage produced by the

fertilized rotation. The balance of the operating capital was invested in hogs. This hog program would require about nine sows for breeding purposes.

In Plan XI the dryland cropping program remained the same as before but the irrigation program changed slightly. There were now 148 acres of rotation I_2 instead of 153 as in the previous plan and the other 5 acres were used for rotation I_8. This rotation has 33 per cent alfalfa as well as wheat, oats, flax , sweet corn and sugar beets.

In Plan XI it was assumed that $5,000 more of operating capital was available and most of this was used to expand the livestock program. There were 16 steers (on feed for 305 days), 193 farrow and feed hogs, 25 summer feeder hogs and 25 winter feeder hogs. This particular type of farm organization developed because several of the resources were exhausted. The investment steps which took place in this plan may be listed as follows:

a) capital was first invested in 153 acres of rotation I_2 and 35 acres of rotation 2F.

b) enough steers were purchased to use the alfalfa produced by rotation 2F.

c) farrow and feed hogs were increased until spring labor was finished.

d) winter and summer feeder hogs were purchased until barn space was exhausted.

e) balance of capital was used to purchase more 305-day steers.

f) a sufficient number of acres in rotation I_2 were replaced

by I_8 to provide these additional steers with the forage they required.

In Plans IX to XI the MVP of capital showed a pattern similar to that outlined previously for dryland plans. At the $4,000 level of operating capital the return per dollar was $.98. This was high and reflected the fact that there was still opportunity to invest more in irrigated land. Increasing profits by adding operating capital beyond the amount required in Plan IX was possible only by more intensive production and adding operating capital at a lower rate of return per dollar invested. This caused the MVP of capital to decrease to $.30 at the $10,000 level and to $.17 when it was assumed that $15,000 of operating capital was available.

Irrigation plans with market for alfalfa hay

Plan XII assumes that $4,000 was available for operating capital and this was all invested in crops. There were 90 acres of rotation I_2 and 35 acres of rotation 2. In this plan capital was very restricted and profits were increased by investing the money in an unfertilized dryland program first and the balance of the capital in an irrigation rotation which required the least capital per acre. There was 63 acres of irrigable land left unused because of this shortage of capital. None of the available capital was invested in livestock.

In Plan XIII the assumed level of capital was $10,000. This was sufficient for 153 acres of rotation I_8 and 35 acres of rotation 2F. The dryland acres shifted from unfertilized to fertilized rotations and rotation I_8 which was relatively high in forage replaced rotation I_2. The balance of the capital was invested in a hog enterprise which

TABIE XVI

IRRIGATION PLANS AND FINANCIAL SUMMARY

Enterprises in Plan	Level of Enterprise	Receipts	Expenses	Return to Labor and Fixed Factors
		$	$	$
IX Capital at $4,000 with no alfalfa market				
Rotation I_2	84.87 ac.	-	3482.18	-3482.18
Rotation 2	35.0 "	-	292.58	-292.58
Dairy	2.881 cows	607.94	225.24	+382.70
Sell oats	91.81 bu.	55.09	-	55.09
" wheat	812.47 "	1186.21	-	1186.21
" flax	350.92 "	1165.08	-	1165.08
" sunflowers	41.65 cwt.	187.42	-	187.42
" corn	1588.82 "	1588.82	-	1588.82
" sugar beets	249.52 ton	3281.29	-	3281.29
Total		$8071.85	$4000.00	$407.85
X - Capital at $10,000 with no alfalfa market				
Rotation I_2	153 ac.	-	6277.44	-6277.44
Rotation 2F	35 "	-	395.74	- 395.74
Dairy	4.12 cows	869.22	322.09	547.13
Hogs farrowed and fed	129.04 hogs	4287.37	1504.55	2782.82
Light feeders	.78 steers	174.81	82.04	92.77
Buy barley	1101.14 bu.	-	957.99	- 957.99
Buy oats	754.35 bu.	-	460.15	- 460.15
Sell wheat	1349.47 "	1970.23	-	1970.23
" flax	591.82 "	1964.88	-	1964.88
" sunflowers	47.60 cwt	214.20	-	214.20
" corn	1432.08 "	2864.16	-	1432.08
" sugar beets	449.82 ton	5915.13	-	5915.13
Total		$18260.00	$10000.00	$8260.00

TABLE XVI (CONTINUED)

Enterprises in Plan	Level of Enterprise	Receipts	Expenses	Return to Labor and Fixed Factors
		$	$	$
XI - Capital $15,000 - with no alfalfa market				
Rotation I_2	148.4	-	6088.97	-6088.97
Rotation I_8	4.6	-	208.82	- 208.82
Rotation 2F	35.0	-	395.74	- 395.74
Light feeders	16.23 steers	3745.12	1757.57	1987.55
Farrow and feed hogs	193.57 hogs	6428.27	2255.84	4172.43
Winter hogs	25.87 "	871.04	461.38	409.66
Spring hogs	24.21 "	814.55	431.65	382.92
Buy oats	2185.54 bu.	-	1333.18	-1333.18
" barley	2375.68 "	-	2066.85	-2066.85
Sell wheat	1278.15 "	1866.11	-	1866.11
" flax	584.25 "	1939.72	-	1939.72
" sunflowers	47.6 cwt	214.20	-	214.20
" corn	2824.01 "	2824.01	-	2824.01
" sugar beets	451.61 ton	5938.69	-	5938.69
Total		$24641.71	$15000.00	$9641.71
XII - Capital $4,000 - with alfalfa market				
Rotation I_2	90.36 ac.	-	3707.43	-3707.43
Rotation 2	35.0 ac	-	292.57	- 292.57
Sell wheat	857.92 bu.	1252.57	-	1252.57
" oats	190.37 "	114.22	-	114.22
" flax	370.34 "	1229.53	-	1229.53
" sunflowers	41.65 cwt	187.42	-	187.42
" corn	1691.58 "	1691.58	-	1691.58
" sugar beets	265.66 ton	3493.43	-	3493.43
" alfalfa	86.45 cwt	127.95	-	127.95
Total		$8096.70	$4000.00	$4096.70

TABLE XVI (CONTINUED)

Enterprises in Plan	Level of Enterprise	Receipts $	Expenses $	Return to Labor and Fixed Factors $
XIII - Capital - $10,000 - with alfalfa market				
Rotation I_8	153.0 ac.	-	6955.38	-6955.38
Rotation 2F	35.0	-	395.75	- 395.75
Dairy	.88 cows	185.56	68.77	116.79
Hogs farrowed and fed	136.19 hogs	4524.81	1587.87	2936.94
Sell wheat	758.60 bu.	1107.56	-	1107.56
" oats	632.25 "	379.35	-	379.35
" flax	339.53 "	1127.24	-	1127.24
" sunflowers	47.60 cwt	214.20	-	214.20
" corn	1526.94 "	1526.94	-	1526.94
" sugar beets	509.49 tons	6699.79	-	6699.79
" alfalfa	1888.35 cwt	2794.76	-	2794.76
Buy barley	1140.50 bu.	-	992.23	- 992.23
Total		$18560.21	$10000.00	$8560.21
XIV - Capital at $15,000 with alfalfa market				
Rotation I_8	153.0 ac.	-	6955.38	-6955.38
Rotation 2F	35.0 "	-	395.75	- 395.75
Hogs farrowed and fed	96.45 hogs	3204.46	1124.53	2079.93
Winter hogs	102.25 "	3443.76	1824.11	1619.65
Spring hogs	100.58 "	3386.12	1794.37	1591.75
Light feeders	6.88 steers	1578.01	740.55	837.46
Sell wheat	682.33 bu.	996.20	-	996.20
" flax	339.53 "	1127.24	-	1127.24
" sunflowers	47.60 cwt	214.20	-	214.20
" sugar beets	509.49 tons	6699.79	-	6699.79
" alfalfa	1836.46 cwt	2717.96	-	2717.96
" corn	1526.94 "	1526.94	-	1526.94
Buy barley	2275.07 bu	-	1979.31	-1979.31
" oats	304.92 "	-	186.00	- 186.00
Total		$24894.68	$15000.00	$9894.68

