A STUDY OF THE FINANCIAL RETURNS TO PROCESS PEA GROWERS IN HAWKE'S BAY.

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CONTENTS

PART I

CONTENTS (Cont'd).

CONTENTS (Cont'd).

INDEX OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

1.1. Motivation of the Study

This study stemmed initially from discussions between New Zealand farmers concerning the economics of growing certain agricultural crops for food processing. These discussions lead directly to one main problem which may be outlined within a two-fold objective namely:-

(1) To determine the profitability of growing green peas for food processing, and

(2) To assess cost accounting and linear programming as methods for farm management analysis.

Within their National Federation, growers of food processing crops found the support and finance to conduct an economic investigation to provide them with information concerning the costs associated with producing their main crop, peas. Further information was required in the form of the extent of the price fall of peas in relation to existing prices, which could be absorbed by growers before new production alternatives would have to be considered as replacements for the pea crop. The present study stems, then, from the felt needs of farmers producing peas for processing.

Although the problem was one of national interest to growers, it was realised that meaningful answers could only be derived for one district at a time. The National Federation decided that the most suitable area in which to conduct the investigation would be the Central Hawke's Bay area, one of the richest primary producing districts of New Zealand. At this stage, at the invitation of the Federation, the study became the primary concern of the author.

The investigation was directed primarily towards assisting growers within Hawke's Bay to make better informed and more confident decisions as to the place of peas within their respective farm management plans, and to provide the Growers' Federation with actual and imputed costs of growing peas and other crops under the conditions encountered in Hawke's Bay. In other words information obtained and analysed pertained solely to the individual farm level. Macro-economic aspects such as outlets available in overseas trading for processed foods and subsequent effects on the possibility of increasing crop production in New Zealand, food factory production trends, and long-term price changes were ignored.

Both cost accounting and linear programming were used to help study the profitability of pea growing. At the outset, it was suspected that the cost accounting results would not be as useful as those derived by linear programming. In view of this, a concerted attempt was made to extract as much information as possible from the cost accounting results to enable a critical comparison of the two methods to be made. At the same time, the National Federation, and individual farmers, felt that they would "understand" the cost accounting results, whereas they doubted if linear programming results would be intelligible. The relative meaningfulness of the results obtained in these two ways are discussed in the main body of the thesis.

1.2. Characteristics of a Farm Survey

For both linear programming and cost accounting, the only way to obtain the relevant information was to talk to the farmers who were growing peas in Central Hawke's Bay. It was not possible to gain the information from any other source. This fact indicated the collection of information in the form of a series of interviews with farmers about a particular management practice, a "farm survey" in fact. "Farm survey" is here used in the sense of:

> " .....the term 'farm survey,' is used to mean a series of interviews with farmers to gain information about some one management practice. Usually all interviews will be conducted by the research worker himself and particular attention will be paid to the way the farm practice has fitted into each farmer's overall management system. In short, the farm survey is a procedure for interviewing farmers to test the hypothesis that a particular management practice is profitable. At the same time, the research worker attempts to define exactly what are the pre-conditions necessary for success, and what associated changes are necessary." 1/

The above quotation adequately summarizes the objective of the study in relation to pea production in Hawke's Bay.

Thirty-five farmers were actually interviewed for the survey. As the survey was done at the invitation of the New Zealand Vegetable and Produce Growers Federation, the sample of farmers interviewed consisted of 75% Federation Members and 25% Federation non-members. 2/ All the interviews with farmers were conducted by the author, with information being collected on a prepared questionnaire.

1.3. A Guide to the Thesis.

A brief summary of the contents of this Thesis now follows.

Chapter 2 deals with farm surveys. The role of farm surveys in farm management research, and a brief history of the development of surveys and their basic forms is discussed. Chapter 3 is concerned with some problems associated with designing the survey of Hawke's Bay pea growers, and discusses in detail the selection of farms and their

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1/ Candler, W.V.: "Production Economics and Problems of Animal Production." Proc. N.Z. Soc.An.Prod. 22 p.142, 1962.

2/ The details of farm selection appear in (3.4).

classification into the four main groups. Chapter 4 concludes Part I with a detailed discussion of designing and pre-testing the questionnaire.

Chapter 5 provides a critical analysis of cost accounting and budgeting as tools for farm management research. This chapter sets out an algebraic statement of the cost accounting convention which it is hoped, will help to clarify much that has been written about this method of analysis. The results of the cost accounting analysis appear in Chapter 6, while Chapter 7 sets out the linear programming model together with the results obtained. The major points in these results are also discussed. Chapter 8 provides the farmer's comments on the linear programming results for his farm. These comments indicate that the farmer felt that the linear programming model had adequately represented his management problem, and had produced meaningful, and even improved farm plans which he would seriously consider adopting. Chapter 9 deals with a comparison of the results obtained by cost accounting and linear programming, and is followed by the Thesis summary.

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CHAPTER 2

FARM SURVEYS

This chapter deals with three aspects of farm surveys. A brief history of farm surveys, surveys as a research technique, and the main types of surveys used in farm management research.

2.1. The History of Farm Management Surveys.[1]

At the turn of the century, farm management research was in its infancy. Investigators in this early period were starting from scratch. They had no body of principles as exist today on which to work. The pioneers in the American Land Grant Colleges, and the United States Department of Agriculture were people whose main interest centred on the physical and biological sciences. Agronomists of the day were perhaps the first to realize the need for evaluating their own work in economic terms. In order to obtain a practical approach to their problems they turned to the farmers as one of the best sources of information on farm management problems. The attitude at the beginning of the century is represented in the words of G.F. Warren:[2]

> "Of all the men working in agriculture, the agronomists came nearest to seeing the farm as a whole. It was not a long step from crop rotations to cropping systems and from that to the farm as a whole. ...... One distinct advantage (of agronomists becoming interested in farm management) was that it resulted in the immediate adoption of the scientific rather than the philosophical method of procedure. In the early days economics was primarily philosophy rather than science. The agronomists who went into farm management carried over their scientific method at once into all their work."

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1. This section relies heavily on "Fifty Years of Farm Management," H.C.M. Case and D.B. Williams, University of Illinois Press, 1957.

2. "The Origin and Development of Farm Economics in the United States," G.F. Warren, Journal of Farm Economics 14, No.1, pp. 6 - 7, 1932.

The work of these pioneers, although it had shortcomings, gave farm management scientific standing. They carried out general purpose studies of farming systems to provide the facts and descriptions needed in developing courses in farm management and to provide insight into at least a few relationships. The studies were generally of the whole farm business and included only its broader features. Primary interest was in the question: "What are the practices followed by successful farmers?" The answer to this question could, of course, only be fully answered by the farmers themselves. Thus there were three developments from this situation: (i) The Cornell Cost Studies, (ii) the Minnesota Cost-route Studies, and (iii) the use of farm account books.

2.1.1. Cornell Cost Studies. In 1902 and 1903 Cornell University published two studies[3] of costs on poultry farms which indicated the nature of the work then in progress as well as foreshadowed the importance of these studies in the later development of the survey method at Cornell. These early cost studies indicated large variations in the costs associated with the production of a particular activity on several different farms. The variations in costs induced a shift in emphasis to the type of studies in which attention is concentrated on the causes of the variations in costs. The early Cornell studies of the cost of producing a single product were an indication that more detailed records were required for accurate analysis, and emphasized the need to recognise farming as a business. They were, however, the beginning of the development of farm management investigations. Further mention will be made of the work at Cornell in the development of the survey method (2.1.4).

3. The two studies are reported in: "Co-operative Experiments in the Cost of Egg Production," H.H. Wing, New York, Cornell Agricultural Experiment Station, Bulletin 204, 1902.
"Second Report on the Co-operative Records of the Cost of Producing Eggs," H.H. Wing, New York, Cornell Agricultural Experiment Station Bulletin 212, 1903.

2.1.2. Minnesota Cost-route Studies. In 1906 the era of cost studies began in earnest. This was the beginning of the cost-route studies initiated when the Minnesota Agricultural Experiment Station and the U.S.D.A. published jointly the results of studies of "The Cost of Producing Farm Products," as reported in the Minnesota Agricultural Experiment Station Bulletin 97, 1906.[4] The main aims of this study were "(i) to supply many averages which the farmer rarely secures from his own business, as costs per acre of various labour operations, and cost of producing field crop products and livestock products; (ii) to secure the data necessary to supplement the records of experiments in crop rotations made by experiment stations, that the net profits from the various rotations be compared; (iii) to determine and compare the net profits in various systems of present day (1906) agriculture and (iv) to collect maps of actual surveys from many farms to be used in working out examples of re-organized field plans with systematic crop rotations."

As distinguished from studies showing the cost of producing a single product, cost-route studies attempted to allocate all costs involved in operating the farm as a unit. The aim, as emphasized in the Bulletin, was to establish farming as a business. Cost of production studies as reported in Bulletin 97 were said to be "the basis from which all study of methods should be made in agriculture as well as in other industries." This type of statement set the standard for many cost of production studies in the years to follow. The improvement of methods of collecting and interpreting cost data

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4. This quotation, and all subsequent quotations from the Minnesota Agricultural Experimental Bulletin 97, 1906, have been reported in "Fifty Years of Farm Management," H.C.M. Case and D.B. Williams, Chapter 2, University of Illinois Press, 1957.

and of determining desirable practices, constituted a major goal for workers in farm management.

The field method employed in collecting statistics on the business of farming consisted principally of what came to be known as the "cost-route method." Initially (1902) this method involved a "route" of up to fifteen farms. "Route Statisticians" interviewed each farmer daily throughout the entire year collecting information on labour usage, and at less frequent intervals - each fortnight - collecting further information on stock foods used, milk yields etc.

In 1904 a departure was made from the plan first inaugurated. The number of farms on each route was reduced from fifteen to eight. The route statisticians boarded at each of the eight farms three days each month. All farms were visited each day to obtain the labour record for the previous day, while the remainder of the information was collected during the three days - thirty-six days at each farm during the year - the route statistician lived at the farm. By developing a thorough procedure for data collection, it was possible to record all costs and to allocate them to one or more of the final products. The presentation of results of this nature was a great advance. But later studies and experience showed the limitations of the use which can be made of information of this type.[5]

The demand for increased accuracy in information relating to agricultural production led to the cost-route method. The method of recording data achieved the details and accuracy required in the information. However, a complete integration of the cost data and farm

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5. Even absolute accuracy as to actual expenditure does not solve the problem of how to allocate fixed costs to individual products.

management principles was not achieved. One of the main limitations of the cost-route method was the expense in both finance and time.

2.1.3. Farm Account Books. Through the work of the U.S.D.A. the period 1911 - 1920 saw the work with farm records develop into one of the most important methods of securing data from farms. The main idea was to secure regular and general collection of information for demonstration work. Information was recorded by farmers in various forms of account books supplied by the U.S.D.A. The particular purpose for which the records were to be kept determined the system adopted. Simplicity of recording was the key factor. Yet detailed records from which a reasonably complete analysis could be prepared, but which would require less time than the cost-route method, were provided. Records from farm account books were regarded as being far more accurate than farm survey records by farmers and extension workers of 1916. Thus farmers were reluctant to accept recommendations based on survey records, because they held that these records included too many estimates in the form of crop and livestock inventories to be reliable.

In 1916 the College of Agriculture at the University of Illinois prepared a "Farm Account Book" which was the development of a new system of farm accounting acceptable to farmers. Earlier attempts to encourage the use of account books among farmers had depended for success on close supervision. The Illinois book provided for classification of expenses and farm enterprise analyses. Thus, although there had been account books in use as part of research programs, the work at Illinois marked the beginning of a farm accounting service designed for practical use by the farmer and for ease in complete farm analysis. Previously, there had been little emphasis on classification of receipts and expenses for ease and accuracy of analysis.

The success of the record book depended on its acceptance by farmers. This was achieved because supervision was provided by workers on the extension staff when it became obvious that this was necessary. For example farmers who used the books, were first shown how to start keeping records, were visited once during the year by the extension officer, and at the end of the year the farmers were invited to convenient centres for demonstrations on closing the books. Thus the method used in farm management extension work in Illinois was established. It consisted of (i) helping groups of ten to forty farmers start their records at the beginning of the year; (ii) visiting each individually on his farm to check the records during the year; and (iii) assisting them in closing the records at the end of the year. By means of the farm account book, the farmer was assisted by extension officers to calculate simple analytical measures of the farm business.

The regular and general collection of information in the farm account books was used for farm demonstration purposes. Dixon[6] illustrated the emphasis placed on keeping records in farm account books in relation to the collection of survey information in 1919:

> "Many of the earlier surveys received what might be termed skeleton figures or only those of the more important receipts, expenses and inventories, and for the use for which they were desired they were probably as good as any. Today (1919) it is important to use business analysis data not only in the terms of an average for a large group of farms, but as a study of the individual variations affecting any particular phase of the business. The data must, therefore, be in complete enough form to enable the proper interpretation of the results of each farm."

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6. "Farm Business Analysis Studies", H.M. Dixon, Journal of Farm Economics 2, No. 2, p. 89, 1920.

Thus the early survey phase of farm management work had aroused the farmers' interest, and was regarded as the prelude to keeping more careful records as a basis for analyzing farm organization and operations. The emphasis had shifted to the aim of getting detailed correct records for increased accuracy in analysis. Both farm account books and the cost-route studies were the main methods for achieving this type of information. The research program in Illinois consisted of testing methods of reaching large numbers of farmers and enlisting their interest in keeping accounts, giving farmers the necessary direction to ensure the completion of records, and working out practical methods of analysis which would enable farmers to evaluate the records they had kept.

2.1.4. The Survey Method. One of the obvious problems in farm management research is how to obtain information at reasonable cost. The "cost-route" ensured accuracy at high cost. The farm account books prepared by the Land Grant Colleges was a less expensive method, but a certain amount of supervision of farmers was still required. Thus in order to reduce the costs of obtaining information Cornell developed the survey method. "Survey" as used here, implied only one meeting of the research worker with the farmer on his farm in order to secure data. Studies employing the survey method usually included a relatively large number of farms.

Workers at Cornell prior to 1911 became interested in securing data from actual farms, but were at first concerned with less complete studies than those which later came to be known as farm management surveys. From a survey method embracing a purely technical study of agricultural production, there gradually evolved the farm management survey as adopted at Cornell. The survey provided a method of securing cost data; although not always complete, it included the items of information most relevant to the farm management decisions made on farms.[7]

The farm survey, including the productive and financial organisation of the entire farm, was a relatively quick means of securing data from a considerable number of farms. It provided a good means of showing the range in conditions found on farms. Although the surveys failed to convince farmers of their accuracy, they were useful in emphasizing differences between farms.[8]

By 1911 farm management surveys and cost of production studies were the two leading types of research. This early period had established the need for reliable empirical data to be secured in sufficient detail to analyse the economics of farm operations. Working at Cornell, G.F. Warren devoted his time to improving the survey method as a farm

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7. That is, the survey could hope to collect the information actually used by farmers to make decisions. It could not obtain information which had neither been recorded nor remembered.

8. The change in emphasis from survey results to farm account book records about 1916, was in a sense, a return to the consideration of the problems of the individual farm. The work of G.F. Warren at Cornell, and the popularity of the survey method had stressed the need for the facts concerning the farming situation, but the emphasis had been on average results. The original cost-route studies had focused on the individual farm and its problems. The re-emphasis of the individual farm, encouraged by the farm account books, was in part, a reflection of the need for a technique to provide data that farmers would accept as applicable to their own farm problems. In a sense, the new emphasis was a forerunner to the budgeting technique which was to achieve considerable popularity in the twenties.

management technique. Warren's approach and insight into the possibilities of the survey method are illustrated in the Cornell Bulletin 344.[9]

The underlying principles of the survey method as Warren considered them are:-

(i) "First find out the facts about farm conditions and farm practice."

(ii) "Find out the usual conditions. After this information is obtained it is possible to study the more successful and less successful with intelligence .... If one does not know the normal, and the usual variations from that normal, he is more likely to attribute the success or the failure of a farm to the wrong than to the right cause."

(iii) "Some facts can be determined only by studying farms, ...because the facts exist on the farms and nowhere else."

(iv) "Survey methods are often the cheapest."

(v) "When large numbers of records are used (e.g. up to 1000) the average will be more accurate than the individual records. ....If we kept the most accurate cost accounts on 50 farms, the results would be much less reliable than survey figures from 1000 farms."

(vi) "The accuracy (of survey records) depends primarily on the person who asks the questions." Warren then defines several factors necessary for success in a survey:

(vii) "Define the objective of the survey."

(viii) "Too much should not be attempted. Before starting survey work, one should decide on the absolutely essential facts that he desires to obtain. He should be very slow to add any other points."

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9. "An Agricultural Surveys" G.F. Warren, Cornell Agricultural Experiment Station, Bulletin 344, 1914.

(ix) "Every record should be completely filled."

(x) "The year for which data are obtained should be a normal year, or should be obtained for several years if possible."

(xi) "Number of records necessary:- 1000 records are a good number for use. In some cases 500 will do."

(xii) "Questions should be asked in terms in which the farmer thinks."

Warren then concludes Bulletin 344 with some comments on analysing the data:-

(xiii) "Sort by the cause, not by the effect." Thus if labour income is used as a measure of earnings, it should not be used to separate farms into groups; rather the farms should be sorted on the basis of the causal factor (e.g. soil type), so the influence of that factor on income may be studied.

(xiv) "In every tabulation one must see that differences are not due to some other correlated factor." Warren found that farms sorted on the basis of the number of work horses showed significant differences between groups, but those sorted on a farm-size basis showed a correlation between farm-size and work horses per farm. "One should always look for and consider the effect of such 'invisible variables.'"

(xv) "Publication of least changeable data." Data should be published in terms of physical quantities so as to remain applicable when prices change.

Thus Warren was basically concerned with handling large numbers of farms in order to reduce the variability between farms. He argued that given a large enough sample, averages could be used as the basis for reliable conclusions. He was also concerned with causal relationships within the pattern of farming. Most of the analyses he presented were based on the cross-classification procedure, whereby averages of one variable were worked out for different groups of farms classified on the basis of another variable. For example in one of his studies[10] comparisons of the labour income of tenants and owners were made, then the relationship between capital invested and labour income was presented. But no attempt was made to describe the variability of data around the mean of each group. The general approach, however, was a "break through" in data handling. From 1911 to 1920 impetus was given towards consideration of the organization of resources and selection of suitable enterprises as the basis for determining a satisfactory farm management system. Since this time, farm surveys have become a routine technique in farm management research.

During the development phase of surveys, cost of production studies covering the entire farm business continued to have an important place in farm management research. The cost-routes established in Minnesota were continued as a major line of research until the outbreak of the First World War. Even after this time, cost-route studies were carried out, but the number of farms supervised by one fieldsman was increased from 12 to 60 at an approximate cost of $200 to $300 per farm. In 1948 a new system of rotating the geographical area for the cost-routes was introduced in Illinois. The plan was to shift the cost-route every two years to a new type of farming area.

The collection and application of data pertaining to farm management secured by the cost-route, the survey and the farm account book used in

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10. "An Agricultural Survey," G.F. Warren, K.C. Livermore et.al., Cornell Agricultural Experiment Station Bulletin 295, 1911.

actual farm organisation and operation in the United States, has been one of the major contributions to farm management research over the past sixty years.

Over the last fifty years work in the field of agricultural economics was also being developed in Great Britain. Farm costing studies, and comparisons of farm costs were being carried out by the Institute for Research in Agricultural Economics, Oxford (now known as the Agricultural Economic Research Institute) prior to 1920.11/ As a result of experiments in agricultural costing, and of the need for regulating prices, the Government of 1918 set up a national costing organization. This was short-lived, but when it disappeared the system of providing economic advisory services for farmers began.

> "Between 1920 and 1939 the Institute for Research in Agricultural Economics, and the Provincial Department of Agricultural Economics at many British Universities had proved to a large number of farmers the practical value of financial recording and accounting in many forms." 12/

Records were obtained by the farm management survey method in the form of general financial accounts, cost accounts of all enterprises within the farm, and in the form of records of costs of single enterprises. Individual and collective results of these systems of financial recording were analysed and returned to farmers both individually and collectively. One of the main aims of the Provincial Agricultural Economics Service has been to foster the study of the principles of farm management and to disseminate economic and financial information to farmers.

The present day Provincial Agricultural Economics Service in England and Wales is the descendent of the pre-war Provincial Advisory Service

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11. "Farming Costs," C.S. Orwin, Oxford University Press, 1920.

12. This statement is taken from "Farm Accounts", F.S. Bray and C.V. Dawe, Oxford University Press, 1948.

based on university departments of agriculture.[13] The rest of the Provincial Advisory Service was absorbed into the National Agricultural Advisory Service when the latter was established in 1946. The Agricultural Economists however, remained in the employ of the Universities. One reason for this is that the provincial economists are responsible for the collection (by farm surveys) and analysis of financial and economic data from farms. For example, some 2,500 farmers make their accounts available to the P.A.E.S. by co-operating in the 'Farm Management Survey' which gives a picture of the relative profitability of different types and sizes of farms. This information is considered in the annual Government agricultural price review. The increasing concern of the British Government with more economic production in agriculture, led the Ministry of Agriculture, Fisheries and Food in 1950 to inaugurate a scheme whereby its own advisory service, N.A.A.S. could call upon the Provincial Agricultural Economics Service operated by the Universities, for assistance in giving advice to farmers on their management problems.

The organisation of British agricultural economic services have been primarily concerned with collection of farm information by the survey method for governmental policy and price decisions. This general situation has led to the development and use of farm standards.[14]

2.1.5. Summary of the History of Farm Surveys. The history of farm surveys may be summarized as follows:-

1902 - The first of the Cornell Cost Studies

1906 - The cost-route studies initiated by the U.S.D.A. and Minnesota University were gaining popularity.

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13. These comments about the P.A.E.S. have been made with reference to "The Ministry of Agriculture, Fisheries and Food," Sir John Winnifrith, New Whitehall Series No. 11, p.217, George Allen and Unwin Ltd.

14. A criticism of the farm standards approach appears in "Farm Standards and the Theory of Production Economics," W.V. Candler and D. Sargent, Journal of Agricultural Economics, 15, No. 2, p.282, December 1962.

1911 - Farm management surveys and cost of production studies were the two leading types of research.

1914 - F.G. Warren published "Agricultural Surveys" and formulated the basic ideas of surveys.

1916 - Emphasis had shifted from survey results to results of farm account books.

1917 - The first British cost studies.

From 1920 - Farm surveys gained popularity in the United States, but cost-routes and farm account books still used.
U.S. emphasis directed towards determining "methodologies" for farm management research.
British development of farm record collection by farm surveys.

From 1945 - British development of farm standards approach.

2.2. The Place of Farm Surveys.

Sample surveys have become an accepted method for collecting information relating to farm management problems, and are now used routinely. No other method can replace the survey when some sorts of information are required about farming practices.

G.F. Warren established the survey method as a means of securing a great deal of information on the agricultural organization and practices in a particular area. However, many workers saw in the method, a means of obtaining data required to answer specific questions of more limited scope; and the term "survey" has since come to have this more specific meaning.[15] As far back as 1919, Billings[16] foreshadowed this trend

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15. Refer to the definition of survey quoted from Candler in Chapter I of this Thesis.

16. "President's Address," G.A. Billings, Journal of Farm Economics I, No. 1, p. 26, 1919.

towards specialized surveys when he said:-

> "Farm management surveys provide a basis for analyzing systems of farm organization and the results from certain operations. Farm practice studies, on the other hand, will show the methods employed and why certain results are obtained."