TABLE XVII

RESOURCES AVAILABLE, USED AND LEFT OVER IN IRRIGATION PLANS

	Spring Labor (hours)	Summer Labor (hours)	Fall Labor (hours)	Winter Labor (hours)	Winter Space (sq.ft)	Spring Space (sq.ft)	(acres) Land irrigated	(acres) Land dry	Capital (dollars)	Alfalfa (cwt)	Oats (bu)	Barley (bu)	Wheat (bu)	Flax (bu)	sun flowers (cwt)	Canning peas (cwt)	Sweet corn (cwt)	Sugar beets (tons)
Plan IX - Capital $4,000.																		
Available	855	1170	1035	1315	1176	1165	153	35	4,000	173.25	190.34	-	812.47	350.92	41.65	-	1588.82	249.52
Used	474.15	462.00	510.25	278.39	345.81	345.81	84.88	35	4,000	173.25	98.53	-	-	-	-	-	-	-
Sold	-	-	-	-	-	-	-	-	-	-	91.81	-	812.47	350.92	41.65	-	1588.82	249.52
Left over	380.85	708.00	524.75	1036.61	830.19	819.19	68.12	-	-	-	-	-	-	-	-	-	-	-
Plan X - Capital $10,000.																		
Available	855	1170	1035	1315	1176	1165	153	35	10,000	265.65	1032.81	1101.14	1410.05	591.82	47.60	-	2864.16	449.82
Used	849.62	813.38	919.05	527.41	1165	1165	153	35	10,000	265.65	1032.81	1101.14	60.58	-	-	-	-	-
Sold	-	-	-	-	-	-	-	-	-	-	-	-	1349.47	591.82	47.60	-	2864.16	449.82
Left over	5.38	356.62	115.95	787.59	11.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Plan XI - Capital $15,000.																		
Available	855	1170	1035	1315	1176	1165	153	35	15,000	371.80	2502.24	2375.68	1392.41	584.25	47.6	-	2824.01	451.61
Used	855	866.30	899.61	530.7	1176	1165	153	35	15000	371.80	2502.24	2375.68	114.26	-	-	-	-	-
Sold	-	-	-	-	-	-	-	-	-	-	-	-	1278.15	584.25	47.6	-	2824.01	451.61
Left over	-	303.70	135.59	784.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plan XII - Capital $4,000																		
Available	855	1170	1035	1315	1176	1165	153	35	4,000	86.45	190.36	-	857.92	370.34	41.65	-	1691.58	265.66
Used	443.85	443.84	478.57	92.74	-	-	90.36	35	4,000	-	-	-	-	-	-	-	-	-
Sold	-	-	-	-	-	-	-	-	-	86.45	190.36	-	857.92	370.34	41.65	-	1691.58	265.46
Left over	411.15	726.16	556.43	1222.26	1176	1165	62.64	-	-	-	-	-	-	-	-	-	-	-
Plan XIII - Capital $10,000.																		
Available	855	1170	1035	1315	1176	1165	153	35	10,000	3832.08	1552.19	1140.50	822.54	339.53	47.60	-	1526.94	509.49
Used	855	1003.23	944.07	295.39	813.21	813.21	153	35	10,000	52.79	919.94	1140.50	63.94	-	-	-	-	-
Sold	-	-	-	-	-	-	-	-	-	3779.29	632.25	-	758.60	339.53	47.60	-	1526.94	509.49
Left over	-	166.77	90.93	1019.61	362.79	351.79	-	-	-	-	-	-	-	-	-	-	-	-
Plan XIV - Capital $15,000.									1									
Available	855	1170	1035	1315	1176	1165	153	35	15,000	3832.08	1857.10	2275.07	822.54	339.53	47.6	-	1526.94	509.49
Used	855	1101.75	1013.22	475.88	1176	1165	153	35	15,000	156.66	1857.10	2275.07	140.21	-	-	-	-	-
Sold	-	-	-	-	-	-	-	-	-	3675.42	-	-	682.33	339.53	47.6	-	1526.94	509.49
Left over	-	68.25	21.78	839.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-

consisted of nine sows and 135 hogs farrowed and fed to market weight.

Plan XIV included the same cropping program as before, 96 hogs farrowed and fed to market, 100 winter feeder hogs and 100 summer feeder hogs. Spring labor was a limiting resource and this represented a more profitable combination of hogs, Land, barn space, capital and spring labor were limiting resources in this plan.

The return to labor and capital increased as more capital was added. In Plan XII this return was $4096.76 and increased to $8560.25 and $9894.71 in Plans XIII and XIV respectively. The MVP of capital was $.98, $.48 and $.16 as capital was increased from $4,000 to $10,000 and finally to $15,000.

A considerable shift occurred in the farm organization when the assumption with respect to the alfalfa market was changed. When the alfalfa could not be sold rotations which had less alfalfa were included in the plan and part of the capital was invested in a livestock program which would use the forage. This put dairy cows and feeders in a more favorable position relative to hogs. When the alfalfa could be sold the emphasis shifted to rotations which included forage.

2. Stages of Irrigation Development

The purpose of this section of the analysis was to see what changes occurred in farm organization and profits when a farm was developed for irrigation in stages. The results of four stages are shown in Table XVIII. In Plan III 200 acres were in dryland rotations with no irrigation. Plan XV shows what happened when 138 acres were in dryland and 50 acres in irrigation. In Plans XVI and X dryland acres decrease to

TABLE XVIII

RESULTS OF FOUR STAGES OF DEVELOPMENT
FROM DRYLAND TO IRRIGATION

Enterprises in Plan	Level of Enterprise	Receipts	Expenses	Return to Labor and Fixed Factors
		$	$	$
III - Dryland - 200 acres, Irrigation - 0				
Rotation 4F	142.89 ac.	-	2117.92	-2117.92
Rotation 5F	57.11 ac.	-	948.15	- 948.15
Dairy	9.7 cows	2047.71	758.80	1288.91
Light feeders	39.33 steers	9024.25	4235.08	4789.17
Buy oats	1672.0 bu.	-	1019.92	-1019.92
" barley	1057.0 "	-	920.13	- 920.13
Sell wheat	797.05"	1163.69	-	1163.69
" flax	377.17"	1252.20	-	1252.20
" sunflowers	200.00 cwt	900.00	-	900.00
" peas	300.00 "	1410.00	-	1410.00
" corn	1050.00 "	1050.00	-	1050.00
Total		$16847.85	$10000.00	$6847.85
XV - Dryland - 138 acres, - Irrigation - 50 acres				
Rotation I_2	50 ac.	-	2051.44	-2051.44
Rotation 2_F	138 ac.	-	1560.37	-1560.37
Dairy	6.69 cows	1410.70	522.17	887.99
Light feeders	28.19 steers	6469.99	3036.33	3433.66
Farrow and feed hogs	69.79 hogs	2317.78	813.38	1504.40
Sell wheat	945.94 bu.	1381.07	-	1381.07
" flax	377.18 "	1252.24	-	1252.24
" sunflowers	187.68 cwt	844.56	-	844.56
" corn	936.0 "	936.00	-	936.00
Buy oats	1389.87 bu.	-	847.82	-847.82
" barley	1342.47 "	-	1167.95	-1167.95
" sugar beets	147 tons	1933.05	-	1933.05
Total		$16545.39	$10000.00	$6545.39

TABLE XVIII CONTINUED

Enterprises in Plan	Level of Enterprise	Receipts	Expenses	Return to Labor and Fixed Factors
		$	$	$
XVI - Dryland - 88 acres - Irrigation - 100 acres				
Rotation I_2	100 ac.	-	4102.90	-4102.90
Rotation 2_F	88 ac.	-	995.02	- 995.02
Dairy	5.4 cows	1147.88	425.32	722.56
Light feeders	14.88 steers	3414.07	1602.21	1811.86
Farrow and feed hogs	113.47 hogs	3273.99	1148.89	2125.10
Sell wheat	1141.83 bu.	1667.07	-	1667.07
" flax	481.38 "	1598.18	-	1598.18
" sunflowers	119.68 "	538.56	-	538.56
" corn	936.0 cwt.	1872.00	-	1872.00
" sugar beets	294 ton	3866.10	-	3866.10
Buy oats	1081.36 bu.	-	659.63	-659.63
" barley	1225.32 bu.	-	1066.03	-1066.03
Total		$17377.85	$10000.00	$7377.85
X - Dryland - 35 acres - Irrigation - 153 acres				
Rotation I_2	153 ac.	-	6277.44	-6277.44
Rotation 2_F	35 ac.	-	395.74	-395.74
Dairy	4.12 cows	869.22	322.09	547.13
Farrow and feed hogs	129.04 hogs	4287.37	1504.55	2782.82
Light feeders	.78 steers	174.81	82.04	92.77
Buy barley	1101.14 bu.	-	957.99	-957.99
" oats	754.35 bu.	-	460.15	-460.15
Sell wheat	1349.47 "	1970.23	-	1970.23
" flax	591.82 "	1964.88	-	1964.88
" sunflowers	47.60 cwt.	214.20	-	214.20
" corn	1432.08 cwt.	2864.16	-	2864.16
" sugar beets	449.82 ton	5915.13	-	5915.13
Total		$18260.00	$10000.00	$8260.00

TABLE XIX

RESOURCES AVAILABLE, USED, SOLD AND LEFT OVER IN DEVELOPMENT PROGRAM

Resources	Spring Labor (hours)	Summer Labor (hours)	Fall Labor (hours)	Winter Labor (hours)	Winter Space (sq.ft)	Summer Space (sq.ft)	Irrigated land (ac)	Dryland (ac)	Capital dollars	Alfalfa (cwt)	Oats (bu)	Barley (bu)	Wheat (bu)	Flax (bu)	Sun flowers (cwt)	Canning Peas (cwt)	Sweet Corn (cwt)	Sugar Beets (tons)
Plan III - Irrigated - 0 acres, Dryland - 200 acres.																		
Used	554.32	650.13	414.55	1183.60	1165	1165	0	200	10,000	582.5	747.32	174.63						
Left over	300.68	519.87	620.45	131.40	11	-	0	-		167.5								
Plan XV - Irrigated - 50 Dryland - 138 acres																		
Available	855	1170	1035	1315	1176	1165	50	138	10,000	1047.42	2487.80	1342.47	978.69	377.17	187.68	-	936	147
Used	621.87	695.26	564.54	927.92	1165	1165	50	138	10,000	1043.58	2487.80	1342.47	32.75	-	-	-	-	-
Sold	-	-	-	-	-	-	-	-	-	-	-	-	945.94	377.17	187.68	-	936	147
Left over	233.13	474.74	470.46	387.08	11	-	-	-	-	3.84	-	-	-	-	-	-	-	-
Plan XVI - Irrigated - 100 Dryland - 88																		
Available	855	1170	1035	1315	1176	1165	100	88	10,000	667.92	1781.49	1225.32	1188.10	481.38	119.68	-	1872.0	294
Used	732.43	752.59	736.63	733.49	1165	1165	100	88	10,000	667.92	1781.49	1225.32	46.27	-	-	-	-	-
Sold	-	-	-	-	-	-	-	-	-	-	-	-	1141.83	481.38	119.68	-	1872.0	294
Left over	122.57	417.41	298.37	581.51	11	-	-	-	-	-	-	-	-	-	-	-	-	-
Plan X - Irrigated - 153 ac. Dryland - 35																		
Used	849.62	813.38	919.05	527.41	1165	1165	153	35	10,000	265.65	1032.81	1101.14	60.58	-	-	-	-	-
Left over	5.38	356.62	115.95	787.59	11	-	-	1	-	-	-	-	-	-	-	-	-	-

88 acres and 35 acres respectively and irrigation acres increase to 100 and 153 acres. In these four plans it was assumed that there was $10,000 of operating capital was available. It was also assumed that alfalfa could not be sold.

Plan III was discussed previously under the dryland section of the analysis. This plan included 143 acres in rotation 4F and 57 acres in rotation 5F. The livestock program consisted of 10 dairy cows and 39 feeder cattle. The return to labor and fixed factors was $6847.87.

In Plan XV there were 50 acres in an irrigated rotation I_2 and 138 acres in a dryland fertilized rotation 2F. There was no alfalfa included in rotation I_2 so that all the alfalfa in this cropping program was grown on dryland.

This change from a dryland program to one with fifty acres irrigated required a reorganization of the livestock enterprises. The dairy herd decreased from ten to seven and the feeder steers from thirty-nine to twenty eight. In this plan, however, there was a hog enterprise which consisted of five sows and approximately seventy-five hogs farrowed and fed to market weight. This shift from dairy and feeder cattle to hogs occurred primarily because of the smaller amount of forage produced with this cropping program.

The return to labor and fixed factors decreased from 6847.85 to 6545.39. This can be explained partly by the fact that twelve acres were taken out of production for canals and ditches. This would be higher than would likely be the case when only fifty acres are being irrigated.

If an adjustment is made to decrease these unproductive acres from twelve to four the profits would be increased by $120.24 to bring the total return to $6665.63. This is still lower than that of Plan III.

In Plan XVI there were 100 acres under irrigation and 88 in dryland. The same rotations were included in this plan as in the previous one but the acreage in rotation 2F was decreased to 88 and rotation I_2 was increased to 100. There was less alfalfa produced with this cropping program.

In this plan the trend towards more hogs and less dairy cows and feeders continued. Dairy cow numbers decreased from seven to five and feeders steers from twenty-eight to fourteen. The hog program expanded to eight sows and 120 hogs farrowed and fed to market. This shift in the livestock program was brought about partly because the production of alfalfa decreased as the number of acres in irrigation increased and fewer cattle were required to consume this forage. It was also caused partly by the fact that as the number of acres in irrigation increased the amount of operating capital required for the cropping program increased resulting in less capital left over for investing in livestock.

Plan X was the next stage and represented a full irrigation program. There were 153 acres in rotation I_2 and 35 acres in rotation 2F. The operating capital requirements for this cropping program was $6673.28. This compared to $5097.92, $3611.81, and $3056.07 for Plan XVI, XV and III respectively.

There was no feeder program included in Plan X and the dairy enterprise was reduced to four cows. The hog enterprise was relatively

more important and consisted of nine sows with 135 hogs being farrowed and fed to market. Because of the small amount of alfalfa produced on thirty-five acres of rotation 2F only four cows were required to consume this forage.

There was a slight drop in the return to labor and fixed factors when only fifty acres were developed for irrigation but the other plans showed an increase in returns as more acres were irrigated. In Plan III this return was $6848.85 and decreased to $6545.39 ($6665.63 after adjustment) in Plan XV. The return increased to $7377.85 ($7437.97 after adjustment for canals etc.) in Plan XVI and $8260.00 in Plan X. The MVP of capital was very similar in the four stages of irrigation development. In Plan III it was $.31 and the other three plans was $.30.

4. Irrigation and Dryland Competing

The purpose of this section of the analysis was to find out whether an irrigation program could compete with a dryland program at various levels of operating capital. It was assumed that 153 acres of land were available and could all be irrigated or allowed to remain in dryland depending on which of the two alternatives was more profitable. There were four levels of capital used and it was assumed that no market existed for alfalfa hay. Table XX gives the results of this analysis.