The great use of the survey method from 1910 to 1930 led almost inadvertantly to consideration of less extensive, more specific studies, for which surveys are better suited. Investigators using the method, found themselves compelled to narrow the range of problems included in a single survey study. The earlier, general descriptive survey gave way to more purposeful surveys directed towards particular problems. Farm surveys may, therefore, be general in their approach or be of the "special purpose" type.

The general type of survey usually takes the form of the "census approach" to gain general information such as class and size of farm etc. These are usually routine surveys with the information being collected on a prepared questionnaire.

The "special purpose" survey however, is designed to provide information on a specific problem. Problems arising in this category concern for example, high stocking rate per acre, high rate of fertilizer usage, the development of hill country sheep farms, and forestry versus dairy farming on sand country to mention just a few. Information for such studies is usually collected on a survey schedule.[17]

The distinction between these two approaches has been made by Schapper[18] when he defined "Enumerative" and "Interview" Surveys.

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17. The distinction between a questionnaire and a survey schedule is given in Chapter 4.

18. "Uses and Limitations of Farm Surveys," H.P. Schapper, Review of Marketing and Agricultural Economics, 25, Nos. 1 and 2, p. 51, 1957.

"Much of the available data on farming is enumerative data which has been collected because of practical or legal requirements, and which is not related to any specific research objective. The role of surveys in farm management and economic research is basically to supplement this data and to obtain information specifically related to research objectives. Such surveys are usually sample surveys rather than whole population surveys."

Thus the two types of surveys defined by Schapper are:-

2.2.1. Enumerative Surveys. The majority of farm surveys have been of this type. The data collected is mainly quantitative and the results are presented as simple frequency distributions, with or without "relationships." Such a survey consists essentially of the collection of farm records, either by mail questionnaire or by visits, and it does not require a technical agriculturalist to conduct the visit.

Enumerative surveys generally take one of the following forms:-

(i) Cost of production surveys.

(ii) Farm business surveys

(iii) Resource productivity surveys.

(iv) Surveys to investigate social conditions on farms.

(v) Surveys to discover aspects of farming needing investigation.

The general intention behind most of these surveys is to provide guides to action on individual farms for farmers. This approach of using an enumerative survey however, involves the standards approach which has been discussed at length by Candler and Sargent.[19] The use of the survey results in this manner could be criticized on several grounds. Between farm differences in the quantity of resources and subjective aspects such as farmer attitude are usually ignored in the survey, and in the analysis

19. "Farm Standards and the Theory of Production," W.V. Candler and D. Sargent, Journal of Agricultural Economics, 15, No. 2, 1962.

of data, attempts are often made to single out the effect on output of a single factor, when in fact there is usually a high and unknown correlation between most of the factors that contribute to that output. Such analyses often show a high correlation between for example, high profits and high stocking rates. The important aspect, that of <u>how</u> the farmer can achieve high stocking rates and how this relates to other factors is usually unanswered.

Possibly the main use of such surveys is to provide simple descriptive material on farming and to indicate where further detailed research is needed.

<u>2.2.2. Interview Surveys</u>. The interview survey is basically a means of testing a hypothesis, and involves the collection of both quantitative and subjective data. It makes possible the integration of information collected from individuals into the study of aggregate data. The usefulness of aggregate data in the analysis of farm income variability and resource allocation, and the limitations of such analysis, has been discussed by Eisgruber and Schuman.[20]

As the name, interview survey, implies, the information is collected by a series of interviews with farmers, and because of the subjective nature of much of the data sought, a high degree of interviewing skill and agricultural training is needed. It is usually essential that the research worker does the survey work himself.

Such surveys are more likely to lead to an understanding of differences in farming performance and hence to a formulation of <u>useful</u> recommendations

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20. "The Usefulness of Aggregated Data in the Analysis of Farm Income Variability and Resource Allocation," L.M. Eisgruber and L.S. Schuman, Journal of Farm Economics, <u>45</u>, No. 3, p. 587, 1963.

for farmers. In particular this type of survey allows the economic and non-economic aspects of the "gap" between optimum and actual use of farm resources to be investigated and is essential to the analysis of the impact of new technology.

The interview-type survey has several quite serious limitations. While the basis for such a survey is a hypothesis, it may not be possible to start with a well defined hypothesis, particularly in exploratory studies. During the course of the study new and unforeseen implications may arise necessitating a change in the hypothesis and the questions to be asked. There is a danger of interview bias which can lead to question bias and response bias. There may be difficulties in getting reliable confidential data and in measuring or assessing subjective attitudes.

In view of these limitations it would appear that the reliability and value of the results will largely depend on the training and skill of the interviewer. Certainly, the results obtained cannot be divorced from "interviewer effects." All these surveys will rely to some extent on the existence of individual farm records, and the paucity of such records can be a severe limitation. This is particularly the case with studies which attempt to go beyond the current farming year. While it is not suggested that the farmer should keep sufficient records to satisfy the possible future requirements of research workers, there is scope for the improvement and standardization of farm records. The most effective way of doing this would probably be through a standard system of farm accounts. Farmers who become actively interested in their farm as a business proposition (as instanced for example by farm improvement club members) tend to have greater interest in farm recording. These records, although primarily for the use and interest of the individual farmer and his adviser, are likely to contain much of the information required by the research worker.

2.3. Small Sample Surveys[21]

The modern trend in special purpose surveys would appear to be towards the selection of a small numbers of farms. Trained agriculturalists carry out intensive interviews with the farmers to collect information and form a subjective judgement on each farm system.

This kind of survey is particularly appropriate for dealing with problems concerning the effects of changed technology or the success of a new practices at the farm level. Problems arising from this source concern, for example, high stocking rate per acre, high rates of fertilizer usage and the development of hill country sheep farms, to name only three.

The small sample is particularly important when analysing the information. For a small sample (say 30 farms) the interviewer should be able to visualize the farmer and the farm in his mind's eye as he extracts the information, and more importantly when he is drawing conclusions from the results. Intensive interviewing of a small number of farms means that the interviewer gets to know the farmer and the farm. During the interview he should walk round the farm with the farmer. This alone helps the farmer to recollect special problems with greater clarity when he can actually see the paddock where a problem was encountered. Thus because of the intensity of the interview, and his agricultural training, the interviewer is able to provide a great deal of subjective judgement about specific problems, in

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21. The discussion on small sample surveys has been compiled with reference to "Production Economics and Problems of Animal Production," W.V. Candler, Proceedings of the N.Z. Society of Animal Production, 22, p. 142, 1962, and after discussion with fellow Masterate students of Massey University.

addition to the information recorded on the questionnaire. The fact that the research worker can visualize the farm, with its layout, topography, main soil types, and other special physical features; and knows the farmer - what his attitude is, how old he is, and knows at least something of the social conditions of the family - enables him to make a subjective judgement of how the farmer has achieved success, or where he has gone wrong. In many cases it would be difficult to know why a farmer had made a mistake in his management system without some subjective assessment of his situation.

These small sample surveys involve much more in the way of subjective judgement than Warren would allow. For example Warren states:[22]

> "Usually results are not based on opinions but on figures."

At the same time, the small sample size allows the research worker to make subjective corrections for any individual peculiarities in farming practice encountered. Warren relied on his large sample size to "swamp" any unusual practices. Further, the intensive interview should allow the investigator to become aware of any commonly associated practices, and hence to identify Warren's "hidden variables."

The subjective nature of small surveys places an upper limit on the number of farms that one person can work with. In most cases special purpose surveys would involve not more than thirty farms. This is, of course, in direct contrast to Warren's large size samples where he required up to 1000 farms. Warren's philosophy for using such large numbers relied on the size of sample to average out the effects of peculiarities encountered on some farms. Recently, the trend has been to argue for a small number of

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22. "Agricultural Surveys," G.F. Warren, Cornell Agricultural Experiment Station, Bulletin 344, p. 423, 1914.

farms, where the research worker is able to visualize them clearly, and make subjective adjustments for any peculiarities. This aspect involves an element of purposive sampling, but in small samples research workers are willing to have a portion of the sample as purposive. This enables them to reject a priori farms which for one reason or another are regarded as being unsuitable. In some cases, as where a new farm practice is being studied, the small sample may, nevertheless represent a census of the people who are relevant to a particular problem.

The element of purposive sampling may introduce bias in the results of the survey. The absence of farm records, which tends to characterise "below average" managers may, however, make it quite impossible to remove much of this bias. Detailed information is usually required for special purpose surveys, hence collection of records will be sought from farmers who have them. The selected farmers, therefore, may be "above average", but good information will be collected. On the other hand it is extremely difficult to obtain good information from farmers who do not keep good records.

In the author's experience, it has been notable that "good" farmers only keep records which they use regularly. Some farmers who have been asked by Farm Advisory Officers to keep records of all financial transactions and labour involved in every farm operation have found the task overburdening. Many of these records have also proved to be quite useless as aids to the farmer for improving his management system.

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CHAPTER 3

THE DESIGN OF A FARM SURVEY OF HAWKE'S BAY PEA GROWERS - FARM SELECTION AND FARM CLASSIFICATION.

Chapter I, section (1.2) presented a broad outline of the survey. The intention of this Chapter will be to present details of the design of the survey with emphasis on farm selection and farm classification. Choosing the survey area and the time period to which information should be related, will also be discussed.

3.1. Choice of the Survey Area

This study was designed to determine the profitability of growing peas for processing. Several districts in New Zealand, e.g. Nelson, Marlborough, Canterbury, Auckland and Hawke's Bay, produce this crop. Distances between these districts and dissimilarities of local conditions made it obvious that within the restrictions of time and finance available to complete the study, one district only could be surveyed. Further, because survey results applying to one district cannot be applied at all satisfactorily to other districts, the question arose as to which of the main pea growing areas should be chosen.

Hawke's Bay had the triple advantage of being the largest process pea growing area in New Zealand, producing approximately 7,000[1] acs per year relative to a New Zealand total of approximately 13,500 acres[2] per year, of being relatively accessible from Palmerston North, and of having a relatively uniform soil type and climate. Given the necessity to choose one area for the survey, it was seen that Hawke's Bay would provide the

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1. "Annual Report and Hastings Booklet 1962-63." Hastings Chamber of Commerce (Inc.), Hastings, 1963.

2. Calculated from information in the "New Zealand Official Year Book 1963," New Zealand Government Department of Statistics, Wellington, p. 544, 1963.

most useful information at a given cost. Accordingly Hawke's Bay was suggested as the survey area to the National Vegetable Growers' Federation. The National Federation were able to obtain the co-operation of the local Hawke's Bay Vegetable Growers' Association. Figure 3.1. is a map showing the boundaries of the survey area, together with the location of the farms surveyed.

3.2. Choice of the period for which information would be Collected.

The minimum meaningful period for which survey data could be collected is a year. At the same time any one year may be seen to be atypical. These points have been expressed by Yang:[3]

> "Because farming is seasonal, information for a farm survey should cover a whole year in order to include a complete sequence of operations. It should be the most recent year, for its business transactions and other happenings are still fresh in the farmer's memory. Moreover, the investigation must determine to what extent the information for the particular year represents normal or average conditions, particularly for crop yields, animal production and price levels. It is necessary to determine the extent to which the conditions in a particular year differ from those of normal years in order to avoid drawing conclusions based on abnormal conditions."

To help make some allowance for between season variability, relevant data was collected for the three seasons 1959-60, 1960-61 and 1961-62. Prices for the major crops including peas over these periods had remained relatively stable. Further, seasons 1959-60 and 1960-61 were quoted by farmers as being climatically "normal" or "average" seasons. Although, however, the 1961-62 season was climatically atypical of the district because of an extremely wet winter followed by a long summer drought, crop yields were not greatly effected.

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3. "Methods of Farm Investigations," W.Y. Yang, F.A.O. Agricultural Development Paper No. 64, p. 10, F.A.O., Rome, 1958.

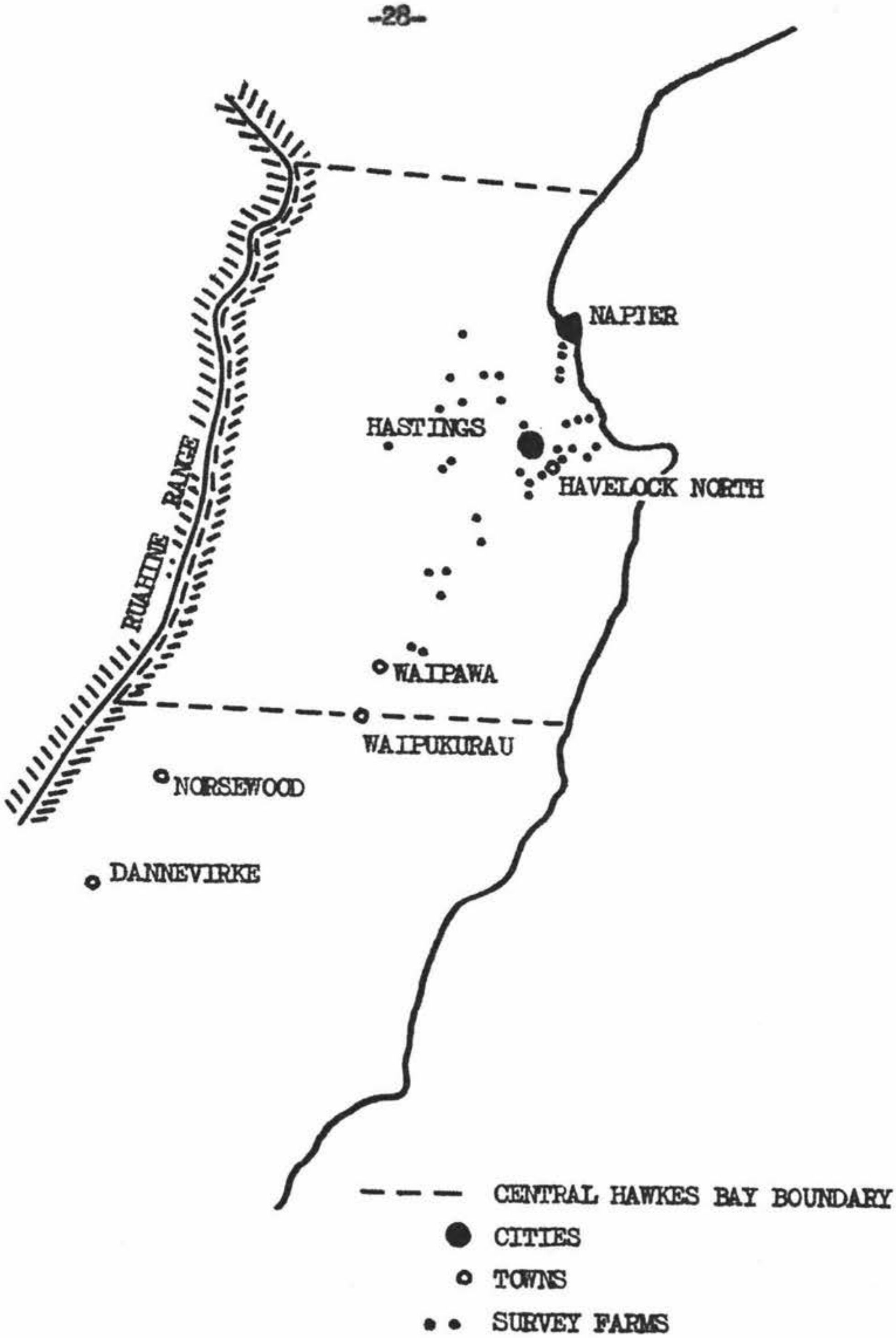

FIG. 3.1: THE SURVEY AREA AND DISTRIBUTION
OF SAMPLE FARMS
CENTRAL HAWKE'S BAY.

The interviews took place at the end of the 1961-62 vegetable crop growing season, namely in February and March 1962. Consequently the production requirements and costs and prices for growing crops in 1961-62 were still fresh in each farmer's memory. This in turn, enabled them to clearly remember similar information for crops grown in the previous two seasons. This factor was a valuable contribution to the farmer's ability to answer questions, especially in cases where few farm records were kept.

Originally it was intended that each season's data would be analysed separately, and finally the average of the three seasons' data for each farm would be analysed. But because of the time involved, analysis of the separate seasons was not carried through to completion. Thus the costs and prices presented in the cost accounting results in Chapter 6, and used in the linear program in Chapter 7, were the average costs and prices derived from the three seasons.

The questionnaire (Appendix A) made provision for collection of data on actual farm management performances, as well as for data on what farmers thought were "average" or "normal" management performances. After a comparison of these two situations, talking to farmers, and assessing the results of the survey, the author has the strong conviction that within the variations of prices from year to year the results obtained from the average of three seasons' data closely resemble the true average conditions of Central Hawke's Bay.

3.3. The Problem of Sampling

It was obviously impossible to interview all growers of peas in Hawke's Bay, hence some sort of sampling procedure was necessary. The diversity of farming systems in Hawke's Bay meant that it was first necessary to determine the main types of farming which produced peas. Knowing these systems, the sample could be "stratified" to ensure that the results of the study would not be biased by one or more particular types of farming. Information on farming systems was gained from Department of Agriculture Farm Advisory Officers in Hastings, Lecturers in Farm Management at Massey University of Manawatu and from two well-known, established and "good" farmers in Hawke's Bay. The latter two "good" farmers were interviewed in a pilot survey designed to test the questionnaire and gain general background information on farming in the Hawke's Bay area. Other people who would have been able to give a valuable assessment of the types of farming in the district, but who were not contacted prior to the survey being conducted, were Advisory Officers of the food processing factories, the Secretary of the Hastings Chamber of Commerce (whose organisation produce an Annual Report of primary production in Hawke's Bay) and stock and station agents. The people who were approached, indicated four main types of farming systems which included peas as a major enterprise.

It was, therefore, desirable that the sample should include farmers from each of these four main groups. The main question then raised was how many? The author knows of no statistical criterion that can be derived for the size of sample for this type of survey beyond the common sense criterion that the research worker must relate his selection to the objective of the study, and at the same time bear in mind the resources at his disposal. Four farms from each type of farming system was decided upon somewhat arbitrarily as the minimum number which should be used to draw conclusions from the cost accounting results.

The upper limit for each group was more difficult to define. One criterion is to include farmers up to the point where the research worker feels that no new information is being derived. This point, however, is impossible to determine in advance, and so the criterion, although ideally perhaps the most reasonable one, is, practically, not very helpful. Six or seven farms from each group would seem to be the optimum number which can adequately be handled by one person. This is "optimum" in the author's opinion, in the sense that though a greater number of interviews could be conducted, they would necessarily be less thorough. For linear programming, and indeed for cost accounting, it is essential that the research worker have a thorough understanding of the physical realities represented by his figures. To recall the physical peculiarities of much more than thirty mixed cropping farms would require a better memory than the author can claim. Within any particular farming pattern, this number of farms gives room for a fair spread of farming practices, and provides reasonable "replication" of the information about any one farming practice. Any number in excess of seven farms only adds to the computational burden without making any further major contribution to the results. In fact the number of farms selected coincided with the criterion of ceasing farm interviews when no new information was being gathered, but there was no knowing that this would be the case at the time of farm selection.

3.4. Selection of Survey Farms

As this survey was done at the invitation of the New Zealand Vegetable and Produce Growers' Federation, they were able to provide a large number of farmers willing to co-operate in the survey. Accordingly, it was intended that the sample of farmers interviewed consist of 75% Federation Members and 25% Federation non-Members. The non-members being included in an effort to detect any marked differences which might make Federation members atypical of pea growers in the area. The main difference indicated in the results was that markedly worse records were obtainable from the randomly selected Federation non-Members. This was due in part to the fact that the Federation sample of farmers to be interviewed was actually nominated by the Executive Committee of the Hastings Association of Vegetable Growers. Having determined the numbers to be interviewed, the 75% proportion of total survey sample chosen by the Federation were selected according to (i) whether the farmer was "typical" of the group he represented, (ii) whether he could provide access to good farm records, and (iii) whether he was willing to billet and transport the interviewer during the survey period. On these grounds the Federation Members may not actually have provided a true representation of the growers of peas because of the very nature of their selection. In short, they were not a randomly selected group. As opposed to this, the Federation non-Members were randomly selected by the author from factory suppliers lists.

However, as previously mentioned, the only major difference noted between the two groups of farmers was in the types of records kept. There was no other major aspect which suggested that any farmer was markedly atypical of the class of farming system which he represented. Hence the "purposive" selection of Federation Members on the points as listed above does not appear to have introduced any obvious bias. Further, where the objective is directed towards studying reasonably general farming patterns, and especially towards one particular farming practice (namely pea growing) which is known to involve standard procedures with no new technological changes, then there does not seem to be any strong case _a priori_ for studying a farmer who is known in advance to be atypical of his group. Thus farmers operating under unusual circumstances were avoided in the survey.

The farmers selected for the survey were drawn from all farmers in Hawke's Bay who incorporated peas for food processing in their respective farm management plans. A farmer was recognised as a grower of peas provided he conformed to the following definition:-

> "A grower of peas for processing, is any farmer who has suitable land for the crop, and who has obtained a contract to grow a specified acreage of not less than five acres of green peas."4/

In addition to this definition, the farmer had to comply with certain conditions as laid down by the factories. It is customary for the factory to supply the variety of seed sown, and advise on, or direct, the pre-planting cultivation operations, sowing date and spraying times. The factory harvests the crop as near to the correct stage of maturity as possible.

On the basis of the points discussed above, the final selection of pea growers was made to include 28 Federation Members and 7 Federation non-Members. A full cost accounting analysis of growing peas for processing, together with certain other vegetable crops, was completed for all the 35 sample farms. However only one of these farms was used to carry out a complete linear programming analysis. This one farm was selected for the availability of complete farm records, the large number of production possibilities available to the farmer for inclusion in the farming system, and the great interest that the farmer himself showed in the use of the method to assist him to determine his optimum farming pattern.

In drawing the sample of farmers, the first 35 who were contacted did not all accept the interview. Forty-six farmers had to be approached before the final 35 were selected. The number of refusals were markedly greater within the randomly selected group. One of the prime reasons for this was that the random farmers had little prior warning that the survey was being conducted. Contacting them at relatively short notice (two weeks before the survey was due to start) and the fact that the study was being done for the Federation, caused many Federation non-Members to refuse an interview.

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4. This definition was compiled by the author with reference to the conditions of pea growing contracts as let by the food processing factories. Depending on the factory supplied, the contract might be written or verbal.

3.4.1. Refusal to Co-operate in Survey. The reason why farmers refused an interview were:

Federation Members

One farmer was too busy harvesting crops during the survey period.

One farmer stated his unwillingness and inability to supply the required information.

Thus 30 Federation Members had to be contacted to obtain 28 who were willing to be interviewed.

Federation non-Members

Four farmers were not interested in the study.

Two farmers said they had not sufficient records to be useful.

Two farmers were not prepared to make available any records that they had.

One farmer said he was too busy harvesting his crops.

Thus 16 Federation non-Members or randomly selected farmers had to be contacted before 7 were found to be willing to be interviewed.