At the low capital level ($4,000) the program included thirty-five acres in rotation 2, eighty-five acres in rotation I_2 and three dairy cows. The thirty-five acres in the dryland program were not fertilized. There were thirty-three acres of land unused because operating

TABLE XX

PLANS AND FINANCIAL SUMMARY FOR 153 ACRES
IRRIGATION COMPETING WITH DRYLAND

Enterprises in Plan	Level of Enterprise	Receipts	Expenses	Return to Labor and Fixed Factors
XVII - Capital - $4,000		$	$	
Rotation I_2	84.87 ac.	-	3982.24	-3482.24
Rotation 2	35.00 ac.	-	292.53	- 292.53
Dairy	2.88 cows	607.90	225.23	382.67
Sell oats	91.81 bu.	55.09	-	55.09
" wheat	812.47 "	1186.21	-	1186.21
" flax	350.93 "	1165.09	-	1165.09
" sunflowers	41.65 cwt	187.42	-	187.42
" corn	1588.82 "	1588.82	-	1588.82
" sugar beets	249.53 ton	3281.32	-	3281.32
Total		$8071.85	$4000.00	$4071.85
XVIII - Capital - $7,000.				
Rotation I_2	130.93 ac.	-	5371.79	-5371.79
Rotation I_8	20.20 ac.	-	918.50	- 918.50
Rotation 2F	1.87 ac.	-	21.13	- 21.13
Dairy	8.08 cows	1704.64	631.65	1072.99
Sell wheat	1181.43 bu.	1724.89	-	1724.89
" flax	503.80 "	1672.60	-	1672.60
" sunflowers	2.54 cwt.	11.44	-	11.44
" corn	2652.59 "	2652.59	-	2652.59
" sugar beets	452.21 ton	5946.50	-	5946.50
Buy oats	93.32 bu.	-	56.93	- 56.93
Total		$13712.66	$7000.00	$6712.66

TABLE XX (CONTINUED)

Enterprises in Plan	Level of Enterprise	Receipts $	Expenses $	Return to Labor and Fixed Factors
XIX - Capital $10,000				
Rotation I_2	144.55 ac.	-	5930.62	-5930.62
Rotation I_8	8.45 ac.	-	384.27	- 384.27
Dairy	3.28 cows	692.39	256.56	435.83
Farrow and feed hogs	148.47 hogs	4930.61	1730.28	3200.33
Buy oats	1011.54 bu.	-	617.04	- 617.04
" barley	1242.78 "	-	1081.23	-1081.23
Sell wheat	1164.71 "	1700.47	-	1700.47
" flax	527.07 "	1749.88	-	1749.88
" corn	2790.28 cwt	2790.28	-	2790.28
" sugar beets	453.12 tons	5958.48	-	5958.48
Total		$17822.10	$10000.00	$7822.11
XX - Capital - $15,000				
Rotation I_2	132.83 ac.	-	5450.03	-5450.03
Rotation I_8	20.17 ac.	-	916.75	-916.75
Farrow and feed hogs	221.97 hogs	7371.15	2586.72	4784.43
Winter hogs	3.52 "	118.54	62.81	55.73
Summer hogs	1.85 "	62.42	33.09	29.33
Light feeders	20.64 steers	4735.17	2222.21	2512.96
Buy oats	2622.33 bu.	-	1599.62	-1599.62
" barley	2446.86 bu.	-	2128.77	-2128.77
Sell wheat	1082.72 "	1580.78	-	1580.78
" flax	507.75 "	1685.74	-	1685.74
" corn	2687.91 cwt	2687.91	-	2687.91
" sugar beets	457.68 ton	6018.56	-	6018.56
Total		$24260.27	$15000.00	$9260.27

TABLE XXI

RESOURCE USE WITH IRRIGATION AND DRYLAND COMPETING

	Spring Labor (hours)	Summer Labor (hours)	Fall Labor (hours)	Winter Labor (hours)	Winter Space (sq.ft)	Summer Space (sq.ft)	Irrigated land (ac)	Dryland (ac)	Capital dollars	Alfalfa (cwt)	Oats (bu)	Barley (bu)	Wheat (bu)	Flax (bu)	Sun flowers (cwt)	Canning Peas (cwt)	Sweet Corn (cwt)	Sugar Beets (tons)
Plan XVII - Capital - $4,000																		
Available	855	1170	1035	1315	1176	1165		153	4,000	173.25	190.36		812.47	350.93	41.65	-	1588.82	249.52
Used	474.15	462.0	510.24	278.39	345.81	345.81	84.87	35	4,000	173.25	98.55	-	-	-	-	-	-	-
Sold	-	-	-	-	-	-	-	-	-	-	91.81	-	812.47	350.93	41.65	-	1588.82	249.52
Left over	380.85	708.0	524.76	1036.61	830.19	819.19		33.13	-	-	-	-	-	-	-	-	-	-
Plan XVIII - Capital - $7,000																		
Available	855	1170	1035	1315	1176	1165		153	7,000	485.38	276.39	-	1181.43	503.80	2.54	-	2652.59	452.20
Used	855	793.6	924.82	657.48	969.79	969.79	151.13	1.87	7,000	484.89	276.39	-	-	-	-	-	-	-
Sold	-	-	-	-	-	-	-	-	-	-	-	-	-	503.80	2.54	-	2652.59	452.20
Left over	-	376.40	110.18	657.52	206.21	195.21	-	-	-	-	-	-	-	-	-	-	-	-
Plan XIX - Capital $10,000																		
Available	855	1170	1035	1315	1176	1165		153	10,000	197.04	1081.91	1242.78	1164.71	527.07	-	-	2790.28	453.12
Used	855	753.32	880.77	460.03	1165	1165			10,000	196.95	1081.91	1242.78	-	-	-	-	-	-
Sold	-	-	-	-	-	-	-		-		-	-	1164.71	527.07	-	-	2790.28	453.12
Left over	-	416.68	154.23	854.97	11.0	-			-	-	-	-	-	-	-	-	-	-
Plan XX - Capital $15,000																		
Available	855	1170	1035	1315	1176	1165		153	15,000	470.07	2790.21	2446.86	1189.40	507.75	-	-	2687.91	457.68
Used	855	831.88	869.88	540.63	1176	1165	153	-	15,000	470.07	2790.21	2446.86	106.68	-	-	-	-	-
Sold	-	-	-	-	-	-	-	-	-	-	-	-	1082.72	507.75	-	-	2687.91	457.68
Left over	-	338.12	165.12	774.37	-	-	-	-	-	-	-	-	-	-	-	-	-	-

capital was not sufficient.

In Plan XVIII the operating capital was increased to $7,000 causing changes in both the cropping and livestock programs. Almost all the acres were irrigated with 131 acres in rotation I_2 and 20 acres in rotation I_8. There was less than two acres in rotation 2F and for practical purpose could be considered as zero. The dairy enterprise increased in size from three cows to eight. There were enough acres in rotation I_8 to provide forage for these eight cows.

In Plan XIX all acres were irrigated with 145 acres in rotation I_2 and 8 acres in rotation I_8. The shortage of spring labor in this plan caused a shift out of dairy and into hogs. Fewer acres of rotation I_8 were therefore required to provide forage for the cows.

There were three dairy cows and 148 hogs farrowed and fed to market. There would then be ten sows in the breeding herd. The dairy cows use more spring labor than the hogs and because this was a limiting resource it was more profitable to replace enough dairy cows with hogs to permit all the capital to be invested.

In the final plan the cropping program is similar except that there were 133 acres in rotation I_2 and 20 acres in rotation I_8. A slight increase in acres of rotation I_8 was needed because capital was available in this plan to purchase feeder steers.

There was no dairy enterprise in Plan XX but the farrow and feed hogs were increased to the maximum permitted by barn space. Feeder steers were purchased with the balance of the capital. A small number of winter and summer feeder hogs were also included in the plan. This indi-

cated that if capital were increased beyond $15,000 these feeder hogs would gradually replace the farrow and feed hogs so that more steers could be purchased. The feeder hogs were included in the program primarily because they required no spring labor which was a limiting resource.

The returns to labor and fixed capital increased as the level of operating capital was increased. This return was $4071.85 at the $4,000 level of capital and $6712.66 at the $7,000 level. The returns increased to $7822.11 and $9260.27 at the $10,000 and $15,000 levels respectively. There was however a marked decrease in the return per dollar. The MVP of the operating capital was $.98 at the $4,000 level because there was opportunity to invest more money in crops. This return dropped to $.68 at the $7,000 level, $.34 at the $10,000 level and $.17 when there was $15,000 of operating capital available. The need to include summer and winter feeder hogs in the last plan because of the shortage of spring labor was the main reason for the return per dollar invested to drop from $.34 to $.17.

Returns to labor and capital

The returns to labor and capital for sixteen dryland and irrigation plans are shown in Table XXII. Plans XVII to XX were not included because only 153 acres were being considered in these and could therefore not be compared directly with Plans I to XVI. The following list provides information on the terms used in this table as well as the procedure followed in calculating the returns to these two factors.

1) Return to labor and capital is the amount remaining after

TABLE XXII

RETURNS TO LABOR AND CAPITAL FOR SIXTEEN DRYLAND AND IRRIGATION PLANS

Plan Number	Return to Labor and Capital	Depreciation Machinery & Buildings	Imputed Value of Capital	Return to labor	Return per hour of available labor	Hours Employed	Return per hour Employed	Imputed Return to Labor	Interest on Capital
I	$4821.09	$ 1107.00	$ 1918.68	$1795.41	$ .41	2066	$ .87	$2800.00	2.49%
II	5888.10	1107.00	1918.68	2862.42	.65	2412	1.19	"	5.41"
III	6847.85	1107.00	1905.18	3835.67	.88	2803	1.37	"	8.08"
IV	8396.12	1107.00	1890.18	5399.00	1.23	2982	1.81	"	12.43"
V	5377.48	1107.00	1905.18	2565.30	.59	1971	1.30	"	4.59"
VI	6886.41	1107.00	1849.68	3929.73	.90	1453	2.70	"	8.40"
VII	7718.39	1107.00	1828.68	4782.71	1.09	1585	3.02	"	10886"
VIII	8968.09	1107.00	1828.68	6032.41	1.38	2189	2.75	"	14.42"
IX	4071.85	1319.00	2426.68	326.17	.07	1725	.19	"	-
X	8260.00	"	2467.18	4473.82	1.02	3109	1.44	"	8.74"
XI	9641.71	"	2425.18	5897.53	1.35	3152	1.87	"	11.84"
XII	4096.70	"	2386.18	391.52	.09	1459	.27	"	-
XIII	8560.21	"	2426.68	4814.53	1.10	3098	1.55	"	8.87"
XIV	9894.68	"	2446.68	6129.00	1.41	3446	1.78	"	12.47"
XV	6545.39	1213.00	2054.18	3278.21	.75	2810	1.71	"	6.45"
XVI	7377.85	"	2203.18	5174.67	1.18	2955	1.75	"	7.98"

current operating expenses have been paid and is the return to operator and family labor and the capital invested in land and buildings. Interest on operating capital has been charged but depreciation on machinery and buildings has not been deducted.

2) Depreciation on machinery is taken from Table 6 of the Appendix. Under dryland conditions this amounted to $865.00 for machinery and $242.00 for buildings. Under irrigation the depreciation on machinery increased to $1077.00 while building depreciation remained the same.

3) Imputed value of capital - this was calculated by taking 5 per cent on the value of real estate and 6 per cent on the investment in machinery and breeding stock. For example in Plan I the imputed value of capital was ($27,600 x .05) + ($8978 x .06) = $1918.68.

4) Return to labor was calculated by adding the imputed value of capital and depreciation and subtracting this total from the return to labor and capital. In Plan I this was: $4821.09 - ($1107.00 + $1918.68) = $1795.41.

5) Return per hour of available labor was determined by dividing the return to labor by the total number of hours of labor available, which in this case was 4375 hours.

6) Hours employed was estimated by using the labor coefficients shown in Table 2 of Appendix and applying these to the activities included in each plan.

7) Return per hour employed - the return to labor was divided by the estimated number of hours worked.

8) Imputed return to labor - the operator's labor was valued at

$1,800.00 and the family labor at $1,00.00.

9) Interest on capital - the return to capital was calculated by adding together the imputed return to labor and depreciation and subtracting this total from the return to labor and capital. This return to capital was then expressed as a percentage of the investment in real estate, machinery and breeding stock.

In plans I to IV the return to labor (column 4 of Table XXII) increased from $1,795.41 at the $4,000 level of operating capital to $5399.00 at the $15,000 level. Thus number of hours employed indicated that there was a considerable amount of labor not used in all the dryland plans. This is indicated also by the fact that the return per hour employed (column 7) is higher than the return per hour of available labor. The interest earned on capital ranged from 2.49 per cent to 12.43 percent.

In Plans V to VIII the alfalfa could be sold and returns to labor and capital were higher and hours worked were fewer. This difference was smaller at higher levels of operating capital. The number of hours worked under Plan V was higher than in Plan VI or VII because of the shift from dairy cows to hogs and feeder cattle. This is reflected by the increase in the return per hour employed. The interest earned on capital ranged from 4.59 per cent to 14.42 per cent.

Plans IX, X and XI represent irrigation plans at three levels of capital and no market for alfalfa. The return to labor and capital is very low in Plan IX because the $4,000 of operating capital was not sufficient to put all the acres into production. The hours employed in

this plan were higher than in Plan VI or VII. This was indicated by the low returns per hour of labor available and employed. At the higher levels of operating capital the returns per hour of labor available are higher under irrigation than dryland. The returns per hour employed and the return to capital are very similar for dryland and irrigation program.

In Plan XII to XIV it was assumed that there was a market for alfalfa. The returns to labor and capital were higher when this assumption was made but the difference was smaller under irrigation than the dryland plans. The main reason for this was that one of the irrigation rotations had no alfalfa so the loss of a market for this product didn't present a big problem.

Plans XV and XVI represent two intermediate stages of irrigation development. Plan XV has 50 acres under irrigation and shows a decrease in return to labor and capital when compared to a dryland program. The return to labor in Plan III (dryland) was $3,835.67 and $3,278.21 with 50 acres irrigated. The hours employed under the two plans were very similar. As more acres were irrigated the returns increased steadily until all irrigable acres were developed.

Debt Repayment Capacity for Sixteen Dryland and Irrigation Plans.

In this section of the analysis the plans were assessed in terms of their ability to pay for the land over a 20-year and a 30-year payment period. This information is presented in Table XXIII for Plans I to XVI. An explanation of the terms used in this table was given in Chapter III on pages 45 and 46. Column III, the amount available for

TABLE XXIII

DEBT REPAYMENT CAPACITY FOR PLANS I TO XVI

UNIT $

Plan Number	Return to Labor and Capital	Repayment of Machinery	Available* for Land Payment	Land and Buildings Investment	Annual Payments	
					20-year	30-year
I	4821.09	914.06	1907.03	27,600	2214.62	1795.38
II	5888.10	914.06	2974.04	27,600	"	"
III	6847.85	914.06	3933.79	"	"	"
IV	8396.12	914.06	5482.06	"	"	"
V	5577.48	914.06	2663.42	"	"	"
VI	6886.41	914.06	3972.35	"	"	"
VII	7718.39	914.06	4804.33	"	"	"
VIII	8969.09	914.06	6055.03	"	"	"
IX	4071.85	1185.87	885.98	37,450	3004.99	2436.12
X	8260.00	1185.87	5074.13	"	"	"
XI	9641.71	1185.87	6455.84	"	"	"
XII	4096.70	1185.87	910.83	"	"	"
XIII	8560.21	1185.87	5374.34	"	"	"
XIV	9894.68	1185.87	6708.81	"	"	"
XV	6545.39	995.64	3549.75	30,100	2415.20	1957.97
XVI	7377.85	1090.75	4287.10	32,600	2615.73	2120.53

* $2,000.00 were allowed for living expenses.

land payment can be compared with columns 5 and 6 to determine whether the plan will permit paying for the real estate over a period of 20 or 30 years.

In Plan I, out of the eight dryland plans presented in Table XXIII, it would be difficult to pay for the investment in real estate. The amount available for land payment ($1,907.03) is less than the annual payment ($2,214.62) required to pay for the land over a 20-year period. It is slightly higher than the annual payment when the repayment period is increased to 30 years. In the other dryland plans the returns would seem to be adequate to pay the investment in real estate in either the 20 or 30 year period.