3.5. Description of the Survey Area

The survey area indicated in Figure 3.1. enjoys a temperate climate with an average annual rainfall of 30" - 35". The area is subject to dry spells and occasional droughts over the summer period, but generally the climatic conditions are very favourable to most systems of farming.[5] Soil types of the area vary greatly from Twyford stony gravel soils which dry out rapidly and have limited use as grazing land, to Pakowhai silt loam and clay loam soils. These latter soils are highly fertile and are excellent for the production of grass seed, white clover seed, grazing and all forms of cropping. Selected farms covered most of the diverse soil types between the two extremes above as listed by the D.S.I.R. Soil Survey Maps of Central Hawke's Bay, 1938.

5. Dairy production, sheep production, small fruits, orchards, vineyards, and vegetable crop production are all found in Central Hawke's Bay.

Under these physical conditions, four basic patterns of farm organisation emerged from the farms surveyed. Classification was based on the main enterprises encountered within each of these four main farming systems.

As the survey was primarily concerned with evaluation of farm management practices, in particular the practice of growing peas, classification of farms according to the major systems of management was designed to facilitate analysis. A comparison of results between a mixed dairying and cropping farm with those of a mixed sheep and cropping farm would be difficult, if not hazardous. The two systems of management are entirely different (except for the crop enterprises) and hence marked differences in the resources available for each farm would be apparent. An analogy of the comparison of these two farms could be drawn with a comparison of survey results of growing peas in Hawke's Bay with growing peas in Canterbury. While growing peas in the two districts has much in common there are major dissimilarities. As an example, many growers in Canterbury require irrigation to produce peas successfully while growers in Hawke's Bay do not. Irrigation requires a heavy labour input, and correspondingly higher costs, therefore the comparison cannot be made confidently or satisfactorily.

3.6. Brief Description of Pea Farming Systems in Hawke's Bay

The survey farms were grouped according to the major similarities of enterprises produced, and farm size. While it is true the classification is broad in its terms, it does describe the main farming systems encountered. In all cases cropping was carried out in conjunction with livestock farming of one type or another. That is, either dairying, sheep, or sheep and beef cattle. The number of cash crops grown per farm per year ranged from two to seven. Within each class, there was wide between-farm variability of factors such as farm size, potential cash cropping acreages and actual acreage cash cropped per year. However, each farm was classified according to the relative intensity of the farming pattern as indicated by the percentage of total acreage potentially available for cash cropping, the percentage of total farm acreage actually cash cropped, the number of crops grown, and the winter stocking policy.[6]

3.6.1. Class I. Intensive Cropping and Stocking. Thirteen farms were included in this group. Table 3.1. provides the details of all Class I farms. ~~Total~~ Mean acreage was 99 (16.5 - 220). It may be seen from Table 3.1. that the total acreage of Farm 20 is 16.5 and is substantially smaller than all other farms of this group. Farm 20 (on the basis of farm size only) should have been located in Class IV (Section 3.6.4.). However, Farm 20 was farmed more intensively than Class IV farms. Also, although the farmer was an agricultural contractor and spent much of his time away from the farm, his farming system provided work for much longer periods during the year than was generally the case with Class IV farms. Consequently Farm 20 was included in Class I.

All Class I farms were situated on flat land with a high proportion of fertile land capable of supporting various crops for the food processing industry. Potential cash cropping acreage expressed as a percentage of total farm acreage was high, 85% (36 - 99%), and actual cash cropping acreage per year expressed as a percentage of total acreage 72% (36 - 97%) was also high, although slightly lower than the same figure for Class IV farms. Whether green feed crops were, or were not grown to supply feed to livestock during winter was considered relatively unimportant. Class I farms were the most intensively cash cropped of all farms with as many as seven crops being grown

6. NOTE:- Subsequently where a number is expressed followed by two numbers in parenthesis e.g. 85 (36 - 99), 85 refers to the average of the group, while (36 - 99) refer to the range of values about the average.

TABLE 3.1:

CLASS I - INTENSIVE STOCKING AND CROPPING

FARM NO:-	1	5	12	17	18	20	21	22	23	24	26	28	R7	Mean	Range
TOTAL ACRES	45	196	84	100	72	16.5	55	65	213	100	220	52	71	99	16-220
POTENTIAL CROPPING ACS.	40	183	50	86	52	16	54	60	193	36	217	51	68		
% OF TOTAL ACS AS POTENTIAL CASH CROPPING ACRES	89	93	60	86	72	97	98	92	91	36	99	98	96	85	36-99
% OF TOTAL ACS. ACTUALLY CASH CROPPED	64	56	58	86	68	85	97	60	86	36	86	71	79	72	36-97
% TOTAL ACRES IN GREEN FEED CROPS	7	7	0	0	14	0	0	15	0	23	14	19	0		0-23
STOCK WINTERED															
Breeding Ewes	250		450		250			250		400	1100	250			
Hoggets	150	1450		700	175	150	*	320	1500	300	1200	300	*		
Cattle	20				23										
CASH CROPS	P. P.H. R.	P. P.H. R. W.	P. P.H. R. D.B. Ap.	P. P.H. R.	P. P.H. R. M.H.	P. Pt. D.B. B.B.	P. P.H. Pt. D.B. Asp.	P. P.H. R. T. Pt. M.H.	P. P.H. R. T. S.C.	P. R. T. B.B. L.H.	P. P.H. R. D.B. B.B. M.H. B.R.	P. P.H. R. T. Pt. D.B. B.B.	P. P.H. R. M.H. Cl.H.	5	3-7

in any one year. The number of different crops grown was 5 (3 - 7).

The key to the letters indicating cash crops is now presented. This key has been used for all classes of farms.

Key to Cash Crops as listed in Tables 3.1; 3.2; 3.3; and 3.4.

Ap.	=	Apple Orchard
Asp.	=	Asparagus
B.B.	=	Broad Beans
B.R.	=	Beetroot
Cl.H.	=	Clover Hay
Cl.S.	=	Clover Seed
D.B.	=	Dwarf Beans
L.H.	=	Lucerne Hay
M.H.	=	Meadow Hay
P.	=	Process Peas
P.H.	=	Pea Hay
Pt.	=	Potatoes
R.	=	Ryegrass Seed
S.C.	=	Sweet Corn
T.	=	Tomatoes
W.	=	Wheat

One further point which is not clearly evident from Table 3.1., is that land required for green feed crops may be the same as that used for cash crops. Alternatively green feed crops may be grown on other cultivatable land which is unsuitable for cash crops. The distinction between these two alternatives has not been made in any of the Tables 3.1. to 3.4.

3.6.2. Class II. Sheep and Cropping. Details of Class II farms are provided in Table 3.2.

Eleven farms were included in this group. Total acreage was 548 (181 - 1360), indicating a more extensive system of farming. The land for Class II farms varied from flat, with certain areas available for cash cropping, to rolling hill country. Potential cash cropping acreage expressed as a percentage of total farm acreage was 54% (10 - 99%). The actual area cash cropped per year expressed as a percentage of total farm acreage was relatively low 13% (3 - 31%). This, together with the high numbers of stock wintered, show the tendency towards a basic livestock policy with cash crops playing a minor role in the farming system. This aspect may be compared with Class I farms, where cropping activities provide the greatest proportion of total farm income, with livestock playing a secondary role. The main enterprise on Class II farms was sheep farming, and all but one farm grew green feed for winter fodder. Apart from peas, ryegrass seed and wheat comprised the main sources of income from cash crops, with extra revenue being derived in most cases from sales of hay. This was either lucerne, meadow or clover hay.

Three of the farms incorporated peas into their respective plans to offset the lower returns from fat lamb production in recent years. Six farmers had utilized their more fertile land for a number of years to grow peas. The remaining two farmers grew peas only between ploughing in old pasture and resowing new pasture on their flat country.

TABLE 3.2:

CLASS II - SHEEP AND CROPPING

FARM NO:-	2	3	4	6	7	8	14	19	R_1	R_3	R_5	Mean	Range
TOTAL ACRES	590	530	650	474	721	597	1360	181	250	310	367	548	181-1360
POTENTIAL CROPPING ACRES	585	390	586	300	81	229	500	98	75	285	35		
% OF TOTAL ACRES AS POTENTIAL CASH CROPPING ACRES	99	74	90	63	11	38	37	54	30	92	10	54	10-99
% OF TOTAL ACRES ACTUALLY CASH CROPPED	10	7	31	10	3	9	6	24	13	24	4	13	3-31
% TOTAL ACRES IN GREEN FEED CROP	0	12	12	9	2	3	1	5	7	7	4		0-12
STOCK WINTERED													
Breeding Ewes	2500	2500		2300	1200	2200	3000	750	1000	1500	1350		
Hoggets			5000		800			250					
Cattle	50	200		60	200	160	100				160		
CASH CROPS	P. P.H. R.	P. P.H. L.H. M.H.	P. P.H. W.	P. R. Cl.H.	P. P.H. R. L.H. Cl.H.	P. R. M.H.	P. P.H. R. L.H. Cl.H	P. P.H. R. L.H. M.H.	P. P.H. M.H.	P. P.H. R.	P. P.H.		

3.6.3. Class III - Dairying and Cropping. Four farms were included in this group. Table 3.3. provides details of Class III farms.

Total acreage was 183 (78 - 240). These farms were situated on highly fertile flat country as is indicated by the highest figure of all Classes for potential cash cropping acreage expressed as a percentage of total farm acreage, 96% (89 - 99%). Due to the fact that dairy cows were run on these properties, a relatively small proportion of the available land was cash cropped, 35% (11 - 55%). Sources of income were derived from sales of dairy produce, supplemented by sheep, cash crops such as peas, ryegrass seed and sales of lucerne, pea and meadow hay. All of these farms included winter green feed for stock in the farm plan.

This class of land was ideally suited to dairying, fat lamb production and cash cropping. On the three farms of over 196 acre (i.e. Farms 9, 11 and 27, Table 3.3) all three of these enterprises were worked into the farming system. The fourth farm operated a dairying and cropping plan only.

3.6.4. Class IV - Part-time Farming. These farms, as the name implies, were small units supporting the less labour-demanding activities. Because of these two facts, they were not operated as full-time labour units. Owners of such properties usually had a forty-hour week job elsewhere, and operated these properties at the week-ends and during "spare-time" hours. Although the classification scheme was based on farm types, rather than farmer types, these farms couldnot satisfactorily be classified under any of the three previously mentioned systems. They therefore found their own category, classified mainly according to the annual farm labour requirements, which were substantially below those of other surveyed farms.

Five farms were included in this remaining group. Table 3.4. provides details of Class IV farms.

TABLE 3.3.

CLASS III - DAIRY AND CROPPING

FARM NO:-	9	11	25	27	Mean	Range
TOTAL ACRES	217	196	78	240	183	78-240
POTENTIAL CROPPING ACRES	194	192	77	230		
% OF TOTAL ACRES AS POTENTIAL CASH CROPPING ACRES	89	98	99	96	96	89-99
% OF TOTAL ACRES ACTUALLY CASH CROPPED	55	54	18	11	35	11-55
% OF TOTAL ACRES IN GREEN FEED CROP	1	15	14	10		1-15
STOCK WINTERED						
Breeding Ewes	650	350		850		
Hoggets	400					
Dairy Cows	45	89	60	62		
CASH CROPS	P.	P.	P.	P.	4	3 - 5
	P.H.	P.H.	L.H.	R.		
	R.	R.	M.H.	L.H.		
	M.H.	L.H.				
		M.H.				

TABLE 3.4:

CLASS IV - PART-TIME FARMING

FARM NO:-	10	13	15	R_4	R_6	Mean	Range
TOTAL ACRES	21.5	36	80	13	14.5	33	13-80
POTENTIAL CASH CROPPING ACRES	20	35	78	11	13		
% OF TOTAL ACRES AS POTENTIAL CASH CROPPING ACRES	93	97	96	85	90	92	85-97
% OF TOTAL ACRES ACTUALLY CASH CROPPED	93	89	94	85	90	90	85-94
% OF TOTAL ACRES IN GREEN FEED CROP	0	0	0	0	0		
STOCK WINTERED							
Breeding Ewes		200	350				
Hoggets	225						
Grazing Leased				*	*		
CASH CROPS							
	P.	P.	P.	P.	P.	3	2-5
	R.	P.H.	P.H.	P.H.	R.		
		R.	T.	R.			
		M.H.	D.H.				
		Cl.S.	B.B.				

* Leased for Grazing

The average total acreage was 33 (13 - 80). Potential cash cropping acreage expressed as a percentage of total farm acreage was 92% (85 - 97%), while the actual acreage cash cropped per year as a percentage of total farm acreage, was the highest of all Classes, being 90% (85 - 94%). Green feed winter crops were not grown on these farms.

Two methods of stocking during the winter were employed. Either breeding ewes or hoggets were wintered, and were owned by the farmer, or the land was leased for grazing during the winter period.

At other periods during the year the entire farm area would be under cropping, either for vegetable crops for processing or for ryegrass seed or clover seed. This system allows for minimum labour requirements (e.g. week-end labour) and minimum capital requirements.

These small holdings were situated on fertile, high-priced lands in close proximity to Hastings city. Hence they had to be managed to provide high returns to cover running costs and very high land overheads.

An average of 3 (2 - 5) crops were grown per year.

Table 3.5. summarizes the farm descriptions in terms of Class means and ranges.

Commenting generally on the classification system from Table 3.5., the most extensive farming system is Class II - sheep and cropping. The most intensive system in terms of the amount of land available and actually being cropped per year is Class IV - part-time farming. However, on the basis of annual labour requirements, Class I - intensive stocking and cropping, is the most intensive system. The high annual labour requirements for this group are illustrated by the numbers of different crops grown and the actual areas cash cropped per year, together with the amounts of livestock wintered. On this same basis Class II - dairying and cropping, may be considered as a

TABLE 3.5:

FARM DESCRIPTION SUMMARY

CLASS		I	II	III	IV
TOTAL ACRES	Mean Range	99 16-220	548 181-1360	183 78-240	33 13-80
% OF TOTAL ACRES AS POTENTIAL CASH CROPPING ACRES	Mean Range	85 36 -99	54 10 - 99	96 89 -99	92 85-97
% OF TOTAL ACRES ACTUALLY CASH CROPPED	Mean Range	72 36-97	13 3-31	35 11-55	90 85-94
NUMBERS OF CASH CROPS GROWN	Mean Range	5 3-7	4 2-5	4 3-5	3 2-5

relatively intensive system of farm management.

Results of the survey derived by the cost accounting method of analysis for each class of farming system, are presented in Chapter 6.

3.7. Summary

A total of 35 farmers were interviewed. Of these 28 were selected purposively by the New Zealand Vegetable Growers' Federation, and 7 were selected at random.

The 35 farmers could be classified as 13 intensive stocking and cropping farms, 11 "extensive" sheep and cropping farms, 4 dairying and cropping farms and five "part-time" farms.

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CHAPTER 4

DESIGNING AND PRE-TESTING THE QUESTIONNAIRE

This Chapter discusses the problems encountered in preparing the survey questionnaire.

4.1. The Distinction Between a Questionnaire and a Survey Schedule.

The distinction between a questionnaire and a survey schedule has been expressed by Yang:[1]

> "In a questionnaire, all the questions which are to be asked by the enumerator, are worded and listed exactly in the way that these questions should be asked, whereas in a survey schedule, only the headings or items for which information is to be collected, are listed in tabular form, and the enumerator is responsible for framing his own questions when he interviews informants. Whether a questionnaire or a survey schedule should be used depends on the experience of the enumerator, and the number of items to be covered in the survey."

Data was collected with the aid of a questionnaire (see Appendix A) since a large amount of fairly straight forward information was required from each of the 35 farmers to be interviewed.

4.2. Design of the Questionnaire

In a questionnaire, all questions must be related to the major questions which are to be answered by the survey. The major questions are those which originally motivated the study. Questions should be asked in a logical sequence to facilitate the farmer's recollections. The actual order of the major topics for discussion followed the logical sequence suggested by both

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1. "Methods of Farm Management Investigations," W.Y. Yang, F.A.O. Agricultural Development Paper No. 64 P.B. F.A.O., Rome, 1958.

Yang and Gallup.[2] The order of major questions are presented in sections (4.2.1) to (4.2.8). For details of the specific questions relating to each of these major headings see Appendix A.

4.2.1. Characteristics of the Farm. This section covered the physical characteristics of the farm. Questions were asked concerning farm size, climatic conditions, topography, soil types, plant and equipment, buildings, labour employed, stock carried and crops grown.

4.2.2. Pattern of Farm Operations. Calendars of land use and labour use for all major farm operations were obtained. Specific problems of tractor, labour and machinery usage for the various crops were also covered. This was perhaps the most interesting section of the whole questionnaire, and was designed to obtain the farmer's interest and confidence early in the interview, as well as basic data on the farm organisation.

4.2.3. Pea Growing. Detailed information on the history of pea growing on the farm, the input requirements for the crop, and production achieved, together with costs and prices for the past three year period was obtained.

4.2.4. Costs and Returns to Other Enterprises. Input-output data together with costs and prices of all other enterprises were requested. Although this section of the questionnaire was found to be poorly designed, much valuable information was collected. Had more than one interviewer

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2. The sequence of major questions followed the patterns as suggested by Yang (see footnote 1/ for reference), and Gladys Gallup, "Evaluation in Extension", Division of Extension Research and Training, U.S.D.A., p. 64.

been operating for the study, this section could well have led to much confusion, with a possible severe bias in the information collected by the respective interviewers. However, with the author conducting all interviews, the same interpretation and explanation was given to each question asked.

This section (pp. 25 to 28 of Appendix A) was laid out in "survey schedule" form because it had to make provision for all enterprises other than peas, encountered on the survey farms. Careful probing for detailed information on all enterprises was therefore necessary. In spite of a relatively poor design however, almost all the information required was collected.

4.2.5. The Place of Peas in the Farm Plan. Much of this information was subjective in nature. Farmers' opinions were sought as to how they would respond to price changes for peas.

4.2.6. Pea Marketing. Farmers' opinions on various contract terms for growing peas were sought, together with their ideas on the gross returns per acre needed to make the alternative contract terms acceptable. A more appropriate heading for this section might have been "Farmers' ideas on Various forms of Contracts for Growing Peas."

4.2.7. Advisory Service and the Federation. This section was included to provide extra information to the body of farmers who initially requested the survey to be undertaken. It was designed to find out whether there were any shortcomings in the advisory services provided by the food processing factories.

4.2.8. Finance. The final section allowed for collection of financial records of each farm business. These records took the form of Balance Sheets, Profit and Loss Accounts, Trading Accounts and Depreciation Schedules. Approximately 50% of the farmers surveyed provided this information. All farmers however, were willing to provide the specific items asked for, in the form of rates, land tax, Capital Value and Unimproved Value of their respective properties.

In general the layout of the questionnaire worked well. All farmers were willing to provide access to physical farm records, and eagerly expressed their views on questions of farm operations and relations to the processing companies. The type of information sought maintained the farmer's interest, as the majority of questions dealt with a subject on which each could speak with authority - namely, their own individual farm management problems! This, together with the farmers' realizing the thoroughness of the information being asked for as the questionnaire progressed, and a friendly atmosphere throughout the interviews, resulted in relatively few straight refusals to provide access to the farm financial data at the end of the questionnaire. Although only approximately 50% of the financial records were actually obtained, various authentic reasons prevented a greater proportion from being collected. Of the thirty farmers actually surveyed, only four, or 11%, refused access to this information.

4.3. The Five Forms of Specific Questions.[3]

Five forms of specific questions were used to good effect to gain detailed information relating to the major questions outlined in 4.2.

4.3.1. Dichotomous Questions. Answers to these questions are in two definite parts. They present opposite choices designed to get a response such as yes or no, agree or disagree, approve or disapprove. The chief advantage of dichotomous questions is simplicity. They take relatively little time to ask and provide a definite answer which can be recorded easily. This type of question was used extensively in Sections 3 and 7 of the questionnaire (Appendix A). A question answered by yes or no, generally had an accompanying follow-up question to provide reasons for the answer. In this way some ideas on the motivation of certain decisions could be gained.

e.g. Question 53 p. 33 of Appendix A.

"Do you consider peas before ryegrass essential for good ryegrass-seed yield?" /YES/ /NO/

"If /YES/ for what reasons?"

If the answer was "Yes" to the question, then the reasons would explain the farmer's decision to prefer a peas to ryegrass seed rotation.

4.3.2. Multiple Choice Questions. A direct question is asked followed by a number of possible responses. The farmer answering these questions was given an opportunity of choosing one of several possible answers that were true, or represented his opinion or ideas, or those which came closest to them. These questions are difficult to construct and the

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3. The various forms of specific questions have been discussed in detail in "Evaluation in Extension," by Gladys Gallup, Division of Extension, Research and Training, U.S.D.A. pp. 65 and 66.

following example caused many farmers a great deal of trouble in providing an answer. Basically the fault with the question is that the alternative responses did not allow for the answer to adequately cover the complexities inherent in the question.

e.g. Question 43 p. 29 of Appendix A.

"If you didn't grow peas, how would the present pea area be used?"

(a) Grow grain crops - wheat
barley
oats.

(b) Increase lucerne area.

(c) Increase clover area (for seed and hay).

(d) Increase green feed for stock.

(e) Other

(f) Hadn't thought about it."

When asked this question most farmers responded with another alternative crop which they thought could replace peas. To illustrate the difficulties consider a reply (e) "Potatoes". On closer questioning it transpired that the farmer had only idly considered this as an alternative. Potatoes require land for a much longer period than do peas, a heavier seasonal labour input (for picking) and usually contractors are required with the specialized machinery for planting, moulding and digging. When confronted with these facts the farmer had difficulty in visualizing (at such short notice) the re-organisation of his farming system as a whole to incorporate the alternative of potatoes. Because of this sort of difficulty, farmers tended to feel "caught out" by this question and tried to "gloss over" it by providing unsatisfactorily short answers without giving the problem the depth of thought that it required.

The question therefore would have better been left as an open end question (see section 4.3.3.), and should have been asked thus:-

"If you didn't grow peas, how would the land normally occupied by this crop in the rotation be utilized?"

Without any proposed alternatives listed to confuse him, the farmer would then be free to answer as he liked. In short the question would take the form of those included in a survey schedule. Without alternatives suggested to him, the farmer would sense that something more than a short answer was required. Hence he would give the question the thought it required before answering. At the same time, careful probing by the interviewer would assist the farmer to give a complete answer to the question. Provided all the interviewing was done by the one person, much more valuable and reliable information could have been collected in answer to the suggested open end type of question above, than was actually achieved.

4.3.3. Open End Questions. These are usually the main types of questions used in personal interview questionnaires. The farmer is free to answer as he chooses. One of the problems of these questions is concerned with analysis. Usually such a variety of answers is given, that the job of classifying and analyzing is both time consuming and difficult. These questions are valuable however, for obtaining farmers' views and opinions, and by careful probing by the interviewer, much is often learnt about how and why farmers make decisions on certain points. Open end questions were used a great deal as follow-up questions to explain a choice or action as indicated by an answer to a dichotomous question.

e.g. Question 28 (e) p.22 of Appendix A.

This is part of a question dealing with farmers' experiences of, and preferences for static versus mobile pea viners.

The dichotomous question asks:-

"Which do you prefer? /MOBILE/ /STATIC/"

The open-end question then asks:-

"For what reasons?"

Thus in reply to the definite answer mobile (or static), as the case may be, the follow-up question allows the farmer to state the reasons for his preference.

4.3.4. Tabulations. Wherever possible answers to a question were recorded in the questionnaire in table form. This method saves a great deal of time and space when a large amount of information will be forthcoming from a single question. Tables are perhaps the best method of recording physical inputs and outputs on a farm. Examples of the types of tabulations used in the questionnaire are given on pp. 3 - 6 of Appendix A. One of the most useful tables is shown by question 15 of the questionnaire, and also illustrated in Table 4.1, which was concerned with tractors, labour and machinery usage for the 1961-62 pea crop. It provided excellent data for labour and machinery inputs for the cost accounting section of the analysis. Data in Table 4.1. has been extracted from the questionnaire for farm number 23.

TABLE 4.1:

TRACTOR, LABOUR AND MACHINERY USAGE. (1961-62 PEA CROP)

	TRACTOR				LABOUR		MACHINERY	
OPERATION.	Strokes	Ac/hr.	Total Hours	Cost of Fuel & Oil	Hours	Costs Per Hour	Hours	Total Costs/Hr.*
Ploughing	1	15	20	(Diesel) 1.5 gals/hr	22.5	7/-	20	2/-
Discing	5	3	50	"	56	"	50	2/6
Cultivating	1	2	15	"	16.5	"	15	1/-
Harrowing	3	6	15	(Diesel) 1 gal/hr.	16	"	15	1/-
Rolling	1	5	6	"	6	"	6	1/6
Sowing	1	5	6	"	9) 2 9) men	"	6	2/6
Spraying	1	6	5	"	7	"	5	1/6

*Rough Estimates

As an illustration of how the information was derived for Table 4.1. consider discing. Firstly the farmer was asked how many times he disced the pea paddock for the 1961-62 crop. His reply was "5". In answer to how many acres he disced per hour, the farmer was able to quote "3", and he illustrated this by saying how he derived the figure, working from the total tractor hours spent discing the paddock. Total tractor hours (50) stated by the farmer was checked by the author by the calculation:-

3 acres/hr x 30 acres = 10 hours for one discing.

5 strokes x 10 hours = 50 hours total.

The farmer knew from past experience the fuel consumption per hour for his tractor for the various operations. In this case his tractor consumed one and-a-half gallons of diesel fuel per hour when discing.

The estimate of labour hours was considered as the time the driver operated the tractor while discing (50 hours) plus the time taken to grease the discs, refuel the tractor and drive to and from the pea paddock. The farmer considered an extra six hours was involved in these latter tasks. He valued an hour of labour for discing at 7/- per hour, the rate he would have to pay a hired man to do the job.

The total hours the discs were worked, corresponded of course to the total tractor hours for the actual discing operation.

The estimate of the total costs per hour for machinery in the example of Table 4.1. was based on a costing analysis made by the farmer when he did a lot of agricultural contracting work. Only two other farmers in the survey were prepared to provide estimates of these costs. They also were agricultural contractors. Their estimates covered all running costs, such as repairs and maintenance, and grease, and overhead costs of depreciation and interest on the discs. The farmer of farm 23 estimated total costs per hour for discs at 2/6 per hour.

All other figures in Table 4.1., and in similar tables for all other farms, were calculated in similar ways to those described above.

4.3.5. Calendars. These are in essence tabulations. However, they proved to be so valuable that they deserve special comment. Two calendars were used. One for the pattern of land use for each paddock on the farm over the past three years (see Appendix A p.11), and one for what the farmers considered to be the "average" or "usual" pattern of labour use throughout a single year under the present farm management system (see Appendix A pp. 12 to 15). Both the labour use calendar and the land use calendar indicate the importance of the time pattern for labour use and land use respectively. Hence they indicate the importance of planning a management system with reference to timing farm operations to avoid clashes of labour use between activities. These calendars are similar therefore to land and capital "profiles" as used by workers in England. For example Stewart[4] points out that:-

> "Each coefficient in a labour profile, as customarily used in linear programming matrices, indicates the discrete per unit labour requirements of the relevant activity for a particular time period."

Similarly Harrison[5] was concerned with a capital profile. He states the concept of a capital profile thus:-

> "Three items are of particular importance in assessing the merit of any change which is planned in farm organisation. The surplus of receipts over expenses which it is anticipated will arise; the additional capital required to put the change into effect; the time period and the manner in which capital is needed

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4. "Farm Operating Capital as a Constraint - A Problem in the Application of Linear Programming", J.D. Stewart, The Farm Economist, 9 p.463, 1960.

5. "The Capital Profile as an Aid in Decision Making in Farm Management", A. Harrison, Journal Agricultural Economics, 12, No. 1, p. 64, 1956.

and income yielded over that period. The concept of the capital profile is designed to help in the assessment of these factors."

(i) The Land Use Calendar

The pattern of land use calendar, in conjunction with a sketch map of the farm, provided a complete picture of crop rotations for each paddock over the three seasons. One of the most important features was that it showed the period of time any particular crop occupied the land. For example boundary lines indicated the start of cultivation in the particular month for each crop in each paddock.

Table 4.2. illustrates a "completed" land calendar taken directly from the questionnaire of farm number 22.

By way of explanation consider paddock 3. A boundary line is shown in September 1959. At this time ploughing for potatoes began, the potato crop requiring land from September 1959 until the end of August 1960. From this time paddock 3 was used for pea production until January 1961, when cultivation for resowing back to pasture commenced. Thus from the calendar it is seen that potatoes require the land for eleven months and peas for five months. All other crops may of course be treated in a similar manner.

Once the calendar was filled in, repeated reference to it throughout the interview, enabled the farmer to visualize his pattern of land use over the past three years. By having the plan in front of him, he was thus able to confidently and quickly answer many questions which otherwise would have taken time while he tried to remember for example "what certain conditions prevailed when he grew tomatoes in paddock 4 in 1959." The actual time taken to complete the calendar as shown in Table 4.2. is more

TABLE 4.2:

PATTERN OF FARM OPERATIONS

THREE YEAR CALENDAR OF LAND USE.

		1959												1960												1961											
Paddock Number	Acres	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1	3.5		P		E		R		M		A		N		E		N		T				P		A		S		T		U		R		E		
2	12.0		P		E		R		M		A		N		E		N		T				P		A		S		T		U		R		E		
3	4.5		G	R	A	Z	E	D					P	O	T	A	T	O	E	S		P	E	A	S				P	A	S	T	U	R	E		
4	10.0		G	R	A	Z	E	D					TOMATOES							Stock Green Feed				P	O	T	A T	O E	S		(ROTTED)				PEAS		
5	5.0		G	R	A	Z	E	D					P	O	T	A	T	O	E	S		P	E	A	S				P	A	S	T	U	R	E		
6	1.5		P		E		R		M		A		N		E		N		T				P		A		S		T		U		R		E		
7	5.0		P	O	T	A	T	OES				PEAS		PEAS					RYEGRASS			SEED					G	R	A	Z	E	D			TOMATOES		
8	5.0		R	Y	E	G	R	A	S	S	S	E	E D			G	R	A	Z	E	D				TOMATOES						Green Feed Ryecorn				POTATOES		
9	5.0		R	Y	E	G	R	A	S	S	S	E	E D			G	R	A	Z	E D					TOMATOES					"		"				PEAS	
10	2.0		P	A	S	T	U	R	E			PEAS				R	Y	E	G	R	A	S	S	SEED			G	R	A	Z	E	D			TOMATOES		
11	1.0		P		E		R		M		A		N		E		N		T				P		A		S		T		U		R		E		
12	2.0		P		E		R		M		A		N		E		N		T				P		A		S		T		U		R		E		
13	3.5		P		E		R		M		A		N		E		N		T				P		A		S		T		U		R		E		

than justified when consideration is given to the substantial assistance it provides farmers when answering questions about farm management problems in subsequent sections of the questionnaire.

The land use calendar was also used as a cross-check on farmers' estimates of acreages of each crop grown in any particular year, as indicated by later answers. Any special features of the farm management plan shown on the calendar, together with a statement of general crop rotation policy, were noted on page eleven of the questionnaire. This system provided a clear picture of farm operations early in the interview, and enabled the interviewer to ask following questions with real interest and meaning for the farmer concerned.

(ii) The Labour Use Calendar.

The labour use calendar (see Appendix A, question 14 pages 12 to 15) was an attempt to find out when the major farm operations were carried out. Table 4.3. presents a small section by way of illustration, from data collected from farm number 20. It indicates the pattern of all work "normally" carried out on the pea crop. Note that each month is divided into weeks.

Ploughing for peas usually takes place in the last two weeks of September. The furrow is rolled, then the ground is worked by discs, harrows and roller, to a suitable seed bed usually in the first two weeks of October. Depending on the actual sowing date for peas, spraying is usually done about the middle of November. Harvesting takes place in the third or fourth week of December. Record marks as indicated in Table 4.3. were made in the questionnaire for every major operation on the farm. Thus a week by week description of the labour usage on the farm under "normal"

TABLE 4.3:

A SECTION OF THE CALENDAR OF

FARM OPERATIONS - LABOUR USE.

OPERATION	SEPT.	OCT.	NOV.	DEC.
PLOUGHING	------	-- Peas		
DISCING		---- Peas		
HARROWING		---- Peas		
ROLLING	------	---- Peas		
SOWING		------	Peas	
SPRAYING			---- Peas	
HARVESTING				Peas ------

or "average" conditions was achieved. A subjective appraisal of the record mark in this calendar provided a cross-check to question 50 page 32 of the questionnaire, which enquired as to the presence of labour requirement clashes of one activity with another at any period during the year. It also provided an illustration, when compared with the calendar of pattern of land use, of the differences between actual crop planting times, and times when farmers said they would like to plant them under "normal" conditions.

The two calendars provided a very satisfactory means of recording information quickly and accurately on the organisation of land and labour use. These, together with the other four types of questions already described in 4.3., enabled most of the information to be collected at the one interview with each farmer. This information was adequate for the cost accounting analysis, but a further visit was required to the farm on which the linear program was based. The second visit was necessary to obtain detailed information for estimating the input-output coefficients of the programming matrix. Much of this detailed information was not previously requested in the questionnaire.

4.4. Pretesting the Questionnaire.

No matter how carefully a questionnaire is drafted, there is always some doubt about its suitability under the conditions of the area to be investigated. As Hawke's Bay supports many varied systems of farming, the questionnaire had to be designed to cope with any of the systems likely to be encountered in the sample farms. Hence the length of the questionnaire. To find out whether the content of the questions and the form of the original questionnaire was satisfactory, it had to be tested. Two important points were observed:

(i) The questionnaire was tested on two farmers with management systems which it was thought would resemble those finally selected for the survey.

(ii) The questionnaire was tested under conditions similar to those in the study.

Information was obtained about the following: the time to complete the questionnaire; the logical order of the questions; the space needed for each answer; whether all items listed were relevant for local conditions; and assurance that items of importance had not been overlooked. From all these points and the opinions and suggestions of the pre-test farmers, the revised questionnaire (Appendix A) was completed. Pre-testing of the revised version was considered unnecessary. Experience gained from using the questionnaire in the field, indicated however, that certain sections could well have been modified as being unsuitable in their present form (see Section 4.3.2.). A great deal of time was unnecessarily taken up in obtaining the detailed information laid out in the lists of plant and equipment (pages 3 and 4), and buildings and yards (pages 5) of the questionnaire. The reason that these sections were not modified may be attributed to the author's inexperience prior to the survey, and the fact that a request was made to collect the above-mentioned data fully for possible use in a future study. The suggested improvements became apparent after the first five or six interviews. By that time it was too late to modify questions, and as a great deal of detailed information on plant, equipment and buildings had been collected by then, the decision was made to continue in the same manner. However, in cases where the <u>relevant</u> information to a particular study alone, takes more than two and-a-half hours to collect per interview, the author would strongly discourage anyone else from collecting extra data in the hope that it will be useful in the future. For further allied comments on the interview time factor, see section 4.5.

4.5. Limitations of the Questionnaire.

Some of the limitations specific to certain questions have already been dealt with in section 4.3. One of the major limitations was the length of the questionnaire. The average time taken to complete an interview was four and-a-half hours, and the maximum time taken was seven and-a-half hours. The average time was far in excess of the <u>maximum</u>

time usually recommended, of two and-a-half hours. Time in excess of this recommended period makes the task of interviewing difficult and tedious for both the interviewer and farmer.

At the time the survey was conducted, in February and March 1962, many farmers were busy with harvesting their late crops, and difficulties arose when arranging times for the interviews. This fact meant that two farmers had to withdraw from the sample. Also, the long time taken per interview caused difficulty in maintaining the farmer's interest. The problem was largely overcome, but towards the end of the survey, the author found that the strain in sustaining interview technique became great. A number greater than the 35 farmers interviewed would have required a second enumerator, or an extension of survey time from four weeks to a much longer period. By deleting the sections concerned with details of plant and equipment (pages 3 and 4); buildings and yards (page 5); all questions except questions 56 and 57 in the "Pea Marketing" section and all of the section concerned with the Advisory Services from the questionnaire, it would probably have been reduced by approximately one and-a-half to two hours, whilst still obtaining the really relevant data.

Other limitations were concerned with the questions asked, and layout. The sections on buildings and equipment, although not completely irrelevant were poorly designed for the purposes of this study. (In a study mainly concerned with detailed information on these items, then the format would be very satisfactory). In considering equipment, cultivation and harvesting machinery were the items of interest. These items only, should have been listed together with the relevant data on size, original value, present value, and use per annum. A follow-up question seeking information on major items of equipment necessary for cultivation or harvesting operations but not owned by the farmer should have been incorporated.

Buildings should have been listed together with their original and present values. The suggested modifications to the tables on buildings and equipment could have saved up to forty-five minutes of interview time.

Stock reconciliation tables were designed to accommodate all types of livestock activities encountered in the various farming systems. These tables could have been modified to record the basic stock policy, the appropriate numbers carried each year, the approximate numbers bought and sold each year and the periods these transactions took place. A broad outline only was needed for this portion of the questionnaire, and the main criticisms of the actual reconciliation tables was thattoo much detailed information was recorded. Modification of this section could well have reduced interviewing time by a further thirty minutes. It was not until part way through the survey that the author realized the great difficulty that farmers had in presenting accurate detailed records of stock numbers and transactions for a three year period.

The only other major deficiency concerns the table, question 38, page 27 Appendix A.[6] This table was poorly designed mainly from the viewpoint of space available. The main points of interest for each crop should have been listed to facilitate discussion, and to ensure that the important points were not overlooked.

The remainder of the questionnaire proved to be satisfactory, and valuable experience was gained from its use.

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6. Unfortunately this table is too large to include in the text.

PART II

CHAPTER 5

COST ACCOUNTING AND BUDGETING

One major objective in the evaluation of farming practices is often to help farmers to increase their farm profits. The ideal objective is of course, to maximise farm profits within the resources available to the farmer.[1] Generally, however, it is sufficient to raise the farmer from his present level of financial returns to a higher level.

The survey of Hawke's Bay pea growers was undertaken to provide information to a number of farmers in an attempt to assist them in making more confident decisions for improving their individual levels of farm returns. Determination of the profitability of growing peas would not enable them to maximize farm profits, but it could provide information which would help them to decide whether it was more profitable to grow peas than some other crop. Estimation of the profitability of individual enterprises may therefore be thought of as an attempt to provide a short cut to increased profits. If the "profit" on the individual enterprise could be determined, then the farmer could increase the amounts of these enterprises, with a corresponding increase in overall farm profits.[2] Basically there is only one safe way in evaluating this type of problem, and that is to find an alternative farm plan which is both feasible and more profitable than the

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1. This presupposes that the evaluation concerns the short term during which time the farmer may not increase the supply of his major resources such as land, capital, machinery etc.

2. The case however is not as simple as this. The "profitability" of an enterprise depends on the scale of the enterprise and the allocation of overhead costs. We really need to know therefore <u>how</u> profits are effected as the farm plan changes with increasing amounts of any single enterprise.

present plan. By definition this leads to a higher level of income. The rationale of cost accounting for individual enterprises rests on the hope that these individual enterprise results will assist the formulation of feasible and more profitable plans.

These two approaches may be illustrated by considering two main questions which arise when evaluating the profitability of growing peas. The first question is, "Will it pay farmers, in terms of a cash profit, to include peas in their respective farm plans?" The second question is rather more searching. "Could farmers make a bigger profit out of some other crop?" Both questions are relevant but the information required to answer them is rather different. Farmers tend to think in terms of the first question, and base many of their decisions whether or not to grow a crop purely on the basis of average per unit cash return. The second question however, is the really important one, because the answer to it, although more difficult to obtain, will provide all of the information necessary to make a correct decision as to which production alternatives should be included in the farm plan.

The first question can be answered after a fashion without knowing anything about alternative crops which could be produced instead of peas. It is only necessary to estimate the monetary worth[3] of the resources required for the production of peas. The principles of diminishing returns, marginal returns, marginal costs, substitution rates, competing crops and opportunity costs are ignored in answering this first question. These principles become evident however, in answer to the second question.

In answering the second question attention is directed towards finding

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3. "Monetary worth" means, here, something other than the opportunity cost of the resources. It refers to the actual monetary costs of the resources. Estimation of the correct value of resources, is of course, in reality a very complex problem.

the combination of resources between alternative production possibilities which will raise the level of farm income. Over the short term period, resources on a farm remain more or less fixed, hence enterprises will compete for their use. Alternative farm plans will be examined until the one which most profitably uses the available resources is obtained.

These two basic concepts illustrate different approaches when assessing the profitability of a particular crop. The first apparently simpler approach, leads the investigator to find out what has been done in the past. He examines the farm accounts and financial records to see how expenditure has been incurred in past years, because he will want to allocate costs to the activities in the farm plan, and see which activities have made profits. The second approach leads him to postulate and evaluate alternative farm plans for the future. This involves evaluation of total farm profit associated with each plan. In estimating future plans, however, there is a need for incorporating some information derived from the past.[4] Planning future farm operations requires agricultural training and skill, as there are more than financial considerations to be born in mind when dealing with alternatives of cropping and livestock enterprises. As opposed to this, a person with less training in agriculture would be able to allocate costs to activities. The first approach is called cost accounting and is similar to the method of determining profitability of individual enterprises as used in industry. Cost accounting is a method of splitting up total costs, so that total cost is allocated to individual activities. The resulting "cost" figures, which may not be related either

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4. Factors such as cultivation rates, seed and fertilizer rates, yields, stock carrying capacities, repairs and maintenance costs to machinery etc., observed from past years for a particular farm, will all be useful information for deriving future production plans.

to average or marginal cost in any real sense are called "average per unit costs." The second approach of estimating the most profitable whole farm plan with respect to setting down the different combinations of crops and livestock policies which can be produced and estimating which plan is most profitable, is called budgeting, and is often carried out with the aid of linear programming.

5.1. Cost Accounting.

The objective in cost accounting is to allocate all costs, in some more or less orderly way, to the various products produced. This results in a , so called, "average per unit cost."

In the case of a single product enterprise, to arrive at this "average per unit cost", it is only necessary to divide total cost by output.

In a multiple product firm, however, the existence of overheads means there is no unambiguous right way to arrive at average per unit costs. Any one way of allocating costs is referred to as a cost accounting convention. The above points may be illustrated by an algebraic definition of the meaning of "average per unit cost" and a "cost accounting convention."

We may consider a firm producing $i = 1, 2, ..n$, products. Say $i = 1$ for peas, $i = 2$ for rye-grass seed, and so on, where x_i is the output of the ith product. If c_i is the total variable costs incurred in the production of the x_i units of the ith product, and F is the total overhead (or fixed) costs incurred by the firm. Then any set of multipliers k_i ; $i = 1,2, ..n$, such that $\sum_{i=1}^{n} k_i = 1$, will result in the allocation of total overheads costs to the various products, if the ith product is imputed k_iF of the fixed costs. For a rational cost accounting convention it would be reasonable to insist that:

$$\sum_{i=1}^{n} k_i = 1 \qquad (5.1)$$

and

$$k_i \geqslant 0 \quad ; \quad i = 1,2, \ldots n \qquad (5.2)$$

Equations (5.1) and (5.2) may, then be taken to define an "acceptable cost accounting convention." For this convention, the corresponding "average per unit cost," for the ith activity would be defined as:

$$a_i = \frac{k_i F + c_i}{x_i} \qquad (5.3)$$

The dichotomy by which all costs can be split into fixed (or overhead) and variable costs, means that the "cost accounting convention" (5.1) and (5.2.); and, the definition of "average per unit costs" (5.3), result in the necessary identity:

$$\text{Total cost} \equiv F + \sum_{i=1}^{n} c_i \equiv \sum_{i=1}^{n} a_i x_i \qquad (5.4)$$

This latter identity; Total cost equals the sum of output multiplied by appropriate per unit costs, gives cost accounting much of it psychological appeal. The simple fact is, however, that <u>any</u> set of non-negative multiplies, summing to one, as given in (5.1) and (5.2), together with (5.3) will result in the identity (5.4). For instance the rule "allocate all overheads to peas" (or $k_1 = 1$; $k_2 = k_3 = .. = k_n = 0$) would make peas appear to be a costly crop to produce but it would not be inconsistent with identity (5.4).

The above definition of a cost accounting convention can be expanded to take account of the case where there are $j = 1,2, .., m$ classes of overheads. In particular, $j = 1$, might refer to managerial labour, $j = 2$

might refer to rates, ... and so on. F_j would then be the total expenditure on the jth overhead item, and we would have $\sum_{j=1}^{m} F_j = F$. In this case a cost accounting convention may be defined as a set of multipliers, k_{ij}, such that:

$$\sum_{i=1}^{n} k_{ij} = 1 \qquad ; j = 1,2, ..m \tag{5.6}$$

$$k_{ij} \geq 0 \qquad ; i = 1,2, .. n ; j = 1,2, ... m \tag{5.7}$$

The corresponding "average per unit cost," should then be defined as:

$$a_i = \frac{\sum_{j=1}^{m} k_{ij} F_j + c_i}{x_i} \tag{5.8}$$

The necessary identity still holds:

$$\text{Total cost} \equiv \sum_{j=1}^{m} F_j + \sum_{i=1}^{n} c_i \equiv \sum_{i=1}^{n} a_i x_i \tag{5.9}$$

<u>5.1.1. Theoretical Considerations of Cost Accounting</u>. As illustrated in section (5.1), cost accounting is a method for breaking up total firm costs so as to allocate them to individual activities in such a way that there is no residual. Any sort of rules which achieve this aim may be said to be an acceptable cost accounting convention. It is, however, desirable that these conventions not only allocate total costs without a residual, but also be reasonable and justifiable in common sense terms. No convention can be proved "right" since there is no <u>right</u> way of allocating costs. The very nature of fixed costs, is that they are not effected by marginal changes in output, and hence cannot rightly be charged to any one activity. No matter what cost allocation is made, cost accounting must still present difficulties. For example the cost accounting results may suggest expansion of one or more crops. But there may be absolute limits of resources available which will in

fact, prevent this expansion and which cannot possibly be identified, examined, or allowed for by cost accounting procedures.

The salient features of cost accounting have already been discussed in Section 5.1. Identities (5.4) and (5.9) show how total costs are divided into variable costs and fixed costs which are respectively costs of variable and fixed resources. Variable resources relate to those whose quantity is affected by output, while fixed resources relate to resources whose quantity is unaffected by (small) changes in output.