Plans IX to XII represent the six irrigation plans. Of these six plans it would seem that Plans IX and XII would yield returns too small to pay for the investment in real estate in either a 20-year or a 30-year period. The other four plans are satisfactory in this respect.

Two things seem to stand out as being critical when trying to determine whether the returns from any particular plan are sufficient to repay a 20 or 30 year mortgage. The first is the level of living costs. In this analysis $2,000.00 was allowed for living costs. If this cost increases there is that much less money left over for debt repayment. The second point which appears critical is the assumption made with respect to land values under irrigation condition. If land prices increase considerably over those used in this study ($150.00 per acre) repayment would be more difficult. Using Plan X as an example, if the price of irrigation land increased to $300.00 per acre the annual payment required to pay

for the investment in 20 years would be $4845.81. At this level of land prices the returns from Plan X would be just sufficient to make the annual payment.

CHAPTER VI

SUMMARY AND CONCLUSIONS

An irrigation project is being proposed for the Morden-Winkler area in South-central Manitoba which could make irrigation water available for approximately 20,000 acres. The main purpose of this research study was to determine the effect it would have on farms in the area in terms of changes in farm organization and in returns to labor and capital.

Two surveys were made in the area to obtain information on capital investment, receipts, expenses, land-use and farm practices used. On the basis of this information fourteen farms of similar size and type were selected from the modal groups and were used to develop a case farm. This case farm was 240 acres in size with 200 acres suitable for cultivation. It was estimated that 153 acres on this farm would be suitable for surface irrigation. Surface irrigation was used in the analysis because the costs seemed to be considerably lower than with a sprinkler system[1]. A comparison of these costs is shown in Appendix Table 7.

The procedure used in this study involved a budgetary

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[1]This cost of the sprinkler irrigation system was based largely on discussions with Professor Herbert M. Lapp of the University of Manitoba, and representatives of Perma Underground Irrigation System Ltd. of Winnipeg.

analysis as well as linear programming. Both methods were used so that a comparison of the two methods could be made. The objectives of the study were to:

1. determine optimum dryland programs with varying levels of capital
2. determine optimum irrigation programs using different levels of capital.
3. find out which irrigation programs would compete with dryland programs at different levels of capital.
4. determine the effect on farm organization and income if irrigation development proceeded in stages.
5. indicate the importance of an alfalfa market to farm income.
6. compare the results from a budgetary analysis of the problem with results obtained by using the linear programming technique.

The Dryland Program - no market for alfalfa

At low levels of operating capital the optimum program consisted of an unfertilized rotation relatively low in forage, ten dairy cows and six steers. Under these conditions it was more profitable not to fertilize so that limited capital could be used to put more acres into production and establish a livestock program which could make use of the forage. Captial was invested in dairy

cows until barn space was limiting and the balance in 305-day feeder steers.

As capital was increased fertilizer was used on those crops for which it was recommended and the steer enterprise was expanded until operating capital was exhausted. The expansion of the feeder enterprise created a need for more forage and caused a shift to a rotation with a higher percentage of forage. At the $15,000 level of capital money was available to buy enough steers to use up most of the forage. When this happened the dairy cows were gradually replaced by hogs farrowed and fed to market on the farm.

With a market for alfalfa.

When it was assumed that alfalfa could be sold the cropping program remained the same at all levels of capital and consisted of a fertilized rotation relatively high in forage. At low levels of capital the dairy enterprise was more profitable but this was soon replaced by hogs farrowed and fed to market. The hog program was expanded as much as barn space would permit and the balance of the capital was invested in feeder steers.

In the eight dryland plans which were analyzed the returns to labor varied from $1,795 at the lowest level of operating capital ($4,000) to $6032 at the $15,000 level. The return per hour of available labor ranged from $.41 to $1.38 and the return to capital from 2.49% to 14.42%. The return to labor was about $800 higher when the alfalfa would be sold. In general the plans indicated that

a relatively good return to labor and investment could be realized under dryland conditions.

Irrigation Programs - no market for alfalfa.

When it was assumed that no cash market existed for alfalfa the wheat-flax-corn-sweet clover-sugar beets rotation was the most profitable cropping program on irrigated land at all levels of operating capital. On the thirty-five acres which remained in dryland rotation 2(unfertilized) was the most profitable at the lowest level of capital but was fertilized at all other levels.

At low levels of capital the livestock program consisted of nine dairy cows but these were replaced by hogs farrowed and fed to market when capital increased. This hog enterprise was expanded until spring labor was no longer available and winter and summer feeder hogs were purchased to use the balance of the barn space. The balance of the capital was invested in 305 day feeder steers.

With market for alfalfa.

When a cash market of $15.00 per ton was assumed for alfalfa hay, the alfalfa-corn-sugar beets-wheat-oats-flax rotation (I_8) was most profitable at all levels of capital. The cropping program on the dryland was the same as it was when no alfalfa market existed.

The livestock program consisted entirely of hogs. The capital was first used to put all acres into production and the balance was invested in hogs farrowed and fed to market until spring

labor was exhausted. When this occurred the capital was invested in winter and summer feeder hogs.

The six irrigation programs which were analyzed indicated that the returns to labor were low when operating capital was very limited. At the $4,000 level of operating capital almost one-half of the irrigable acres were not in production because capital was insufficient. Under these conditions the return to labor was $326.17 or $.07 per hour of available labor. At the higher levels of capital, however, the return to labor varied from $4473.80 to $6129.00. When measured in terms of return per hour of available labor this varied from $1.02 to $1.41.

On the basis of the information provided by the fourteen plans the returns to labor were higher under irrigation than dryland. This difference was larger when it was assumed that no market existed for alfalfa. Under these conditions the returns to labor was $638.13 higher under irrigation than dryland at the $10,000 level of capital. This program required 306 more hours of work but the return per hour worked increased from $1.37 to $1.44. At the $15,000 level of capital the difference was very much the same.

When it was assumed that alfalfa could be sold the difference between dryland and irrigation was smaller. At the $10,000 level the returns to labor increased only by $31.82 but the return per hour employed dropped from $3.02 to $1.55. This was partly because of the low labor requirements of the dryland program when the alfalfa was

sold and hogs were substituted for dairy. The difference was slightly more favorable for irrigation at higher levels of capital.

Stages of Irrigation Development

A comparison of Plans III, XV, XVI and X indicated that returns were increased as a farm approached a full irrigation program but at the early stages returns were lower. This drop in income in the initial stages of development occurred partly because the capital requirements of the dryland cropping program was considerably less and left more capital available to develop a larger livestock enterprise. There were also certain investments which had to be made regardless of the number of acres irrigated. As more acres were developed these fixed costs were spread over more acres.

Dryland Programs Competing with Irrigation

At low levels of operating capital there was both dryland and irrigation rotations in the program but as capital was increased to $7,000 and up all acres were irrigated. With very limited capital ($4,000 and less) it seemed to be more profitable to include at least a partial dryland program because the operating capital requirements were less per acre and more acres could then be put into production.

Linear Programming and Budgeting Results Compared

It was difficult to make a close comparison of the budgets presented in Chapter III and the various plans computed by linear

programming because of different levels of capital. Using the two methods, however, indicated several important points:

1. the use of linear programming provided a much clearer insight into the problems which could be expected when changing from a dryland program to irrigation. This was because of the larger number of alternatives considered with varying levels of operating capital and assumptions made with respect to markets.
2. both methods indicated that profits were increased by changing to irrigation. In making this comparison the budgets were compared to the linear programming plans which assumed no market for alfalfa.
3. the returns to labor calculated by the two methods were quite similar. When adjustments were made to make perquisites (which were included in receipts in the budgets) and capital comparable the returns were higher using linear programming.
4. both methods indicated that a farrow and feed hog enterprise and dairy cows would be the most profitable livestock program to integrate with dryland and irrigation plans when the alfalfa was not sold. In Budgets VII and IX the capital requirements were over $17,000. If the capital were decreased to compare with the other two, and the size of the program

decreased accordingly, the feeder steers and feeder hogs would be less profitable.