In economic terms there is a dichotomy between fixed and variable factors. The value of variable factors is <u>fixed</u>, because for example, more fertilizer can be bought at the fixed market price. On the other hand, the value of fixed resources is <u>variable</u> because this value attached to fixed resources is a function of the products which could be produced if more of the fixed resource was available. This in turn depends on known production alternatives, and the amount of other factors available to the farmer. This stresses the point that, in one sense, the real economic problem is concerned with the valuation of resources. Correct valuation may well involve violation of the acceptable cost accounting conditions in identities (5.1) and (5.2). There is, for instance, no real reason to expect the firm's total cost function to be a simple linear function of output. If the total cost function is non-linear, there is no reason to expect the calculated per unit average costs to have any sort of close relation to marginal costs. The discussions in sections 5.2 and 5.3 illustrate that budgeting and linear programming tend to solve the allocation and valuation problem simultaneously. That is, budgeting and linear programming are concerned with <u>how</u> resources should be allocated between production alternatives, and hence the value of additional units of scarce resources.

5.1.2. Practical Considerations of Cost Accounting. In practice some farm costs are easily observed and identified with single activities. Other variable costs however, may have been paid for in a lump sum. The petrol bill, for example, is usually paid for in a lump sum, but the petrol of course is used in various quantities for the production of each individual activity on the farm. Also, to be realistic, a certain amount may be used by the farmer for private consumption. Therefore, there is an element of guess or arbitrariness in allocating this type of "jointly paid for" variable cost. That is, each activity which uses petrol, must be debited with "its share" of the petrol bill, depending on how much petrol it uses. If the farmer has kept good operating records such as a"tractor diary", recording work done, and amounts of petrol used, then it would be possible to confidently allocate many of these "lump sum" variable costs. It is only reasonable to note, however, that the cost of keeping such records could well exceed the benefit to the farmer from having this information available.

Another difficulty in practice is encountered when attempting to allocate factors of repairs and maintenance and depreciation charges. Usually farm account books show a single cost item of repairs and maintenance, and no idea is given as to which particular items of machinery and equipment this refers. Similarly, depreciation schedules may not be very helpful. For example, a tractor may have been written off the books, and yet the farmer may still be doing a substantial amount of useful work with the tractor.

Because of these types of illustrated conceptual difficulties it is necessary to try and build up or synthesize some of these costs to be allocated to individual activities. Information such as total annual tractor hours, and tractor hours spent on each crop, is required to make the synthesis possible. Thus although the cost accounting identities (5.4) and (5.9) indicate an analysis for allocation of total costs, the very nature of some costs and the difficulties associated with their derivation, involves an element of synthesis of certain variable costs.

There may be several reasonable criteria for allocating costs according to the cost accounting procedure. Processing firms and farmers who may wish to use the cost accounting figures to guide them as to a reasonable price for a crop, can be expected to demand that the convention used is not only "acceptable" in the sense of section 5.1. but also "reasonable." Two alternative "reasonable" criteria are presented for illustration.

(i) Charge the activity on a per acre, per time basis. Much farm information is presented on a per acre basis, and as such it is readily understood by farmers. Costs such as fixed costs, may be expressed on a per acre basis; these apply to that acre for the full year. But where a crop occupies land for less than a full year, it is therefore "reasonable" to allocate fixed costs to the crop in proportion to the time the crop occupies the land.

Consider the situation of a crop to pasture rotation. Average per unit costs may be calculated for the crop according to the equation (5.8). However, using "the time land is in crop," to calculate the appropriate

k_{ij}'s a difficulty arises in defining "time land is in crop." One could charge the crop or the grass to fallow with the cost of regrassing or any period of fallow. The multiplier $(\frac{\text{months land in crop}}{12})$, (5.10), may refer to either the time from preparation of land for the crop until the same area is regrassed after the crop, or the time from preparation of land for the crop until the end of crop harvest. In the first instance the crop is debited with the costs of any fallow and regrassing, while in the second case neither of these costs is debited to the crop. Thus the crop in the first example will have a markedly increased average per unit cost compared with the same crop in the second example. Cost accounting as such, does not give any guidance as to which of the two alternatives should be chosen.

This points to one of the difficulties of cost accounting which is not encountered in budgeting. All that the cost accountant can do is to make a decision on the length of period he will consider, and state clearly what he has done.

(ii) Charge the activity on a gross revenue basis. This criterion may be considered as a form of pro rata taxation for each activity. That is, fixed costs are allocated according to the proportion of gross farm revenue earned by each crop. By way of illustration, consider again the crop to pasture rotation. The problem of allocating the variable costs of any fallow period and cost of regrassing as described in the previous section still remains. But the fixed costs for these periods are handled by the following method:-

A proportion of total farm fixed costs would be allocated to the crop according to the multiplier:

$$\left\{ \frac{\text{Gross crop revenue}}{\text{Gross farm revenue}} \right\} \qquad (5.11)$$

For any fallow period, which does not earn any revenue, fixed costs of course would not be allocated. Hence for allocation of fixed costs, this method does not consider the time factor, but is a function of the gross revenue earned by each activity.

The above two criteria are both "acceptable" cost accounting procedures, and illustrate the point that there is no "right" way of allocating fixed costs.

The foregoing discussion has illustrated that there are different kinds of costs which must be allocated by the cost accounting procedure. In fact there are at least four types of costs which are encountered.[5]

5.1.3. The Four types of Costs. As previously described (5.1.1.) there are two basic categories of costs, variable costs and fixed costs. Variable costs may be further subdivided into three types of costs, (i) "Observable" costs, (ii) "Synthesized" costs and (iii) "Allocated" costs. "Synthesized" and "Allocated" costs together may be termed "imputed variable costs." Fixed costs or "overhead" costs form the fourth type of cost.

(i) "Observable" Costs. "Observable" costs are those variable costs for which cash has been paid, the amounts of which may be obtained directly from invoices received by the farmer. Further, these costs may be obtained directly from the invoices for each particular enterprise. These costs present no problem of interpretation as they are direct costs. They are the only costs which can be claimed to be 100% accurate in a cost accounting

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5. Still further sub-division, including, for instance synthesized and "imputed" fixed costs would be possible. The classification given will suffice, however, to clarify the major procedural difficulties encountered in this study.

study.

Gross revenue for each enterprise may be included here, as it is also directly observable from receipts held by the farmer.

Inputs with observable costs are: seed, fertilizer, cartage, spray materials, and agricultural contractor charges.

(ii) "Synthesized" Costs. These costs are variable costs of factors for which cash has been paid in a lump sum. The total cost for each factor is obtainable directly from the farm financial information, but there is usually no direct indication of how much of the total cost was contributed by each enterprise. If a cost accounting formula is used to allocate this lump sum amongst enterprises, these costs may be described as "allocated" costs as discussed in the next section. It is possible, however, that the amount recorded for legal and taxation purposes are not closely related to the actual costs incurred. Petrol used for family running, is one example. Repairs and maintenance, which may include capital improvements, is another. With costs of this type it is necessary to build up or synthesize costs from other information. For example tractor fuel is usually bought in bulk for farm supply. In this study the amount used by each crop was calculated or imputed from tractor hours spent on each crop, and the fuel consumption per hour of the tractor for each operation. The appropriate market price for farm petrol was multiplied by the quantity consumed, to arrive at the "synthesized" fuel cost per crop. The very nature of these costs makes it essential to derive them by synthesis. This method is therefore not cost accounting as defined in 5.1., but gives a better estimate of the cost of producing crops than could be obtained by an "acceptable" cost accounting convention.

Items for which costs have been imputed or synthesized in this way are, fuel and oil, tractor and implement repairs, and maintenance.

(iii) "Allocated" costs. These variable costs are paid for in a lump sum, and are allocated to each activity by a cost accounting formula. Labour is the only item included in this category. If the labour price is assumed to be 8/6d. per hour, this allows the farmer approximately £900 in wages per year. Then, if this £900 is the total annual labour cost, the cost accounting procedure may be used to allocate this amount to all enterprises. The allocation of labour costs is completed in two cost accounting stages. This procedure is outlined in Section 5.1.4.

(iv) Overhead Costs. These are all fixed costs, and are allocated to each enterprise as illustrated in the identity (5.8). Previous mention has also been made of the criteria which may be used for allocating these costs (5.1.2. subsections (i) and (ii)), for example on a per acre per time basis, or on a gross revenue basis. Items included in this category of costs are: Tractor and implement overheads, land overheads, and general farm expenses. An illustration of how overhead expenses were allocated to single enterprises in the pea survey is given in section 5.1.4.

<u>5.1.4. Application to the Pea Survey</u>. In order to explain the general procedure for allocating costs to individual enterprises, examples are now given of the procedures used in the study to allocate labour costs and general farm expenses.

(i) Allocation of Labour Costs. The allocation of labour costs was completed in two stages.

Firstly, labour was charged at 8/6d. per hour which closely approximates a wage of £900 per year. The amount of labour directly associated with producing each enterprise was calculated from the number of hours the farmer said he spent on each operation for each enterprise. Once these "direct" enterprise labour costs had been estimated, they were totalled to give total annual "direct" labour costs. This may have amounted to say £600. That is, summing the individual labour costs which had been allocated to all the enterprises, we might find the farmer had "income in the role as farm labourer" of £600. On the assumption of a £900 return to the farmer this still left £300 of labour costs to be allocated among the enterprises. The remaining labour to be accounted for was considered as "overhead" labour and refers to the time a farmer spends walking over his farm, or say, arranging for a bank overdraft, or in general on tasks which are necessary for the running of the farm, but cannot be associated with any particular crop.

The second stage of the cost accounting procedure was to allocate the "overhead" labour. The method employed in the survey was to allocate total "overhead" labour by charging an activity according to the proportion of gross farm revenue it earned.

Thus the method used was:-

$$\pounds 900 \times \left(\frac{\text{Gross enterprise revenue}}{\text{Gross farm revenue}}\right) - \left\{\begin{matrix}\text{total variable costs of} \\ \text{labour charged to enterprise}\end{matrix}\right\}$$

$$= \left\{\begin{matrix}\text{Total "Overhead" labour} \\ \text{charged to the enterprise}\end{matrix}\right\} \qquad (5.12)$$

This is an "acceptable" cost accounting convention in terms of the general convention outlined in Section 5.1, and was the actual method used to achieve the cost accounting results.

At a late stage in the study, however, it was realised that this procedure had not achieved what the author intended. It was intended that enterprises be charged firstly for the labour used directly on the enterprise, and that to this should be added a portion of the residual (or "overhead" or "unallocated") labour the proportion that enterprise gross revenue bore to total gross revenue. This would have been achieved by the formula:

$$\left(\begin{matrix}\text{£900 - Total Variable}\\ \text{Cost of Labour}\end{matrix}\right) \times \left(\frac{\text{Enterprise Gross Revenue}}{\text{Farm Gross Revenue}}\right)$$

= "Overhead" labour charged to enterprise.

Looking back to the formula actually used (identity (5.12)), it is easy to see this can be re-arranged to give:

$$\begin{matrix}\text{Total Labour Cost}\\ \text{Charged to Enterprise}\end{matrix} = \left(\begin{matrix}\text{Total Variable + Total Overhead}\\ \text{labour charged to enterprise}\end{matrix}\right)$$

$$= \text{£900} \left(\frac{\text{Crop Enterprise Revenue}}{\text{Farm Gross Revenue}}\right) \qquad (5.13)$$

That is, the formula actually used resulted in the assumed £900 labour return to the farmer being allocated to enterprises in the proportion of enterprise gross revenue to total gross revenue.[6]

Both the above methods are "acceptable" cost accounting conventions. This illustrates the point that care must also be taken to ensure that the acceptable convention used is reasonable, and achieves the objectives of the cost analysis.

(ii) Allocation of General Farm Expenses. These expenses include general insurance, electric power, telephone, accountancy and legal fees, sundries and working expenses. Although some of these items do in fact

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6. This error is particularly irritating to the author since he went to considerable pains to get and use reasonably accurate estimates of crop labour requirements.

involve a direct cash outlay they cannot be attributed directly to any particular enterprise. The criterion for allocating overheads items adopted in the study was to charge an activity on a per acre, per month basis. Thus the method used was:

$$(\text{Total General Expenses}) \times \left(\frac{\text{Months land in crop x acres in crop}}{\text{12 x Total Farm Acres}}\right)$$

$$= (\text{Total general expenses charged to crop}) \quad (5.14)$$

The multiplier k_{ij} corresponding to the equations (5.6) and (5.7) is given by:

$$\left(\frac{\text{Months land in crop x acres in crop}}{\text{12 x Total Farm Acres}}\right) \quad (5.15)$$

Hence:-

$$\left(\frac{\text{Total general expenses x } k_{ij}}{\text{Acres in crop}}\right) = (\text{Total general expenses charged per acre of crop}). \quad (5.16)$$

In this formula, the "months land in crop" or k_{ij} can be ambiguous as already described in subsection (i) of 5.1.2. Once again this points to the fact that there is no "right" way of allocating overheads. Regardless of the accuracy with which costs are observed, even to the extent of the cost-route method of data collection, the inherent problem of allocating fixed costs by cost accounting methods remains. So long as fixed costs are met by the total returns from all enterprises they need not necessarily be met by any one particular enterprise.

Because of the difficulties associated with allocation of fixed costs to a single enterprise, the only figure to which any real meaning can be attached is the gross margin. Gross margin is given by:

Gross margin = Gross returns - Variable Costs (5.17)

It is important to remember that the "average per unit cost" derived by a full cost accounting analysis, which of course includes both variable costs and fixed costs, bears no direct relationship to marginal cost. Economic decisions should, of course, be related to marginal costs.

5.2. Budgeting.[7]

Budgeting basically involves the construction of a physical production plan for a farm by selection of a set of outputs which will be operable within the physical resources available on the farm. Determination of the set of products requires close examination of the way each product will be produced, and hence the technical restraints are carried along more or less consciously throughout the budgeting procedure. For example, land restraints will probably be checked explicitly, a stock reconciliation will normally be carried out, but the possibility of a feed shortage may not be gone into very carefully. The financial implications of the plan are derived at the same time, which implies in turn, derivation of costs and returns. This budgeting is primarily concerned with what the financial implications will be for the farm as a whole with a projected allocation of resources between activities. That is, budgeting is done <u>ex ante</u>. Budgeting of alternative plans, allows a step by step approach to (but not necessarily attainment of) the most profitable farm plan.

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7. The concept of budgeting has been well documented in the selected references:
"Farm Management Analysis," L.A. Bradford and G.L. Johnson, Wiley and Sons Inc., New York, 1953.
"Farm Management," J.D. Black, The MacMillan Co., New York, 1947.
"Farm Management Economics," E.O. Heady and H.R. Jensen, Prentice-Hall Inc., 1954.

One type of problem encountered in cost accounting was the difficulty of deciding whether a crop or the grass to follow should be charged with the costs of regrassing. In budgeting the investigator thinks in terms of all variable costs involved on the farm in changing the status quo. As long as all variable costs are accounted for in the plan, he is not concerned with the problem of which single enterprise should be charged with regrassing costs. Conclusions drawn from budgeting are made on total net profits above fixed costs. In short-term budgeting, fixed costs do not enter into the calculations.[8] Thus total net profit is the criterion for success. As long as it can be shown that one combination of enterprises is more profitable than another, it is not necessary to say which enterprise is "responsible" for the increase in net profit.

5.3. Linear Programming.

Linear programming is a mathematical form of budgeting. It has been used by agricultural economists for such problems as specifying the optimum organisation of resources and enterprises on farms, and for suggesting desirable farm adjustments. Ordinarily the objective of linear programming in the sphere of agriculture, will be one of maximizing or minimizing quantities. Where the objective of a study is to maximize farm profits, then linear programming can be used to attain the most profitable farm plan.

Within a linear programming model, a large number of production possibilities or activities are defined which could be operated on a particular farm; the physical restraints which will prevent excessive production of any one activity are specified explicitly; and per unit marginal revenues are

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8. Fixed costs, e.g. land overheads, must be paid even if nothing is produced on the farm. Hence returns above fixed costs only are considered.

calculated. Then within the limits of the restrictions the optimum set of products is derived. The body of information for a linear program is difficult to derive for a farm. This involves the per unit requirements of activities for each resource. It requires considerable agricultural knowledge, and several visits to a farm to obtain this information, and even then many estimates have to be made because some production alternatives may never have actually been produced on the farm, and yet should be considered. The deficiency in available data is one of the major limitations to wider practical use of linear programming, but is not, of course, a fault of linear programming itself.

Once the data is obtained, and a solution derived, it is then necessary to check the results with the farmer. Consideration must be given to the plausibility of allocation of resources to the activities in the final plan and to the sensibility of the maximum total net returns. In addition to this information, the linear program solution provides the marginal product values of the limiting resources, and an indication of the change in net revenue which would be required to bring an excluded activity into the program. It is important to check that <u>both</u> the suggested <u>allocation</u> of resources, and the suggested <u>valuations of</u> restraints are reasonable.

Linear programming has been used to analyse the profitability of pea growing on the survey farm number 23. This is reported in Chapter 7. The farmer's comments on the program plan are recorded in Chapter 8.

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CHAPTER 6

DETAILS AND RESULTS OF THE COST ACCOUNTING PROCEDURE.

The last chapter illustrated the cost accounting conventions and discussed four types of costs encountered in this study. This chapter deals with the ways total costs were derived and allocated to single enterprises according to the cost identities and other considerations given in Chapter 5.

6.1. Identities Used in the Cost Accounting Study.

The identities used in the cost accounting study were:

"Observable" Costs + Imputed Variable Costs
= Total Variable Costs (6.1)

where

Imputed Variable Costs = "Synthesized" costs
+ "Allocated" Costs

Gross revenue - Total Variable costs = Gross margin (6.2)

Gross revenue - Total variable Costs - Imputed fixed costs
= Gross margin - Imputed fixed costs = "Profit." (6.3)

$$\frac{\text{"Profit"}}{\text{Output}} = \text{"Average per unit returns."} \quad (6.4)$$

Similarly:

Total variable cost + Imputed Fixed costs = Total costs (6.5)

$$\frac{\text{Total Costs}}{\text{Output}} = \text{"Average per unit Costs"} \qquad (6.6)$$

and

$$\frac{\text{Gross Margin}}{\text{Output}} = \text{Average per unit gross margin} \qquad (6.7)$$

6.2. Derivation and Allocation of Individual Costs.

Within each equation in Section 6.1. there are a number of components for which costs must be derived. The various ways these individual costs were determined for each enterprise are now presented.

6.2.1. Gross Revenue and "Observable" Costs.

(i) Gross Revenue. Gross revenue was obtained from the receipts sent to the farmer by the processing factory or trading company. It is the actual amount paid to the farmer based on the weight and grade of product produced. Where applicable, the Vegetable Growers' Federation levy of 3/8 of 1% of gross returns was deducted.

(ii) "Observable" Costs. Costs of seed, fertilizer, cartage and spray materials of each enterprise, were obtained from the invoices of the respective variables, received by the farmer. These costs present no problem of interpretation or allocation.[1]

6.2.2. "Synthesized" Costs.

As pointed out in the previous chapter, derivation of these costs is not cost accounting in the sense defined in Section 5.1. The reason being that actual costs of variables in this category were obtainable as annual lump sum payments, but indices of use by

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1. Agricultural contractor charges are also straight cash costs. However, as all farmers did not employ contractors, and while those who did, employed contractors for different cultivation operations, contract services were included under "Allocated" costs.

each enterprise were not available. Hence values to these variables were synthesized from side information obtained from farmers concerning management practices, and from other information obtained from New Zealand sources[2] other than the farmers surveyed. Synthesis of costs from side information was considered to be more reliable than an arbitrary break up of the global figures appearing on the farmer's balance sheet.

The variables included in this group of costs were tractor fuel and oil, and tractor and implement repairs and maintenance.[3]

(i) Fuel and Oil. Some of the farmers surveyed kept a record of the annual fuel and oil expenditure for the tractor, but only one kept a record of consumption for each enterprise. Most farmers were able to supply estimates of tractor fuel and oil consumption on the various operations of ploughing, discing, rolling, harrowing, drilling, general farm "hack-work" and the like. They could also give the number of times an operation was performed for each crop and the acres covered per hour for that operation. In this form farmers were able to supply all the information necessary to estimate fuel and oil costs for each crop. The use of this information is illustrated for deriving fuel and oil costs per acre of peas for Farm number 23.

Example 6.1. (page 87), illustrates how fuel and oil costs were synthesized.

(ii) Tractor Repairs and Maintenance. Estimates of repairs and maintenance costs for tractors were not obtainable from farmers or the N.Z. Department of Agriculture. Farm profit and loss accounts typically

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2. These included N.Z. Department of Agriculture Advisory Officers, N.Z. Farm Machinery Texts, N.Z. Insurance Companies, and the N.Z. Post Office.

3. Depreciation on tractor and implements may also be considered as a "synthesized " cost. However, it is also an overhead cost and therefore may be considered as a "synthesized" overhead cost. For this reason, depreciation is dealt with under imputed fixed costs.

EXAMPLE 6.1: Fuel and Oil Costs Per Acre of Peas (Farm No. 23).

OPERATION	AVERAGE HRS/AC.*	DIESEL FUEL CONSUMPTION**	FUEL AND OIL COSTS. (£'s)
Plough	0.67	1.5 gals/hr.	0.10
Disc and Harrow	1.65	1.5 " "	0.24
Cultivate	0.50	1.5 " "	0.07
Harrow	0.85	1 gal/hr.	0.08
Roll	0.20	1 " "	0.02
Drill	0.20	1 " "	0.02
Spray	0.16	1 " "	0.02
Total Fuel and Oil Costs per acre of peas			£0.55

* Average hours per acre refers to average tractor hours per acre. Average tractor hours per acre is derived by: (Hours per acre x number of strokes).

** In addition to diesel fuel consumption, oil consumption was calculated at 1.5 gallons per 100 tractor hours, which is equivalent to 0.015 gallons per hour.

The cost of diesel fuel = 1/8.5 per gallon
The cost of oil ≠ 16/- per gallon.

contained a lump sum for "repairs and maintenance," but there was no indication of how much of this annual cost was attributable to each item of machinery, nor indeed whether this included items of a capital nature. Consequently estimates in this study were built up from work by McLay and Garrett[4]. These workers provided estimates of repairs and maintenance for various classes of tractor. A

4. "Implements and Cultivation," A.K.McLay and H.E. Garrett, Canterbury Agricultural College Rural Education Bulletin, February-May, 1959.

total cost to repairs and maintenance of 50% of the original new cost of the tractor was used, this sum being spread over an assumed economic service life (ten years or 10,000 hours) of the tractor. McLay and Garrett say this estimate of the repairs and maintenance cost "covers all repairs and maintenance likely to be encountered, including tyre replacements where necessary, but it makes no allowance for farm labour involved in general maintenance work, and greasing and changing oil."

In order to take account of employed labour for maintenance work, for example, to pay for transportation and a mechanic's time to obtain parts, and pay a wage to a mechanic doing the work, an extra 25% of new tractor price was added to the 50% covering total repairs and maintenance materials.[5]

EXAMPLE 6.2: Total Tractor Repairs and Maintenance

New Cost of Tractor	£1,000
Total repairs and maintenance materials at 50% new cost	£500
Hired labour on repairs and maintenance at 25% new cost	£250
Total Repairs and Maintenance at 75% new cost	£750

If employed labour on repair work is considered at an average rate of 15/- per hour (approximately equivalent to a mechanic wage rate), the total number of hours (333 hours) spent on this work is equivalent to 3.3% of the service life (10,000 hours) of the tractor. If anything this estimate is probably conservative.

Having thus derived total repairs and maintenance over the economic life spah of the tractor, an hourly charge was calculated in one of two

5. It should be noted that if the farmer did all the repairs and maintenance himself, then the 25% labour allowance allowed here would not apply, since if allowed here, then "double counting" of farmer's labour for repairs and maintenance will result, because of the estimation of farmer "overhead" labour in section 6.2.4. part (iv). The time spent on machinery repairs and maintenance by the farmer was not collected during the interview. It is now realised that it should have been.

ways.[6]

The first method assumes the tractor reaches the end of its economic life before it becomes obsolete. That is, 10,000 hours are worked in less than ten years, or on average the vehicle works more than 1,000 hours per year.

Therefore:-

$$\text{R and M per hour} = \frac{\text{Total R and M } (\cong \text{ 75\% new cost})}{10{,}000}$$

The second method assumes that the tractor works less than 1,000 hours per year. Obsolescence then causes the tractor to be "dumped" (no salvage value) before it has worked 10,000 hours.

In this case:-

$$\text{R and M per hour} = \frac{\text{Total R and M } (\cong \text{ 75\% new cost})}{\text{Hours worked per year x 10 (service life in years)}}$$

$$= \frac{\text{Total R and M } (\cong \text{ 75\% new cost})}{\text{Hours worked during the tractor's life.}}$$

The actual method chosen from the above two examples was determined by the number of hours each farmer said his tractor worked per year.

By calculating the repairs and maintenance cost on an hourly basis, the imputed value per crop acre was readily derived by:

(R and M per hour x Total tractor hours per crop acre)

= R and M per acre of crop.

Alltractor repairs and maintenance costs were synthesized in this way.

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6. It was assumed that a tractor has a service life of ten years or 10,000 hours, whichever is reached first, and that it has no salvage value.

(iii) Implements: Repairs and Maintenance.

The implements costed in this study were all tractor-drawn cultivation implements.[7] They included plough, disc, harrows, roller, drill, tiller, spray unit, rotary hoe, mower and side rake. Variable costs associated with these implements involved repairs and maintenance charges only. Unfortunately no New Zealand data was available for imputing repairs and maintenance costs to implements. Bainer, Kepner and Barger[8] suggest values for estimating annual repairs and maintenance charges under United States conditions. The annual average charges suggested are:-

> " ...charges for repairs, maintenance and lubrication of various implements, expressed as a percentage of the original new cost of the machine. In the case of tillage implements, the costs of sharpening and replacing shares and other soil-working units are included. ..... The suggested rates are intended to represent an amount large enough to keep the machine in good repair, pay for transportation and a man's time to obtain parts, and pay a wage to the mechanic doing the work."

The suggested values are given in Table 6.1.

As the American writers state:

> "It should be kept in mind that the charges indicated (in Table 6.1) are for normal amounts of annual use, ranging from 50 to 150 hours per year for most machines ......"

The American annual average values were used in this study and are not thought to differ greatly from New Zealand conditions. In particular, the hours worked per year as calculated for implements under Hawke's Bay conditions all came within the suggested range. Total hours worked per year

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7. Where equipment such as header harvesters, hay balers, potato diggers, potato planters, potato moulders and corn pickers were encountered which were owned by the farmers (and these cases were few) no attempt was made to carry out a detailed implement costing, because of a complete lack of information. In such cases contractor rates were charged.

8. "Principles of Farm Machinery," R. Bainer, R.A. Kepner and E.L. Barger, John Wiley and Sons, New York, 1960, p.36.

TABLE 6.1:

SUGGESTED VALUES FOR ESTIMATING ANNUAL REPAIR, MAINTENANCE, AND LUBRICATION CHARGES
(After Bainer, Kepner and Barger)9/

TYPE OF MACHINE	AVERAGE ANNUAL CHARGE PER CENT NEW COST.
Plough	7.4
Discs	3.5
Harrows	1.1
Roller	1.5
Drill (13-coulter)	2.2
Cultivator (11-tine)	3.8
Spray Unit	4.0
Rotary Hoe	6.8
Mower	4.2
Side Rake	2.5

for each implement were calculated from the total hours each implement was used for each crop.

The repairs and maintenance cost per hour for a particular implement was obtained by dividing the appropriate annual average charge by the number of hours the implement worked per year. Finally the imputed cost per crop acre was derived by:-

(R and M per hour x Hours implement worked per crop acre)

= R and M per acre of crop.

Example 6.3 indicated how repairs and maintenance costs per acre of peas for all implements were derived for farm number 23.

6.2.3. "Allocated" Costs. Two variables are included in this group of costs, contract charges and labour costs.

9. Ibid., p.36.

EXAMPLE 6.3:

Implement Repairs and Maintenance Costs

Per Acre of Peas.

Implement	Average Annual Charge (£)	Total Hours Worked Per Year	*R and M per hour (£s)	Hours per pea acre	R and M per pea acre (£s)
Plough	10.87	118	0.09	0.67	0.06
Discs	5.88	290	0.02	1.65	0.03
Cultivator	2.85	88	0.03	0.50	0.02
Harrows	0.68	150	0.01	0.85	0.01
Roller	1.68	35	0.05	0.20	0.01
Spray Unit	3.00	81	0.04	0.16	0.01
Total Implements Repairs and Maintenance per Pea Acre					£0.14

* Taken to the nearest £0.01.

(i) Contract Charges. Agricultural contractor charges should be more correctly be classed under "observable" costs. These costs are obtained directly from invoices held by the farmer and hence can be allocated directly to each enterprise. However as pointed out in footnote 1. of this chapter, all farmers did not emply contractors, and those who did so, employed them for different cultivation operations.

The reason contract charges were not included in "observable" costs therefore, was to try and standardize "observable" costs for all farms for the benefit of the survey farmers. A bulletin was circulated to these farmers indicating "observable" costs for each crop. The inclusion of contract charges as an "observable" cost would have made it more difficult for farmers to make comparisons between farms on the basis of seed, fertilizer and spray costs. The variation in "observable" costs between farms was of interest to farmers because of the various seeding rates, fertilizer applications and spray applications employed by growers. For this reason contract charges were included in "allocated" costs.[10]

(ii) Labour Costs. Labour Costs are allocated according to the definition of cost accounting in section 5.1. That is, the total cost of farmer labour is allocated to all enterprises so that there is no residual. It was, therefore, necessary to find out the total annual cost of the farmer's labour.[11]

Provision was made in the questionnaire (Appendix A pages 6 and 16) to find out the rate of payment for permanent hired labour, and also at what rates farmers considered an hour of their own time was worth on various

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10. Farmers who used contractors saved on their own tractor expenses. Farmers who did not employ contractors had correspondingly higher tractor expenses. But pooling of "synthesized" costs and "allocated" costs to imputed variable costs means both situations were included under the same heading.

11. No allowance was made for a reward for management skills in the cost structure; the net profit for the enterprises is interpreted as having to cover this charge.

operations. Farmer estimates of their own worth on an hourly basis varied from 6/- to 25/- per hour. The farmer's labour was, however, charged at the same rates as for permanent hired labour.

Various estimates were available for imputing labour costs. These included contract labour charges at 10/- per hour and farmer estimates of actual wages which must be paid to obtain hired labour. These estimates ranged from 7/- to 10/- per hour, with the mean of nineteen farms being 8/6 per hour.

Under normal conditions, contractors' labour charges are usually higher than those actually paid to farm labourers. Wage rates were therefore based on 8/6 per hour. This was acceptable to most farmers. All permanent farm labour for all farm operations for all crops was charged at 8/6 per hour.

This wage rate closely approximates an annual wage of £900, and was taken as the total annual labour cost to be allocated to all enterprises. The two stage process of allocating total labour costs has been dealt with in 5.1.4. This above section points to the fact that labour costs can be considered to comprise a variable component (direct labour costs) and an "overhead" component (the costs of labour not directly associated with any particular enterprise).

Hence "allocated" labour costs in this section is only concerned with the direct variable labour costs allocated to each enterprise. The residual labour cost:

£900 - Direct Labour Costs = "Overhead" labour or residual labour costs

is dealt with in the section on imputed fixed costs (6.2.4. subsection (iv)).

Variable labour costs were allocated on the basis of the number of hours the farmer said he spent on each operation for each enterprise. Any hired labour employed in the production of an enterprise was also included in this section of costs.

Calculation of all costs mentioned so far, for example "observable" costs, "synthesized" costs and "allocated" costs, provides total variable costs. Hence identity (6.2.) can be calculated. That is:

(Gross revenue - Total variable costs) = Gross margin.

The allocation of total fixed costs is now considered. This allows average per unit returns to be obtained.

6.2.4. Fixed Costs. Cost accounting demands that total farm costs be allocated amongst the farm enterprises. The ways of allocating the component fixed factors are dealt with separately for overheads of tractor and implements, land overheads, general farm expenses and labour overheads.

(i) Overheads of Tractor and Implements. These may be considered under the single item of overheads of farm machinery. Farm machinery overheads include depreciation, (an annual cost plus interest on invested capital), and sundry costs such as registration, insurance and shelter. Like the variable costs of repairs and maintenance, machinery overheads must be synthesized. Overhead items appear in farm financial records, such as the depreciation schedule. But the method by which these estimates are derived is not indicated. As farm financial records are compiled mainly for taxation purposes, depreciation is often based on a much shorter economic machine life than would be justified on the basis of wear.

It is therefore necessary to synthesize overhead costs for each machinery item to obtain annual overhead costs, before they can be allocated to invidivual enterprises.

Depreciation and Interest:

Various methods are available for calculating depreciation.

Firstly there is the straight-line method, which is the simplest and most commonly used. It gives a constant annual charge for depreciation throughtout the life of the machine. In the straight-line method, the amount of the annual depreciation is equal to the new cost minus the resale or salvage value, divided by the estimated life in years. As in this study, many investigators consider that a machine will have no salvage value at the end of its economic life. Interest on invested capital must also be allowed. Strictly speaking, the charge for interest should decrease over the life of the implement as the value decreases. But the straight-line method assumes a constant annual charge. Thus the interest charge is calculated on the basis of the average investment during the life of the machine. With straight-line depreciation the average investment is usually half the sum (50%) of the new cost (assuming no salvage value). The rate of interest should reflect prevailing rates.

EXAMPLE 6.4: Straight-line Method for Imputing Average Annual Depreciation and Interest Charges.

Imputed constant annual charge for depreciation:

Assume new cost of machine	=	c	=	£1,000
Economic service life in years	=	n	=	10

∴ Constant annual charge for depreciation

$$\frac{c}{n} = \frac{£1000}{10} = £100$$

Imputed constant annual charge for interest:

Assume interest rate	=	r	=	6%
Average investment of capital	=	k	=	50% (of new cost)

∴ Constant annual charge for interest:

$$r \times k \times c = £\frac{6 \times 50 \times 1000}{100 \times 100} = £30$$

∴ Total average annual depreciation and interest charges = £130.

The total average annual cost is then reduced to a per hour estimate by:

$$\frac{\text{(Total average annual cost)}}{\text{(Total hours machine worked per year)}}$$

To obtain the depreciation and interest cost per acre of crop, it is then only necessary to multiply the per hour cost by the average number of hours worked per acre of crop.

The second method involves the formal calculation of a single annual sum to cover depreciation and interest. It is less arbitrary than the first method and is the method adopted in this study. It may be considered as a "sinking fund" method.

A single sum is required, which paid year after year (up to the end of the economic life of the machine) will just enable a new machine to be bought, and which will pay interest on all sums outstanding on the machine. The situation may be thought of as an overdraft situation.

EXAMPLE 6.5: "Sinking-Fund" Method for Imputing Average Annual Depreciation and Interest Charges.

Let new cost of machine	=	c	=	£1000
Economic service in years	=	n	=	10

(no salvage value at the end of this time)

Interest rate = r
Annual overdraft repayment = A

At the end of year one, the machine owner has an overdraft of c =£1000, less an annual repayment A, plus interest on the outstanding overdraft which he must pay.

Thus at the end of year one, the annual payment is:

$$(c - A)(1 + r) = c(1 + r) - A(1 + r)$$

Similarly at the end of year two, the annual repayment is:

$$\left[c(1+r) - A(1+r) - A \right] (1 + r) = c(1+r)^2 - A(1+r)^2 - A(1+r)$$

At the end of year n (n = 10), the final annual repayment is:

$$c(1+r)^{10} - A(1+r)^{10} - A(1+r)^9 \ldots\ldots\ldots\ldots\ldots - A(1+r)^2 - A(1+r) = 0$$

At this stage no further repayments are made because total depreciation has been accounted for, and interest on all outstanding sums have been paid.

An estimate of the annual repayment A, can now be obtained.

Equating the expression for years 1 to 10:

$$c(1+r)^{10} = A(1+r)^{10} + A(1+r)^9 + \ldots\ldots + A(1+r)$$

Let $d = \frac{1}{1+r}$

and dividing by $(1+r)^{10}$

$$c = A + Ad + Ad^2 + \ldots\ldots Ad^9$$

or $c = A \sum_{i=1}^{n} d^i \qquad i = 1, 2, \ldots\ldots n.$

$$\therefore A = \frac{c}{\sum_{i=1}^{n} d^i}$$

Having thus derived the annual repayment for depreciation and interest on invested capital, the cost may be allocated per acre crop by the procedure outlined for the first method. That is, first calculate the annual repayment per hour, and multiply this estimate by the average number of hours worked per acre of crop.

The second procedure outlined above for synthesizing annual depreciation and interest charges was used for calculating the overhead costs of tractors, ploughs, discs, harrows, rollers, drills, cultivators, spray units and side rakes encountered in this study.

Table 6.2 shows the service life in years and total hours, on which calculations of machine overheads were based.

TABLE 6.2:

ESTIMATES OF ECONOMIC SERVICE LIFE OF VARIOUS FARM MACHINES

Machine	Service Life	
	Years	Hours
Tractor	10	10000
Plough	15	3750
Discs	12	2400
Harrows	15	3750
Roller	15	3750
Drill (13 coulter)	15	2000
Cultivator (11-tine)	12	3000
Spray Unit	10	-
Rotary Hoe	10	2500
Mower	10	2000
Side Rake	15	3750

The figures in Table 6.2 for the various machines were derived from farmer estimates recorded on page 3 of the questionnaire (Appendix A). These estimates are somewhat lower than machine service lines as indicated by McLay and Garrett.[12]

Sundries:

Sundry overhead costs include registration, insurance and shelter for machines where these three factors are applicable. Not even lump sum annual costs for these items were available from farm financial data. An estimate obtained in the literature describing allocation of sundry overhead costs was found in U.S.A. work by Bainer, Kepner and Barger.[13] These workers suggested an overall average annual cost of 1.50% of the new cost of a machine be charged to cover the sundry overheads.

Table 6.3. sets out details of sundry overhead costs as derived from New Zealand sources,[14] with respect to farm tractors. The average of these New Zealand estimates check reasonably well with the American estimate.

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12. "Implements and Cultivation," A.K. McLay and H.E. Garrett, Canterbury Agricultural College Rural Education Bulletin, February - May, 1959.

13. For reference see footnote 8. in this Chapter.

14. Information in Table 6.3. was obtained from the New Zealand Post Office, and New Zealand Insurance Company.

TABLE 6.3:

AVERAGE ANNUAL SUNDRY OVERHEAD EXPENSES FOR FARM TRACTORS UNDER NEW ZEALAND CONDITIONS.

Insured Value of Tractor(£)	Insurance Premium (£)	Registration ("E" Plates)	Shelter Allowance	Total Average Annual Sundries(£)	PER CENT NEW COST
600	5.16.6	7/6	1.7.0	7.11.0	1.16
650	6. 1.6.	7/6	1.7.0	7.16.0	1.15
700	6. 6.6.	7/6	1.7.0	8. 1.0	1.12
750	6.11.6	7/6	1.7.0	8. 6.0	1.04
800	6.16.6	7/6	1.7.0	8.11.0	1.01
850	7. 1.6	7/6	1.7.0	8.16.0	1.00
900	7. 6.6	7/6	1.7.0	9. 1.0	0.95
950	7.11.6	7/6	1.7.0	9.6.0	0.94
1000	7.16.6	7/6	1.7.0	9.11.0	0.92
1100	8. 6.6	7/6	1.7.0	10. 1.0	0.90
				Mean =	1.02%

Notes on Table 6.3:

(a) The insurance premium includes insurance for a comprehensive cover on the machine, plus 1/- per cent for earthquake and war damage.

(b) Registration under "E" plates for a tractor is standard at 7/6 per year. This sum comprises 7/- third party insurance and 6d. label fee.

(c) An allowance for shelter of the tractor was derived from information contained in a Farm Management Guide to Cost and Prices. 15/ Estimation of shelter costs for a tractor and implements was made in the one calculation, and was applied to all farms.

Derivation of Average Annual Shelter Costs for a Tractor and Implements:

15. "Farm Management Guide to Costs and Prices 1962-63", Farm Management and Agricultural Economics Department, Massey University College of Manawatu 1963, p. 42.

Assume a £100 wooden building.

Insurance at 3/- percent	= 3.0
Depreciation at 2.5 percent	= £2.10.0
Total average annual shelter costs	£2.13.0

(Interest on the capital invested in the building is accounted for in general farm expenses - see Section 6.2.4. subjection (iii)).

It was assumed that half shelter costs are allocated to the tractor,

i.e. Tractor shelter costs = £1.6.6.

and half shelter costs are allocated to implements

i.e. Implements shelter costs = £1.6.6.

Say £1.7.0. each for the tractor, and implements.

Table 6.3 shows that the average annual sundry overhead costs, expressed as a percentage of new cost of the tractor is 1.02% of new cost. However, for all calculations a figure of 1.20 of new cost was used. This figure is slightly lower than the American estimate of 1.50%.

Calculation of the average annual sundry overhead costs for farm tractor-drawn implements was based on the same procedure as adopted for tractors. Table 6.4 sets out details of sundry overhead costs for the various price ranges of tractor-drawn implements.

TABLE 6.4:

AVERAGE ANNUAL SUNDRY OVERHEAD EXPENSES
FOR TRACTOR-DRAWN IMPLEMENTS UNDER N.Z. CONDITIONS

Insured Value of Implement	Insurance Premium	Shelter Allowance	Total Average Annual Sundries	Per Cent New Cost
100 and less	2.8.0	3/-	2.11.0	2.28
110	2. 9.0	3/-	2.12.0	2.17
120	2. 9.0	3/-	2.12.0	2.11
130	2.10.0	3/-	2.13.0	1.95
140	2.11.0	3/-	2.14.0	1.80
150	2.11.0	3/-	2.14.0	1.73
160	2.12.0	3/-	2.15.0	1.63
170	2.13.0	3/-	2.16.0	1.61
180	2.13.0	3/-	2.16.0	1.50
190	2.14.0	3/-	2.17.0	1.48
200	2.14.0	3/-	2.17.0	1.43
350	3. 2.0	3/-	3. 5.0	0.85
			MEAN =	1.71%

Notes on Table 6.4:

(a) Tractor-drawn implements are generally insured for an amount close to their new value.

(b) The insurance premium is that allowed for a comprehensive cover, less 15% of the premium of the insured value for tractor-drawn implements. In addition 1/- percent insured value is added in all cases for earthquake and war damage cover.

(c) From the notes on Table 6.3. part (c), shelter expenses to be covered by all farm implements are at the rate of £1.7.0 per year. An assumption was made that on average, all farms would have nine implements under cover. Therefore the allocation of shelter expenses per implement is 3/- per year.

From Table 6.4 the average annual sundry overhead costs expressed as a percentage of new cost of implements is 1.71%. However, for all calculations a figure of 2% was used. This figure is slightly higher for implements, than the American estimate of 1.5%.

Given the above procedures for imputing average annual tractor and implement overheads, the proportion of these costs allocated per acre of each single enterprise may be readily derived. The average annual cost is divided by the number of hours worked per year to give the overhead cost per hour. Overhead cost per hour is then multiplied by the number of hours a machine works per enterprise acre, which gives the overhead cost per enterprise acre.

The method employed for imputing values to tractor and machinery overheads is a fixed cost synthesis procedure and as such cannot be regarded as cost accounting as defined in Section 5.1. Comments relevant to such "synthesized" costs and their relationship to the cost accounting convention are contained in the previous chapter.

(ii) Land Overheads.

One disadvantage of cost accounting is that values for fixed resources must be assumed. Farm information may be collected even to the intensity of the cost route method, but it will not give any idea of how fixed costs should be allocated between enterprises. Land overheads illustrate the point. All the detailed information that could be collected on land values will not give any indication of, for example, what an extra acre of land is worth at any particular time of the year. Land values will vary at different times of the year. For example on an intensively cropped farm growing vegetable crops for processing, land will have a "high" value in spring and summer when crops are competing for land. The land value however may be lower in autumn and winter when only grass and stock fodder crops are grown. Another illustration is that light stony land may have a higher value in winter when it can safely carry all the livestock in very wet weather, than it will have in summer when its productivity and carrying capacity falls considerably. Valuation of land in this sense cannot be achieved by cost accounting.

All that can be achieved in cost accounting is to assume a value for land and allocate this value between all enterprises according to an acceptable, and preferably reasonable cost accounting convention. This method allocates all land costs without leaving a residual, but it cannot represent the variations in land values at different times of the year.

In the cost accounting convention for allocating land overheads, three factors were considered. These were rates, land tax and an imputed rental value.

Rates and land tax paid annually by the farmer were obtainable directly from farm records. These two costs could be considered therefore as "observable" fixed costs. An assumed rental value for land was based on the Capital Valuation of the farm. The Government Capital Value minus a standard sum of £3,500 (to deduct an allowance for the value of the farm house and environs) provided an estimate of the value of the productive portion of the farm.[16] The annual rental value of the property was chosen as the criterion for valuing land. This was considered to be equivalent to the rate of interest paid on capital invested in the land. An interest rate of 6% on invested capital was assumed. Accordingly the annual rental value of the whole farm

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16. The productive portion of the capital value includes all improvements such as drainage and fencing. Repairs and maintenance materials for land such as fencing wire and posts, were included as sundries in farm profit and loss accounts. As such they have been accounted for in general farm expenses in subsection (iii) of 6.2.4.

was assumed to be equivalent to

$$(\text{Capital Value} - £3{,}500) \times 6\% \qquad (6.8)$$

Identity (6.8) indicates the valuation of land for allocation between enterprises. However, "observable" fixed costs must be added to the land value in order to derive total land overheads. Total land overheads per farm acre is given by equation (6.9).

$$\text{Land tax} + \text{rates} + \left[(\text{Capital Value} - £3{,}500) \times 6\%\right] = \begin{matrix}\text{Total annual} \\ \text{land overheads}\end{matrix} \qquad (6.9)$$

As most crops do not occupy land for a full twelve months total annual land overheads were allocated per enterprise acre according to the multiplier k_{ij}:

$$\frac{(\text{Months land in enterprise})}{(12 \times \text{Total Farm Acres})} = k_{ij}$$

The difficulties of determining "months land in enterprise" has already been discussed in Chapter 5. Thus total annual land overheads per farm acre were allocated per acre of enterprise by equation (6.10).

$$(\text{Total annual land overheads} \times k_{ij}) = \left\{\begin{matrix}\text{average annual land} \\ \text{overheads per enter-} \\ \text{prise acre}\end{matrix}\right\} \qquad (6.10)$$

The proportion of land overheads allocated to a single enterprise as illustrated above, can constitute as much as 60% of the average per unit fixed costs. Thus "valuing" land in the cost accounting sense will have a marked effect on average per unit fixed costs. This is discussed further in Section 6.4.

(iii) General Farm Expenses.