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APPENDIX

TABLE 1

LABOR SUPPLY: BREAKDOWN OF FOUR SEASONS

Spring	- April 15 to June 15	-	54 days
Summer	- June 16 to August 15	-	52 days
Fall	- August 16 to October 31	-	66 days
Winter	- November 1 to April 14	-	140 days

	Operator	Family[1]	Total
Spring	54 x 10 = 540 hours	315 hours	855
Summer	52 x 10 = 520 hours	650 hours	1170
Fall	66 x 10 = 660 hours	375 hours	1035
Winter	140 x 6 = 840 hours	475 hours	1315
	2560 "	1815 "	4375 hours

[1]Family labor includes wife and son and is equivalent to approximately .67 man years (8 mos.)

TABLE 2

LABOR REQUIREMENT FOR CROPS AND LIVESTOCK BY SEASON

Crops (dryland)	Spring	Summer	Fall	Winter	Total
Wheat	1.24	.30	1.27	.66	3.47
Oats	1.24	.30	1.27	.66	3.47
Barley	1.24	.30	1.27	.66	3.47
Flax	1.24	.30	1.27	.66	3.47
Rye	.13	.90	.98	.66	2.67
Buckwheat	1.24	.30	1.27	.66	3.47
Alfalfa (unfertilised)	.06	6.67	.09	.21	7.03
Sweet clover	.06	1.31	.40	.21	1.98
Alfalfa (fertilised)	.23	7.33	.09	.21	7.86
Sunflowers	1.60	1.42	1.22	.66	4.90
Corn silage	1.60	1.42	1.50	.21	4.73
Canning corn	1.61	1.42	.40	.21	3.64
Canning peas	.94	.07	.40	.21	1.62
Irrigated Crops					
Wheat, oats and flax	4.02	2.18	2.29	.94	9.43
Alfalfa	2.59	5.87	2.00	.21	10.67
Sugar beets	10.52	12.29	18.32	1.08	42.21
Canning corn	4.26	3.56	.25	.96	9.03
Sweet clover	.06	1.31	1.90	.21	3.48
Labor Requirements for Livestock (hours)					
Weanling pigs	.22	.22	.27	.62	1.32
Farrow and feed hogs	.54	.54	.67	1.485	3.23
Winter feeder hogs	-	-	-	1.88	1.88
Summer feeder hogs	-	.94	.94	-	1.88
Beef-cow-calf	4.30	2.20	3.84	13.64	23.62
Feeders (305-day)	4.09	4.09	1.05	11.23	20.49
Summer feeders	.94	3.78	4.72	-	9.44
Winter feeders	-	-	-	9.44	9.44
Dairy	19.2	14.4	20.4	66.0	120.00

TABLE 3

CROP YIELDS

Crop	Dryland (Unfertilized)	Dryland (Fertilized)	Irrigation
Wheat	19.0	24.8	40
Oats	32.0	46.8	75
Flax	8.8	-	17
Rye	17	-	-
Buckwheat	14	-	-
Sunflower	700 #	800 #	-
Alfalfa	1.5 ton	2.3 ton	3.5 ton
Sugar beets	-	-	15 ton
Canning peas	1 ton	-	-
Canning corn	3 ton	3.5 ton	4.5 ton

TABLE 5

COST OF ITEMS USED FOR PRODUCTION

Commodity	Unit	Price
Seed		
Wheat	ac.	2.40
Oats	"	1.60
Flax	"	2.35
Rye	"	1.35
Buckwheat	"	1.25
Sugar beets	"	2.20
Sunflowers	"	1.50
Potatoes	"	30.00
Canning peas	"	30.00
Canning corn	"	2.80
Fertilizer		
11-48-0	ton	105.60
16-20-0	"	78.10
0-47-0	"	75.00
14-14-0	"	82.15
Dryland per acre	ac.	100.00
Irrigation land	"	150.00
Cost of development		40.00
Water cost (O & M per acre)	"	4.00
Taxes dryland	"	1.15
Artificial insemination		6.00
Taxes irrigation	"	2.00
Feeder steers 700 #		20.00
405 #		21.71
Replacement cost (dairy)	year	20.00
(beef)	"	10.00
Soybean oil meal	ton	90.00
Meat meal	"	100.00

TABLE 4

PRICES RECEIVED FOR PRODUCTS SOLD (1957-61 ave.)

Commodity	Unit	Price
Wheat (2 & 3N)	bu	1.46
Oats No. 1F.	"	.60
Flax 1. C.W.	"	3.32
Sunflowers	cwt	4.50
Rye	bu	.98
Buckwheat	"	1.00
Alfalfa	ton	15.00
Canning corn	"	20.00
Canning peas	"	80.00
Potatoes (field-run)	bu	1.10
Sugar beets	"	13.15
Pasture rent	ac	6.00
Steers (1050 # choice)	cwt	21.75
Feeders 405 #	"	21.71
Market hogs (50% A and 50% B)	cwt dressed	22.14
Weanling hogs (20 #)		9.00
Veal calves	cwt	23.39
Cream	(lb. B.F.)	.64

TABLE 6

MACHINERY COMPLEMENT FOR 240 AC. - 200 IMPROVED

Machine	Size	Present Value	Dep. Rate	Depreciation
1. Tractor	3 pl.	$1874.	15	$ 281.00
2. Car		621.	15	93.00
3. Truck		363.	15	54.00
4. Combine	10'	1050.	12	126.00
5. Swather	10'	380.	12	46.00
6. Plow	3 - 14"	223.	12	27.00
7. One-way	7'	130.	12	16.00
8. Drill	42"	300.	12	36.00
9. Harrow	5 (sec.)	48.	12	6.00
10. Cultivator (faw crop)	7'	100.	15	15.00
11. Cultivator	10'	163.	15	24.00
12. Power mower	7'	204.	12	25.00
13. Rake	10'	100.	12	12.00
14. Planter		200.	12	24.00
15. Miscellaneous		860.	10	80.00
16. Tools		172.		
		$6728.		$865.00

Additional Equipment for Irrigation

Two-way plow	-	$ 600.00
Ditcher	-	250.00
Leveller	-	800.00
Siphons, tubes, etc.		350.00
		$2000.00

TABLE 7

ANNUAL COST OF SPRINKLER AND SURFACE IRRIGATION ON 160 ACRES

Items of cost	Sprinker	Surface
1. Interest and Depreciation[a]	$1599.93	$ 330.00
2. Repairs	127.00	160.00
3. Fuel and oil	580.00	-
4. Labor cost	480.00	480.00
5. Water rate	640.00	440.00
6. Weed control and draining of ditches	-	16.00
7. Annual levelling and ditching	-	120.00
8. Equipment-dams, shovels	-	150.00
9. Loss of crop area	-	320.00
Total cost	$3426.93	$2016.00
Cost per acre	21.42	12.60

[a]Investment in pumping unit, pipes, sprinklers, etc. was $14,204.14 of $85.57 per acre

TABLE 8

IRRIGATION FARM - WINKLER - IRRIGABLE-153, DRYLAND - 35
WASTE-12

Net Price			-41.029	-43.474	-39.54	-45.46	-8.358	-11.307	5.171	14.377
Resource		Level	Rotation I_1 ac	Rotation I_4 ac	Rotation I_5 ac	Rotation I_8 ac	Rotation 2 ac	Rotation 2F ac	Weanling hogs hog	Farrow and feed hogs cwt (dr)
Spring labor	(hrs)	855	4.559	4.649	4.228	5.008	.911	.939	.22	.191
Summer labor	"	1170	4.251	5.31	4.535	5.804	1.706	1.815	.22	.191
Fall labor	"	1035	4.939	4.508	4.489	5.523	.922	.922	.27	.239
Winter labor	"	1315	.828	.72	.743	.729	.512	.512	.62	.528
Building space (summer)	(sq.ft)	1176	-	-	-	-	-	-	2.9	3.464
Building space (winter)	"	1165	-	-	-	-	-	-	2.9	3.464
Land irrigation	(ac)	153	1.	1.	1.	1.	1.	1.	-	-
Land dry	"	35	-	-	-	-	1.	1.	-	-
Capital	dollars	4000	41.029	43.474	39.54	45.46	8.358	11.307	3.829	7.773
Alfalfa	cwt	0	-	-11.65	-5.84	-11.65	-2.47	-3.78	-	-
Oats	bu	0	-	-12.45	-	-8.325	-5.439	-7.956	2.655	4.356
Barley	"	0	-	-	-	-	-	-	2.054	5.583
Wheat	"	0	-8.28	-6.68	-6.68	-4.44	-3.135	-4.092	.029	.313
Flax	"	0	-3.536	-	-2.839	-1.887	-1.452	-1.452	-	-
Sunflowers	cwt	0	-	-	-	-	-1.19	-1.36	-	-
Corn (sweet)	"	0	-9.36	-7.51	-7.51	-4.99	-	-	-	-
Sugar beets	tons	0	-2.94	-2.505	-2.505	-3.33	-	-	-	-