Any general farm expenses which cannot directly be charged to an enterprise and which have not already been mentioned in previous sections of this chapter are included in General farm expenses. These include general insurance, electric power, telephone, accounting and legal fees, sundries and working expenses. Allocation of general farm expenses has previously been mentioned in 5.1.4. subsection (ii).

Total general farm expenses were derived from farm Profit and Loss Accounts. In cases where this information was unobtainable, that is, for just under 50% of the farms, the average of general farm expenses which were obtained, was used.

It is recognised that certain of the general farm expenses, for example working expenses, would not have been incurred if nothing was produced on the farm and hence such expenses should not truly be called "overheads." However, it is difficult to separate these costs from true overheads,[17/] hence they are included in general farm expenses. In practice general farm expenses tend to be a relatively small proportion of costs.

The procedure for allocating general farm expenses adopted in this study was similar to that for allocating land overheads. An activity was charged on a per acre, per month basis. Thus:

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17. In any case overheads can only be defined marginally. In the short-run or for small changes in production, "overheads" will not be affected. But for large changes in production, or in the long-term some fixed resources may become variable.

$$\begin{Bmatrix}\text{Total general} \\ \text{expenses charged} \\ \text{to enterprise}\end{Bmatrix} = (\text{Total general expenses})k_{ij}$$

Where in this case the multiplier k_{ij} is given by the term

$$k_{ij} = \frac{(\text{Months land in enterprise x acres in enterprise})}{(\text{12 x total farm acres})}$$

Hence:

$$\begin{Bmatrix}\text{Total general} \\ \text{expenses charged} \\ \text{per acre of} \\ \text{enterprise}\end{Bmatrix} = \frac{(\text{Total general expenses x } k_{ij})}{(\text{Acres in enterprise})}$$

As previously mentioned in 5.1.2. subsection (i), the "months land in enterprise" can be ambiguous, and illustrates the inherent problem of allocating fixed costs by cost accounting methods.

(iv) "Overhead " Labour.

Subsection (ii) of 6.2.3. described how an allowance was made for the cost of any labour directly associated with the production of each enterprise. This was described as the first stage of labour cost allocation. If the cost of labour directly associated with all enterprises is subtracted from an assumed annual wage allowance(£900), there will remain a proportion of labour costs which has not been allocated. These "residual" or "overhead" labour costs are therefore given by:-

£900 - Directa Labour Costs = "Overhead" Labour Costs

The second stage of labour cost allocation was concerned with the "overhead" labour costs. The method employed in the survey was intended to allocate total "overhead" labour by charging an activity according to the proportion of gross farm revenue it earned.

The method used, however, was:

$$\left\{\begin{array}{l}\text{Total "overhead"}\\ \text{labour charged}\\ \text{to the enterprise}\end{array}\right\} = \left\{£900 \times \frac{\text{Gross enterprise revenue}}{\text{Gross farm revenue}}\right\} - \left\{\begin{array}{l}\text{Total Variable costs of labour}\\ \text{charged to the enterprise}\end{array}\right\}$$

As pointed out in Subsection (i) of 5.1.4. this formula did not achieve what was intended. What it did achieve was to allocate the assumed £900 farmer labour return in the proportion of enterprise gross revenue to gross farm revenue. The formula which should have been used it is now realised was:

$$\left\{\begin{array}{l}\text{Total "overhead"}\\ \text{labour charged}\\ \text{to the enterprise}\end{array}\right\} = (£900 - \text{Total Variable Cost of Labourer}) \times \left(\frac{\text{Gross Enterprise revenue}}{\text{Gross farm revenue}}\right)$$

This formula would have achieved the allocation of "overhead" labour as intended.[18]

Total "overhead" labour charged to an enterprise was divided by enterprise acres to derive "overhead" labour per acre of enterprise.

This section has illustrated how individual costs were derived and allocated. A detailed cost analysis of four main enterprises for farm number 23 is given in Appendix B. All survey farms were subjected to the same costing procedures as illustrated in Section 6.2 and the example farm. Tables giving the complete cost accounting results for eight major cropping enterprises are shown in Appendix C.

Section 6.3 summarizes the complete cost accounting results.

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18. For further details on the two "overhead" labour formulae, see subsection (i) of 5.1.4.

6.3. Summary of Results

The cost accounting results obtained for eight major crops grown in Hawke's Bay are summarized in Table 6.5.

Points to note about Table 6.5 are:-

(a) All costs and prices tabulated are expressed as decimals of the pound, for example £9.7 = £9.35.

(b) All costs and prices are calculated to the nearest 1/- or £0.05.

(c) All costs, returns, acreages and yields are average figures taken from the 1959-60, 1960-61 and 1961-62 seasons' data.

(d) All costs and prices are expressed per acre of crop grown.

From Table 6.5. where all figures are expressed per acre:

Gross Revenue - Variable Costs = Gross margin*

where:

Variable Costs = Cash Costs + Imputed Cash Costs

and further where:

Cash Costs = "Observable" costs

Imputed Cash Costs = "Synthesized" costs + "allocated" costs.

*Gross margin can be considered as returns above variable costs, and hence approximates marginal return.

Further:

Gross Margin - Fixed Costs = "Average per unit" net returns.

The "mean" or average figures refer to the average costs of each group of farms for each column. The minimum and maximum figures refer to the lower and upper cost limits respectively about the mean for each group of farms for each column.

TABLE 6.5:

SUMMARY OF COSTS AND RETURNS : A COMPARISON OF ALL CROPS

CROP		NO. OF FARMS	GROSS RETURNS	CASH COSTS	IMPUTED CASH COSTS	VARIABLE COSTS	GROSS** MARGIN	FIXED COSTS	AVERAGE PER UNIT RETURNS
PEAS Class I	MEAN	12	45.35	9.40	4.75	14.30	31.20	14.90	16.30
	MIN.		31.60	7.80	3.00	12.35	18.25	8.90	1.25
	MAX.		72.75	11.55	7.70	16.50	59.50	21.95	46.80
Class II	MEAN	10	44.95	9.45	4.15	13.60	31.35	7.50	23.90
	MIN.		24.00	7.40	1.95	9.40	10.10	4.60	2.85
	MAX.		54.00	11.40	6.75	16.95	41.90	10.85	34.55
Class III	MEAN	4	49.20	10.25	5.75	15.95	33.25	16.50	16.75
	MIN.		33.70	9.50	4.40	13.90	17.80	13.25	6.55
	MAX.		61.55	11.60	7.20	18.80	42.75	19.35	23.65
Class IV	MEAN	2	45.15	9.15	6.10	15.25	29.90	15.20	14.70
RYEGRASS SEED	MEAN	15	34.85	4.10	9.00	13.10	21.75	11.25	10.50
	MIN.		21.90	2.05	6.00	10.50	6.15	5.10	9.90*
	MAX.		50.00	5.65	11.80	15.80	35.80	18.00	28.85
TOMATOES	MEAN	4	246.00	109.10	16.75	125.85	120.15	27.35	92.60
	MIN.		207.70	82.15	12.75	97.55	65.60	17.30	42.70
	MAX.		328.25	132.15	21.65	144.90	183.35	50.15	166.05
POTATOES	MEAN.	3	197.35	82.95	11.15	94.10	103.25	38.85	64.40
	MIN.		175.20	74.90	7.70	86.15	87.05	20.15	61.15
	MAX.		229.35	88.00	14.45	100.45	133.65	68.45	66.90
DWARF BEANS	MEAN	4	118.90	37.30	9.95	47.25	71.65	31.30	40.35
	MIN.		65.25	8.40	7.05	18.05	47.10	14.30	24.10
	MAX.		265.65	105.25	15.60	120.85	144.80	68.45	76.35
BROAD BEANS	MEAN	3	90.95	43.20	7.65	50.85	40.10	22.40	17.65
	MIN.		68.00	37.00	6.60	43.60	20.85	12.35	3.85*
	MAX		132.10	49.15	8.45	57.85	75.00	28.25	48.35
WHEAT	MEAN	2	28.50	2.85	5.65	8.50	20.05	7.55	12.55
SWEET CORN		1	55.70	7.80	9.20	17.00	38.70	15.30	23.40

** Gross margin approximates marginal returns

*NET LOSS

The number of farms indicates the number of survey farms growing each of the eight major cropping enterprises. In the case of peas, farms have been grouped according to the farming system (Refer to Chapter 3).

From Table 6.5 the position of the crops may be ranked in order of relative profitability as estimated by the cost accounting procedure. Table 6.6 illustrates the ranked order of profitability of crops on the basis of gross margin.

TABLE 6.6.

RANKED ORDER OF PROFITABILITY OF CROPS WITH REFERENCE TO AVERAGE GROSS MARGIN, PER ACRE.

RANK	CROP	AVERAGE GROSS MARGIN
1	Tomatoes	120.15
2	Potatoes	103.25
3	Dwarf Beans	71.65
4	Broad Beans	40.10
5	Sweet Corn	38.70
6	Peas	31.45*
7	Ryegrass Seed	21.75
8	Wheat	20.05

*Average returns of 28 farmers

The Gross margins indicated in Table 6.6 are the average gross margins per acre for each crop taken from Table 6.5. In the case of peas, the average gross margin is the average of 28 farms.

Table 6.7. illustrates the ranked order of profitability of crops on the basis of average per acre net returns.

TABLE 6.7:

RANKED ORDER OF PROFITABILITY OF CROPS WITH REFERENCE TO AVERAGE PER ACRE NET RETURNS.

RANK	CROP	AVERAGE NET RETURNS PER ACRE
1	Tomatoès	92.60
2	Potatoes	64.40
3	Dwarf Beans	40.35
4	Sweet Corn	23.60
5	Peas	18.95*
6	Broad Beans	17.65
7	Wheat	12.55
8	Ryegrass Seed	10.50

* Average of 28 farmers.

The average per acre net returns in Table 6.7 have been taken from Table 6.5. In the case of peas the average per acre net return is the average of 28 farmers.

6.4. Discussion of the Cost Accounting Results.

The first point to consider is the number of farms growing each crop shown in Table 6.5. All 28 farms, of course, grew peas, 15 grew ryegrass seed, but only a small number were found growing the remaining crops. For the small numbers of farms growing tomatoes, potatoes, dwarf beans, broad beans, wheat and sweet corn, estimates will be correspondingly less reliable.

This is especially true when the range of costs for each category of costs is considered for the small numbers of farms. It is difficult, therefore, to confidently interpret the average figures for the crops concerned.

However, from Table 6.6 in spite of the small numbers of farms costed for some crops, a clear idea is obtained of the most profitable and the least profitable crops. For example tomatoes and potatoes are obviously very much more profitable to grow than is wheat. This type of cost accounting information is useful for farmers by pointing out large differences in profitability between crops. But where the differences are less marked, for example between broad beans and peas, it becomes more difficult to confidently say which crop would be more profitable to grow.

As pointed out in Chapter 5, cost accounting is only concerned with deriving the costs of producing enterprises, and no consideration is given to the resources available for producing them. On the basis of a cost accounting study alone a farmer may give consideration to growing say tomatoes. In practice however, there may be factors which would prevent him from growing this "most profitable" crop. For example he may not have the necessary machinery, or soil type, or he may not be able to employ enough gang labour for harvesting the crop. If he was already growing tomatoes and decided to increase his acreage of the crop on the basis of a cost accounting study, he may find that limits on resources of machinery and labour would not allow the increase, or that the processing factory would not increase his tomato-growing contract. Cost accounting does not allow consideration of limits of resources.

The cash costs obtained from a survey for a cost accounting study can provide useful information for farmers. Presented in detail,[19] they can show

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19. This was in fact done by the author. A bulletin was sent to pea growers in Hawke's Bay indicating the cash costs of all crops.

a farmer the various practices adopted by other farmers with respect to seeding rates, fertilizer rates and use of various types of sprays, and the associated costs.

Estimates of imputed cash costs are less useful to farmers, because firstly, it is not obvious to them how they are obtained, and the reliability of the estimates is questionable because of the manner in which some of these costs, for example repairs and maintenance, were "synthesized" for each enterprise.

The gross margin derived by cost accounting methods approximates marginal returns. That is, it indicates the value of an extra acre of crop contract in the sense that there are no limiting resources, and that the "profitability" of the crop being reduced, is known. For example the gross margin of tomatoes is £120 and of potatoes £103. From this, the interpretation is that an extra acre of tomatoes could replace an acre of potatoes with an increase in returns of £17, provided that there are no limiting resources. This information is the best that cost accounting results can provide.

By carrying the cost accounting procedure further to allocate fixed costs to enterprises and hence arrive at an estimate of average per unit net returns illustrates the main disadvantage of cost accounting. The average per unit net returns are at best, extremely difficult to interpret and cannot confidently be used for decision-making purposes.

As the proportion of land overheads allocated to a single enterprise can constitute as much as 60% of fixed costs, land valuation will have a marked effect on average per unit net returns, Cost accounting cannot indicate what an extra acre of land is worth or value land in this sense.

With reference to Tables 6.6 and 6.7, it is unfortunately, important to realize that by using the "wrong" formula $(£900 \times \frac{\text{Gross enterprise revenue}}{\text{Gross farm revenue}})$ - (total direct costs of labour charged to enterprise) =(Total "overhead" labour charged to enterprise) for allocating labour costs, the labour intensive crops such as tomatoes, potatoes and broad beans, have not adequately been penalized. That is of course labour intensive from the point of view of farmer labour. These crops have, of course, been charged the full cost of any casual or gang labour used for harvesting and seasonal operations.

The overall profitability of all crops, after allowing for overhead costs shown in Table 6.7. is somewhat surprising. These are "profits" after allowing £900 per year for the farmer and 6% interest on capital invested in land and machinery. Only "management" has to be rewarded before a "pure profit" is obtained. These returns are surprisingly high in terms of the "generally accepted" fact that farmers usually have difficulty in achieving returns to both labour and capital equivalent at the going wage and rate of interest.

Further, the average net returns in Table 6.7 are net returns per acre of crop grown. Therefore, where there is a rotation of crops within say two years, the profit per acre per year is correspondingly inflated.

With reference to ryegrass seed, the average per unit returns are for the seed crop only. No provision was made for applying the cost accounting formula to livestock which could graze the pasture for the balance of the year. If livestock had been costed, and added to "ryegrass seed" the average per unit returns to "ryegrass seed" may have altered the ranking of the lower order crops. Certainly if livestock were included the overheads to ryegrass seed would have been spread over both livestock and seed. For example ryegrass seed was charged with the full cultivation costs of sowing the pasture.[20] But if livestock had been included, a proportion of regrassing costs would have been debited to livestock and a proportion debited to ryegrass seed.

As all the farms surveyed grew peas the cost of this crop are worthy of mention from Table 6.5. Farm Classes I, III and IV were all relatively intensive cropping systems. Hence peas were in competition with other crops. Class II however was an extensive farming system where peas were not generally a major enterprise. Considering the average gross margins for all classes, it may be seen that there is very little variation between classes. However, there is wider variation between classes for average per unit net returns. This is of course due to the variation in fixed costs. Because classes I, III and IV were all situated relatively close to Hastings city, and occupied high priced land, the rates, land tax and Government Valuation for these farms were substantially higher than for the more extensive farms. Hence land values derived by the cost accounting procedure account for much of the difference between the extensive and intensive farms.

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20. This is the problem of whether the preceding crop or the pasture to follow should be debited with "costs of regrassing," which has previously been mentioned in connection with allocation of land overheads and general farm expenses.

6.5. Summary

Chapter 6 has illustrated the actual cost accounting procedures for allocating all costs to single enterprises. The results derived by these procedures have been presented in summary form and discussed. The most useful information that can be obtained from a cost accounting study is from the per unit gross margin which approximates marginal returns. The average per unit net returns have however less economic significance because of the difficulties of valuing fixed resources. A further discussion comparing the cost accounting results with those obtained by linear programming with reference to farm number 23, appears in Chapter 9.

CHAPTER 7

THE APPLICATION OF LINEAR PROGRAMMING TO A HAWKE'S BAY FARM.

A comprehensive description of linear programming methods in agricultural economics has been given by Heady and Candler.[1] This Chapter is concerned with the application of linear programming to maximize the profits of a farm in Hawke's Bay. Data collection, the basic matrix and the results are discussed in this Chapter.[2]

The farm (No. 23) chosen for the analysis, was selected because of the large number of alternative enterprises which it could produce, the availability of good farm records, and the great interest of the farmer.

7.1. The Farm.

Farm No. 23 consists of 194 acres, comprising 67 acres of "dry" Pakowhai silt loam with a low water table, 117 acres of "wet" Pakowhai silt loam with a high water table, seven acres of wet shingle, and three acres occupied by buildings, stock yards and waste land. The Pakowhai silt loam areas are excellent for grazing and cash cropping. The seven acres of shingle land has only the one production possibility of grazing stock. The labour requirements for shifting stock, and the labour maintenance requirements for this area are extremely small. For these reasons the seven acres of shingle land were not included in the linear programme.

The farm has two houses, a large implement shed, a wool shed, a

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1. "Linear Programming Methods," E.O. Heady and W.V. Candler, Iowa State University Press, Ames, Iowa, 1958.
2. Originally it was hoped that linear programming could be used to analyse a number of different farms. It was found, however, that the time available for the study would not allow this.

store shed, and a wide range of farm machinery. The permanent labour force consists of the farmer and one permanent married man. Casual labour is available at any time of the year, for any length of hiring period. Gang labour is available if necessary for harvesting crops. Working capital up to £5,000 is available at any period during the year.

The farm production pattern for the 1961-62 season was:

Tomatoes	35 acres	(dry land)
Sweet corn	58 "	(wet land)
Ryegrass seed	61 "	(32 acres dry land; 29 acres wet land)
Peas	30 "	(wet land)
	184 "	
Permanent grass	7 "	
Buildings etc.	3 "	
TOTAL	194 acres	

The livestock carried during the 1961-62 season were:

5 yr and 6 yr ewes (Feb-June)	400
4th wethers (Feb-June)	220
Hoggets (Mar-Oct)	1240
TOTAL SHEEP	1860

No stock are carried from October to February. After selling the hoggets in October, the ryegrass paddocks are closed for seed production.

Under this present system the farmer says his farm produces a taxable income of between £12,000 and £13,000.

7.2. Data Collection

During the survey, information was collected from each farm for the cost accounting analysis. During the interview with farmer No. 23, much information was obtained about his present system of farming, but this was found to be insufficient for a linear program. It was therefore necessary to visit the farmer again in April 1963 to collect further information suchas the farmer's objective in farming, possible production alternatives not included in the present farm system, limitations of resources and stock carrying capacities for each month in the year.

The information collected in the first two visits to the farmer enabled a linear program model to be constructed and solved. A third visit to the farmer in November 1963, allowed the discussion of the results of the first program and resulted in the modification of some of the data collected previously.[3] After the third interview with the farmer the final linear programming model was constructed. This appears in the form of the initial linear program matrix in Table 7.6.[4]

The various stages in constructing the linear programming model[5] are presented in 7.3.

7.3. Construction of the Model

The first stage in the construction of the linear programming model was to list the possible production alternatives or activities open to

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3. The farmer's comments on this first linear program are presented in Chapter 8.
4. It was hoped to record the farmer's comments on the final linear programme results. Unfortunately the time available for the study would not allow this. However, the author hopes to publish the farmer's comments at a future date.
5. Compiled with reference to a "A Study in the Application of Linear Programming to an Oxfordshire Farm," J.D. Stewart, University of Reading Department of Agricultural Economics, Miscellaneous Studies, No. 21, 1961.

the farm. Secondly, determination of the resource restrictions and other limitations which were to be imposed on the activities. (These may be grouped under the single title - Restrictions). Thirdly, the requirements of the activities for the resources, and the net revenue of each of the activities had to be specified.

7.3.1. Definition of Activities. The model included all the activities in the present farm plan, together with some additional activities which the farmer was willing to consider. Activities which the farmer was not prepared to use for one reason or another, were ignored.[6] During the second visit, the farmer suggested three basic alternative production patterns.

The first pattern was the present farm plan. This included the production of vegetable crops for the food processing industry with the emphasis on large scale production, ryegrass seed, and the associated stocking policy of running bought-in five-year and six-year old ewes, four-tooth wethers and hoggets over the winter. Little or no stock are carried from October till February. The main activities for consideration under this first system were tomatoes, sweet corn, peas, broad beans, dwarf beans, ryegrass seed, and the above-mentioned stock policy.

The second general policy suggested by the farmer was one of producing fodder crops for sale. Mangolds, pumpkins, and lucerne for hay, would replace the vegetable crops. Depending on stock prices, meadow hay might be produced. The stock policy would be altered to one concentrating on fattening lambs and weaner beef cattle between December and June. All

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6. Potatoes were not considered.

stock would be bought in. Pastures would have a longer life than under the present system (i.e. more than two years). Consequently the farmer estimated that stock carrying capacities could be doubled compared with the present system. The farmer suggested this basic plan as a replacement for the present one, if process vegetable crop prices were reduced. The fodder crop plan was considered a safe "bet" by the farmer in view of the heavy demand for stock fodder crops during winter and summer, mainly by Hawke's Bay hill country sheep and beef cattle farmers.

The third system the farmer suggested was to grow seed and grain crops. Such a system could easily be handled by the farm's present labour and machinery. Wheat, barley and meadow hay would be the main enterprises. Fattening lambs bought in January and February would constitute the stock policy. This plan was considered to be similar to the vegetable crop plan in many respects; especially from the pattern of labour and machinery requirements.

Before the list of activities could be compiled from these three basic farm plans, consideration was given to the farmer's objectives in defining crop rotations. Technically it is possible to grow the same crop year after year on this farm. However, the farmer was keen to settle on a two year rotation of crop followed by ryegrass seed production. Except in cases where the use of land interfered with this objective, activities were defined as short-term, two-crop, rotations.

(i) Definition of a Crop Activity:

Two strategies were available for defining crop activities.[7] Rotation activities could be defined or else restraints could have been used to

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7. "Linear Programming Methods," E.O. Heady and W.V. Candler, Iowa State University Press, Ames, Iowa, p.213, 1958.

tie individual crop activities together by restricting the order in which crops could follow one another. To tie together single crop activities would have required a large matrix. Specification of appropriate single crop restraints would have been particularly difficult since the crops occupy land for different periods of the year, and the cost of establishing a crop or ryegrass is influenced by the preceding crop. Accordingly crop rotation activities were defined. These are listed in Table 7.1.

The rotation activities in Table 7.1. were defined on a yearly basis from the time of ploughing up pasture for a crop, until ploughing again for a crop out of the ryegrass (seed) pasture which followed. Hence each crop rotation was charged with the cost of ploughing up and sowing down pasture.

The difference of the wetter (117 acres) and drier (67 acres) land made it necessary to define activities according to the class of land used. All crops can be grown on the drier land, but tomatoes, broad beans, dwarf beans, mangolds and lucerne cannot be grown on the 117 acres of wetter land. Sweet corn, peas, wheat and barley may be grown on both classes of land, but yields and labour requirements are greater on the drier land. Each of these crops is, therefore, defined as two activities, the first requiring wetter, and the second requiring drier land.