TABLE 8 (CONTINUED)

Net Price			10.56	10.55	9.299	11.52	7.048	7.047	13.277	.60
Resource		Level	Winter hogs cwt	Spring hogs cwt	Cow-calf calf	Light Feeders cwt live	Summer Feeders cwt live	Winter Feeders cwt live	Dairy 25 # BF.	Sell Oats bu
Spring labor (hrs)		855	-	-	1.075	.389	.089	-	1.92	-
Summer labor	"	1170	-	.625	.548	.389	.359	-	1.44	
Fall labor	"	1035	-	.625	.868	.097	.449	-	2.04	
Winter labor	"	1315	1.251	-	3.407	1.071	-	.898	6.6	
Building space (summer)	(sq.ft)	1176	4.4	-	19.68	-	-	-	12	
Building space (winter)	"	1165	-	4.4	19.68	-	-	-	12	
Land irrigation	(ac)	153	-	-	-	-	-	-	-	
Land dry	"	35	-	-	-	-	-	-	-	
Capital	dollars	4000	11.893	11.893	10.245	10.187	14.728	14.728	7.816	0
Alfalfa	cwt	0	-	-	4.92	1.077	.781	.781	3	
Oats	bu	0	2.587	2.587	-	6.05	4.11	4.11	3.42	1.
Barley	"	0	4.215	4.215	-	2.544	1.95	1.95	-	
Wheat	"	0	.312	.312	-	-	-	-	-	-
Flax	"	0	-	-	-	-	-	-	-	-
Sunflowers	cwt	0	-	-	-	-	-	-	-	-
Corn (sweet)	"	0	-	-	-	-	-	-	-	-
Sugar beets	tons	0	-	-	-	-	-	-	-	-

TABLE 8 (CONTINUED)

Net Price			1.46	3.32	4.50	2.00	-.61	-.87	1.48	13.15
Resource		Level	Sell Wheat bu	Sell Flax bu	Sell Sunflowers cwt	Sell Corn cwt	Buy Oats bu	Buy Barley bu	Sell Alfalfa cwt	Sell Sugar beets ton
Spring labor (hrs)		855								
Summer labor	"	1170								
Fall labor	"	1035								
Winter labor	"	1315								
Building space (summer)	(sq.ft)	1176								
Building space (winter)	"	1165								
Land irrigation	(ac)	153								
Land dry	"	35								
Capital	dollars	4000	0	0	0	0	.61	.87	0	0
Alfalfa	cwt	0					-1.		1.	
Oats	bu	0					-1.			
Barley	"	0						-1.		
Wheat	"	0	1.							
Flax	"	0		1.						
Sunflowers	cwt	0			1.					
Corn (sweet)	"	0				1.				
Sugar beets	tons	0								1

TABLE 9

INPUT - OUTPUT COEFFICIENTS USED FOR 200 ACRE DRYLAND FARM

Net Price			-8.350	-11.310	-11.950	-14.822	-12.684	-16.602	5.171	14.377
Resource		Level	Rotation 2 ac.	Rotation 2F ac.	Rotation 4 ac.	Rotation 4F ac.	Rotation 5 ac.	Rotation 5F ac.	Weaning hogs hog.	Farrow and feed hogs cwt.
Spring labor	(hrs.)	855	.911	.939	1.003	1.025	1.003	1.046	.22	.191
Summer labor	"	1170	1.706	1.815	1.451	1.534	2.094	2.266	.22	.191
Fall labor	"	1035	.922	.922	.899	.898	.838	.838	.27	.239
Winter labor	"	1315	.512	.512	.488	.488	.488	.488	.62	.528
Winter space	(sq.ft)	1176	-	-	-	-	-	-	2.9	3.464
Summer space	"	1165	-	-	-	-	-	-	2.9	3.464
Land	ac	200	1.	1.	1.	1.	1.	1.	-	-
Capital	$	4000	8,350	11,310	11.950	14.822	12.684	16.602	3.829	7.773
Alfalfa	cwt	0	-4.95	-7.59	-3.75	-5.75	-7.5	-11.5	-	-
Oats	bu.	0	-5.439	-7.956	-4.	-5.876	-4.	-5.876	2.655	4.356
Barley	"	0	-	-	-	-	-	-	2.054	5.583
Wheat	"	0	-3.135	-4.092	-2.375	-3.1	-4.75	-6.2	.029	.313
Flax	"	0	-1.452	-1.452	-2.2	-2.2	-1.1	-1.1	-	-
Sunflowers	cwt	0	-1.19	-1.36	-.875	-1.	-.875	-1.	-	-
Canning peas	"	0	-	-	-1.5	-1.5	-1.5	-1.5	-	-
Canning corn	"	0	-	-	-4.5	-5.25	-4.5	-5.25	-	-

TABLE 9 (CONTINUED)

Net Price			10.558	10.556	9.299	11.52	7.048	7.047	13.277	.60
Resource		Level	Winter hogs	Summer hogs	Cow-calf	Light Feeders	Summer Feeders	Winter Feeders	Dairy	Sell Oats
			cwt	cwt.dr.	cwt	cwt	cwt	cwt	25# B.F.	bu
Spring labor (hrs)		855	-	-	1.075	.389	.089	-	1.92	-
Summer labor	"	1170	-	.625	.548	.389	.359	-	1.44	
Fall labor	"	1035	-	.625	.868	.097	.449	-	2.04	
Winter labor	"	1315	1.251	-	3.407	1.071	-	.898	6.6	
Winter space(sq.ft)		1176	4.4	-	19.68	-	-	-	12.	
Summer "	"	1165		4.4	19.68	-	-	-	12.	
Land	ac	200	-	-	-	-	-	-	-	
Capital	$	4000	11,893	11.893	10.245	10.187	14.728	14.728	7.816	
Alfalfa	cwt	0	-	-	9.84	2.155	1.562	1.562	6.	
Oats	bu	0	2.587	2.587	-	6.05	4.11	4.11	3.42	1.
Barley	"	0	4.215	4.215	-	2.544	1.95	1.95	-	
Wheat	"	0	.312	.312	-	-	-	-	-	
Flax	"	0	-	-	-	-	-	-	-	
Sunflowers	cwt	0	-	-	-	-	-	-	-	
Canning peas	"	0	-	-	-	-	-	-	-	
Canning corn	"	0								

TABLE 9 (CONTINUED)

Net Price			1.46	3.32	4.50	4.70	1.00	-.61	-.87	.74
Resource		Level	Sell Wheat bu	Sell Flax bu	Sell Sunflowers cwt	Sell Peas cwt	Sell Corn cwt	Buy Oats bu	Buy Barley bu	Sell Alfalfa cwt
Spring labor (hrs)		855								
Summer labor	"	1170								
Fall labor	"	1035								
Winter labor	"	1315								
Winter space (sq.ft)		1176								
Summer "	"	1165								
Land	ac	200								
Capital	$	4000						.61	.87	-
Alfalfa	cwt	0								1.
Oats	bu	0						-1.		
Barley	"	0							-1.	
Wheat	"	0	1.							
Flax	"	0		1.						
Sunflowers	cwt	0			1.					
Canning peas	"	0				1.				
Canning corn	"	0					1.			