All activities presented in Table 7.1. with the exception of P_{17}, supply grass for grazing from the ryegrass pastures. Livestock activities have been dealt with by incorporating them in the rotation activities along with ryegrass. Activities P_1 to P_{14} include the same stock policy. That is

TABLE 7.1:

ACTIVITIES IN THE BASIC MATRIX*

Activity	Description	Unit
ROTATION ACTIVITIES		
P_1	Sweet corn – RGS_1 (w)	2 acres
P_2	Peas – RGS_1 (w)	" "
P_3	Wheat – RGS_1 (w)	" "
P_4	Barley – RGS_1 (w)	" "
P_5	Sweet corn – RGS_1 (d)	" "
P_6	Peas – RGS_1 (d)	" "
P_7	Wheat – RGS_1 (d)	" "
P_8	Barley – RGS_1 (d)	" "
P_9	Broad beans – Sweet corn – RGS_1(d)	" "
P_{10}	Dwarf beans – RGS_1 (d)	" "
P_{11}	Tomatoes – RGS_1 (d)	" "
P_{12}	Mangolds – Broad beans – RGS_1 (d)	3 acres
OTHER ACTIVITIES		
P_{13}	RGS_2 (w)	1 acre
P_{14}	RGS_2 (d)	" "
P_{15}	Grazing (w)	" "
P_{16}	Grazing (d)	" "
P_{17}	Lucerne (d)	" "

* Notes on Table 7.1.

(i) RGS_1 refers to first year ryegrass seed

(ii) RGS_2 refers to second year ryegrass seed.

(iii) Because of the two different types of land, it was necessary to define activities according to whether they were produced on wetter land (w), or drier land (d).

buying five-year and six-year old ewes, and fourth-tooth wethers in February and March and selling them in June. Hoggets are bought in March and April and are sold immediately prior to closing paddocks for ryegrass seed production in the third week of October.

It was found necessary to divide the year into weekly periods. Weekly periods are designated thus:

The first week in January = Jan_1

The third week in October = Oct_3.

Each month is credited with four weeks. Some weeks are eight day weeks. This was more convenient than dealing with fifty-two weeks in the linear program.

The grazing activities P_{15} and P_{16} include the second stock policy. This involves buying lambs in lots from Dec_3. All lambs will have been sold fat to the freezing works by $June_4$. In addition to the lambs, weaner beef cattle would be bought in mid-February and all would have been sold fat by $Sept._2$. Paddocks would then be closed for hay, for sale as a cash crop.

Provision was made for a second crop of ryegrass seed to be taken. These activities appear as P_{13} and P_{14}. Another alternative considered was to allow an area taken for ryegrass seed in the first season, to continue in pasture through the following summer and take a hay crop off it. These activities appear as P_{15} and P_{16} in Table 7.1., and in the basic matrix (Table 7.6). Lucerne for hay production was included as P_{17}. All lucerne hay would be sold.

To a certain extent the rotations in Table 7.1. "beg the question." At the same time the short term rotations have been defined within the farmer's planning framework, and, within this framework, the program is able to select longer-term rotations. The inclusion of activities P_{13} to P_{16} allows some flexibility in the definition of rotations, since the program can select peas - RGS_1, or peas - RGS_1 - RGS_2, or peas - RGS_1 - Grazing. Thus activities P_{13} to P_{16} enable the program to change the length of rotation.

A comparison of activities P_9 and P_{12} in Table 7.1. shows that for P_{12} sweet corn does not follow broad beans. The reason for this is the different time that broad beans are in the ground for the two activities. Figure 7.1. illustrates a land use calendar for P_9 and P_{12}.

Figure 7.1. brings out the short fallow period in P_{12} between harvesting of broad beans and preparatory cultivation for the ryegrass pasture. In this case fallow is the only real alternative.

Figure 7.1. also illustrates how each rotation activity may be broken up into its component crops. For example if a rotation succeeded itself, the land use pattern with respect to activity P_2, would be as follows:

Peas	$Sept_2$ - Jan_3	ROTATION I
RGS_1	Jan_4 - Dec_4 - $Sept_2$	
Peas	$Sept_2$ - Jan_3	ROTATION II succeeds ROTATION I
RGS_1	Jan_4 - Dec_4 - $Sept_2$	

Knowing this timing pattern, it is possible to derive the labour coefficients for each monthly or weekly period in the year.

There are several other enterprises or combinations of crops which could be grown on farm No. 23. For example longer rotations could be used but the activity rotations defined in Table 7.1. adequately describe the

ACTIVITY		YEAR I	YEAR II	YEAR III
P_9	Time Land Used		Apr_1 Nov_4 Dec_1	Mar_3 Mar_4
P_9	Crop		BROAD BEANS / SWEET	CORN / RYEGRASS
P_{12}	Time Land Used	$Sept_1$	May_4 $June_1$ Dec_3 Dec_4	Jan_4 Feb_4
P_{12}	Crop		MANGOIDS / BROAD BEANS / FALLOW	FALLOW / FYEGRASS

FIG. 7.1: LAND USE CALENDAR FOR P_9 and P_{12}.

alternatives which the farmer was keen to have explored. There is no doubt that further interesting results could have been obtained if more time had been available.

7.3.2. Definition of Restrictions.

To determine the restraints, it was necessary to identify those resources on the farms for which there was an effective limit. The actual resources available and the constraints they imposed upon the level of activities were defined after consultation with the farmer. The resource restrictions may be divided into land and labour availability; biological, institutional and "farmer preference" restrictions on the area of crops grown; and land transfer rows . Operating capital was not included as a restraint. The farmer stated that up to £5,000 working capital would be available for any feasible program. Similarly the plant and equipment was considered by the farmer to be adequate for any feasible program. For example he possesses three tractors, a corn harvester, a threshing mill, two trucks and a full range of cultivation equipment.

(i) The Land Restrictions.

As described in 7.3.1. land was divided into two classes according to the drainage characteristics. The two restrictions of 67 acres of drier land and 117 acres of wetter land are essentially self explanatory.

(ii) Crop Restrictions.

Maximum restrictions imposed on the acreage of crops grown, for example 20 acres of tomatoes, 40 acres of corn and 57 acres of lucerne, are more or less subjective restraints imposed by the farmer.[8]

(iii) Labour Restrictions.

The main problem in the linear program was to find out how much labour was available at any period in the year. Labour restrictions were very important because timing of farm operations such as planting, spraying and harvesting vegetable crops is extremely important in Hawke's Bay. It was convenient to divide the year into forty-eight weekly periods (four weeks per month) to estimate the labour supplies available in each period. The fixed farm labour force consists of the farmer and a permanent married man. Extra labour units may be hired at any time of the year for any length of time.[9]

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8. In addition to the farm plan for farm No. 23, the farmer has leased 60 acres of extra land on which he intends to grow 60 acres of sweet corn. The farmer was unwilling to grow more than a maximum of 100 acres of sweet corn per year, hence a 40 acre "corn maximum" restriction was imposed in the farm plan.

A maximum restriction of 20 acres was placed on tomatoes, as this was all the farmer was prepared to handle. In the past he has grown 35 acres of tomatoes, but he considered this area was too big to handle adequately, if top grade whole tomatoes for canning were to be produced.

A maximum restriction of 37 acres was imposed on the acre of lucerne which could be grown. Of the 67 acres of drier land, the farmer considered that only the northern portion of 37 acres of this was suitable for growing lucerne.

No restrictions were imposed for soil fertility reasons because the farmer maintained the soil would yield at least one cash crop per year, regardless of the type of crop, for at least a period of ten years.

9. Gang labour for weeding or harvesting crops is also readily available. However, this form of labour has been accounted for as a deduction, in calculating net revenues.

Specification of the labour restraints presented a problem since ideally the labour of the farmer and his permanent man should be treated differently to any labour which has to be hired by the hour. Hired labour should only be used if its marginal value productivity exceeds the hourly wage rate. During slack periods, the permanent labour force may be used profitably, even if its value marginal productivity is less than the going wage. Indeed, from a purely profit maximising point of view, permanent labour should be used up to the limit of its availability, provided, only, that its value marginal productivity is positive.

This difficulty can be overcome by putting the permanent labour hours available in the B column, for each week, and then allowing the programme to buy additional labour, at the going wage rate, if this is profitable. This approach was used in the first program. To allow labour hiring in all weeks would have exceeded the capacity of the computer in the second program. This was due to the extra activities and restraints which were suggested by the farmer's comments on the results from the first program.

Thus the size of the computer forced the author to specify one value for the price at which additional labour would be used in the programme. To specify that labour would only be used if it earned 7/- an hour, would have resulted in the permanent labour force remaining idle, when each additional hour worked could earn as much as 6/11 per hour. Alternatively, to specify zero supply price for labour could result in labour being hired, when it was earning as little as a penny an hour (again resulting in a loss of 6/11 for every hour used).

In fact, the author decided to specify zero supply price for labour, but to limit the amount that could be purchased. (The farmer was limited to hiring at most one, or two, or three, or four, extra men in any one week). Fortunately, the plans which were produced from this analysis, proved to be stable, even if the cost of hired labour rose to as much as £1 an hour. If this had not been so, additional programming analysis might have been necessary.

The specification of the hours of work available from the permanent labour force, also presented problems. Permanent and hired labour were considered perfect substitutes in calculating labour restraints.[10]

Labour supplies were obtained by combining permanent and hired labour, in all weeks of the year. The maximum number of hours the farmer and the permanent man could work was determined for each week. The farmer stated that "casual labour was easy to get." Accordingly four different labour situations were examined. These were:

(i) Permanent labour supply plus four extra men available for 70 hours per week per man.

(ii) Permanent labour supply plus three extra men available for 70 hours per week per man.

(iii) Permanent labour supply plus two extra men available for 70 hours per week per man.

(iv) Permanent labour supply plus one extra man available for 70 hours per week.

B columns were calculated for each of these four situations. The labour requirements for each week refer to the jobs that have to be carried out in that period.

Estimation of the permanent labour supplies for each weekly period was actually done by the farmer. Careful questioning of the farmer enabled

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10. Initially an attempt was made to separate managerial labour from manual labour. However, the farmer said his managerial ability would not be an effective restraint for any plan consistent with the upper limits on crop acreages discussed above. Accordingly managerial labour was not included as a restraint.

him to pin-point the peak working periods. For example in Feb_3 and Feb_4 when harvesting of corn clashed with harvesting tomatoes, he estimated that he normally worked from 3.30 a.m. until 9.30 p.m. six days a week, over this period. On the seventh day he could work for a maximum of six hours. The farmer could, therefore, work for a maximum of 112 hours per week for Feb_3 and Feb_4. For the same period, he estimated that he would not let his permanent man work for more than 90 hours per week. Permanent labour supply for Feb_3 and Feb_4 was therefore a maximum of 202 hours per week.

In a similar manner, the maximum permanent labour supplies were derived, using the weeks of Feb_3 and Feb_4 as the criterion of absolute maximum permanent labour supply.

For the periods other than Feb_3 and Feb_4, the farmer's estimate of maximum permanent labour supplies were somewhat arbitrary. They were derived with reference to his present yearly work pattern indicating his present busy and slack periods. Fortunately no difficulty arose from these estimates in the linear program plans. If however, the linear program plans had indicated an entirely different annual work pattern with a labour "bottleneck" not in Feb_3 and Feb_4 but in some other period, it would have been necessary to check with the farmer to see whether he would have revised his weekly estimates of permanent labour supplies.

Table 7.2. provides the details of permanent labour supply by weeks for a full year.

TABLE 7.2:

PERMANENT LABOUR SUPPLY AS ESTIMATED BY THE FARMER.

Period	Max.Farmer Hours/week	Max.Perm Man Hours/week	Max.Permanent Labour Hours/week.
Jan_1 - Jan_3	80	70	150
Jan_4 - Feb_1	90	70	160
Feb_2	90	80	170
Feb_3 - Feb_4	112	90	202
Mar_1 - Mar_4	80	70	150
Apr_1 - Apr_2	66	60	126
Apr_3 - Apr_4	60	60	120
May_1	66	60	126
May_2	60	60	120
May_3 - May_4	Vacation	60	60
$June_1$ - $June_2$	60	55	115
$June_3$ - $June_4$	60	50	110
$July_1$ - $July_4$	55	50	105
Aug_1 - Aug_2	60	Vacation	60
Aug_3 - Aug_4	66	60	126
$Sept_1$ - Oct_4	80	60	140
Nov_1 - Nov_2	80	70	150
Nov_3 - Nov_4	74	70	144
Dec_1 - Dec_2	70	70	140
Dec_3	84	70	154
Dec_4	70	70	140

The vacation periods in Table 7.2. closely approximate the vacation periods mentioned by the farmer, and are included at slack periods.

From the total maximum permanent labour supplies in Table 7.2., the labour requirements necessary to farm the 60 acre lease block under a one-year corn-pasture-for-grazing rotation, were deducted. The balance gave the permanent labour supplies available for work on the farm. Twenty-seven labour restrictions were included in the basic matrix. The maximum hours available from the farmer and his permanent men after the 60 acres lease land requirements have been taken into account is given in Table 7.3.

From Table 7.3. it can be seen that in periods Mar_3 and Nov_2 the labour requirements for the 60 acres of lease land have not been met by the permanent labour force. Thus labour must be hired even to complete work on this area. From the final linear program plan, the amount of labour hired for these two periods will be given for the farm plan. But the extra 40 hours and 24 hours must be added to find the total hours of labour hired for the Mar_3 and Nov_2 periods respectively. Hence considering the farm and the 60 acres of lease land together, the total amount of labour (both permanent and hired) required can be calculated.

The actual labour restrictions appearing in the basic matrix are self-explanatory.

(iv) Land Transfer Rows.

Restrictions (5) and (6) in the basic matrix are land transfer rows for wetter land and drier land respectively. These restrictions allow land used by a rotation activity to be followed by second year ryegrass seed, or to go into second year grazing and a hay crop. The transfer rows ensure that the latter two crops cannot be grown without being preceded by a rotation activity

TABLE 7.3:

TOTAL PERMANENT LABOUR SUPPLIES AVAILABLE FOR FARM 23 AFTER ACCOUNTING FOR 60 ACRES OF LEASE LAND.

PERIOD	HOURS AVAILABLE
Jan_1	150
Feb_1	142
Feb_2	170
Feb_4	44
Mar_1	90
Mar_2	110
Mar_3	-40
Mar_4	0
Apr_2	126
Apr_3	120
Apr_4	120
May_1	110
May_4	54
$June_1$	109
Aug_3	108
$Sept_1$	134
$Sept_2$	132
Oct_1	1
Oct_2	41
Oct_3	140
Oct_4	140
Nov_1	0
Nov_2	-24
Nov_3	144
Nov_4	144
Dec_1	140
Dec_4	140

containing first year ryegrass pasture and consequently that the levels of the latter two activities do not exceed the amount of first year ryegrass pasture in the plan.

Table 7.4. illustrates the function of the transfer rows with reference to wetter land.

TABLE 7.4.

THE TRANSFER ROW

Restriction	B.Col.	P_2 Peas - RGS_1	P_{13} RGS_2
Land (W)	117	+2	+1
Ryegrass Transfer (W)	0	-1	+1

Table 7.4. illustrates that P_{13} may not enter the plan alone, because of its unit requirement in the ryegrass transfer row which has a zero supply in the B. column. Hence P_2 must enter the plan first. A unit of P_2 entering the plan will require two acres of land, and will supply one acre to the B column of the ryegrass transfer row. The supply of one acre in the ryegrass transfer row may now be used by P_{13}. That is, a unit of P_{13} may now enter the plan requiring one acre of land and one acre of the land available for transfer from first year ryegrass pasture. The crops grown per year would then be extended from one acre of peas and one acre of RGS_1 after peas (if P_2 above came into the plan) to one acre of peas, one acre of RGS_1, after peas and one acre RGS_2 after RGS_1. That is to say the effect of the transfer rows is to allow the program the opportunity of extending a two-year

crop rotation to a three year rotation including second year pasture.

A similar interpretation is applicable for the transfer row for drier land, and the dry land activities.

7.3.3. Derivation of the Individual Coefficients. In principle the derivation of the individual coefficients for the basic matrix is straight forward. The information for the per unit requirements of each activity for each resource may be obtained directly from the farmer. In practice the task is not an easy one, and three visits to the farmer were required to obtain and check the coefficients. The individual coefficients may be described with reference to Table 7.5. which presents part of the P_1 (corn-RGS_1) rotation activity in the basic matrix.

TABLE 7.5.

SOME INDIVIDUAL COEFFICIENTS
FOR ROTATION ACTIVITY P_1.

Restriction	B.Col.	Coefficients for P_1
LAND (W)	117	+2
RYEGRASS TRANSFER(W)	0	-1
CORN MAXIMUM	40	+1
LABOUR Feb_4	233.6	+2.72

(i) Land Coefficient.

As rotation activities were defined on a yearly basis and corn-RGS_1 is a true year rotation, one unit of P_1 requires two acres of land per year. That is in any year, one acre of corn, and one acre of RGS_1 following corn from the previous year will be grown. Other land requirement coefficients were calculated similarly.

(ii) Land Transfer Coefficient.

The meaning and derivation of the land transfer coefficient has been dealt with in subsection (iv) of 7.3.2. with reference to P_2. In any <u>rotation</u> activity including RGS_1, a -1 will appear in the appropriate ryegrass transfer row indicating that a unit of the rotation activity entering the plan will supply one acre of RGS_1 to become available for continuation into second year pasture for either ryegrass seed, or hay production. The RGS_2 and Grazing activities have a +1 coefficient in the ryegrass transfer row.

(iii) Corn Maximum Coefficient.

A restraint of 40 acres of sweet corn was imposed. Hence the +1 coefficient in the row ensures that the rotation activity P_1 may enter the plan at not more than 40 units.

(iv) Labour Coefficient.

The supply in the B column for the labour restriction refers to the "four extra men" plan. The method of deriving the labour coefficient in Table 7.5. is illustrated in the following example:

<u>EXAMPLE 7.1</u>: Derivation of the Labour Coefficient of P_1 for the Feb_4 Labour Restraint.

Total per unit labour requirement of P_1		= 2.72 hours
This comprises:		
Sweet corn	2.64 hours	
Ryegrass pasture	0.08 hours	
Derivation of the sweet corn coefficient:		
Harvesting: Involves labour at the rate of 0.5 acres/hour		= 2.00 hours/acre
Cartage: Based on an average of 64 hours to transport the yield from 100 acres		= 0.64 hours/acre
Total per unit requirements for sweet corn		2.64 hours/acre

Derivation of the ryegrass pasture coefficient:

In Feb_4 2 hours per week are spent buying old ewes and 4th wethers. Basing this on an average of 49 acres of ryegrass pasture	= 0.04 hours/acre[11]
Two hours per week tending stock. Basing this on an average of 49 acres of ryegrass pasture	= 0.04 hours/acre
Total per unit requirements for ryegrass pasture	= 0.08 hours/acre

The listed operations are the only ones carried out for the P_1 activity in $Feb._4$. All the labour coefficients were compiled in a manner similar to Example 7.1. Coefficients for vegetable crops were derived from average labour performance figures given by the farmer for individual operations such as ploughing, discing, rolling, harrowing, drilling, weeding spraying, harvesting and cartage. For a crop such as mangolds which the farmer has never grown, information was obtained from a grower in the Manawatu. The coefficients were derived for Manawatu conditions and checked with the farmer as being reasonable under Hawke's Bay conditions.

The livestock labour coefficients incorporated into all activities containing ryegrass pasture were derived from information from the farmer. This information concerned timing of buying and selling stock, hours spent per week on various jobs such as drenching, drafting and shifting stock, and a detailed list of the stock carrying capacities and general stock movements on the farm over the period from Feb_1 until Oct_3. The original per unit labour requirements for stock work were checked and revised with the aid of the farmer.

11. It could possibly be assumed that the time spent buying and selling stock is fixed. This labour allowance (0.4 hours/acre) should have then been subtracted from the total labour requirements (2.72 hours/acre) for the Feb_4 period to leave the requirement of variable labour (2.68 hours/acre) only. The 2 hours used to buy and sell sheep would then have had to be subtracted from the 233.6 in the B column. However, as the allowance for buying and selling stock is small, the effect of including this fixed labour as if it varied proportionately with stock carried, will not greatly affect the linear programming results.

7.3.4. Derivation of Net Revenues. The method used for deriving the net revenue per unit of activity was to deduct from the gross revenue per unit, the direct variable costs per unit. The net revenues calculated for each crop used for the linear program are not identicle to the gross margins for individual crops as derived by the cost accounting procedure in Chapter 6. In that Chapter, Gross margin = Gross revenue - Total variable costs.

The net revenues used for the linear program were derived by:

Gross revenue - (Direct cash costs + tractor fuel and oil
+ hired gang labour)
= net revenue.

Thus we can express net revenue as used in the linear program as:

Net Revenue = Gross Margin + Labour costs
+ tractor and implement repairs and maintenance costs.

The gross revenues and the direct cash costs of seed, fertilizer, spray materials, fertilizer, cartage and sacks; together with the fuel and oil and hired gang labour costs, were all taken directly from the cost accounting study and applied to the respective crops for the linear programs. Thus the costs and returns used in the linear program were the average costs and returns for seasons 1959-60, 1960-61 and 1961-62.

A summarized cost analysis for deriving the per unit net revenue for activity P_{11} (Tomatoes - ryegrass seed) illustrates how all net revenues were calculated. This example also illustrates how gang labour has been taken into consideration as a variable cost. It shows that labour has been considered an "overhead" cost and hence does not appear as a variable cost factor.[12]

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12. Further comments on the labour costs appear in the discussion of the linear programming results. The cost accounting variable costs of tractor and implement repairs and maintenance are also considered as fixed costs in the linear program.

EXAMPLE 7.2:

CALCULATION OF THE PER UNIT NET REVENUE FOR ACTIVITY P_{11}.

(All Costs and Returns Per Acre)

(1) Tomatoes

VARIABLE COSTS			RETURNS	
Plants	£19.50		Gross Returns	£255.00
Spray	7.87			
Fertilizer	3.30			
Fuel and Oil	1.31			
Cartage: Plants	0.57			
Cartage: Fruit	12.75			
Harvest: Gang Labour	63.75	£109.05	LESS Variable costs	109.05
			NET PROFIT PER ACRE	£145.95

(2) First Year Ryegrass Seed

VARIABLE COSTS			RETURNS	
Seed	£2.60		Gross Returns	£45.00
Spray	0.50			
Fertilizer	Nil			
Sacks	0.25			
Fuel and oil	0.66			
Cartage	0.18	£4.19	LESS Variable costs	4.19
				£40.81
			PLUS[13]	
			Net returns from ewes and wethers	3.95
			Net returns from hoggets	19.80
			NET PROFIT PER ACRE	£64.56

TOTAL PER UNIT NET PROFIT FOR P_{11} = £210.51

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13. The budgets for deriving the net returns from livestock are given in Appendix E.

The per unit net revenues for all other activities were calculated in a similar manner and appear in the basic matrix, Table 7.6.

7.4. The Basic Matrix

Having defined the activities 7.3.1, restrictions 7.3.2., and the individual coefficients, 7.3.3., the linear programming matrix was reduced in size and increased in computational efficiency by methods suggested by Heady and Candler.[14]

Firstly all the dominated rows were eliminated. This reduced the number of labour restrictions from 48 to 27.

The second method of eliminating rows was through the crop maximum restrictions. This is also a form of dominance. As an example, a maximum restriction of 60 acres was imposed by the farmer on the acreage of peas he would grow on the wetter class of land. When, however, peas are combined with ryegrass to form the peas - ryegrass rotation activity (P_2), the "peas maximum" restriction becomes ineffective. This is because the per unit requirement of P_2 for land (w) is 2. As the amount of land (w) available is 117 acres, only half this area, 58.5 acres, could be in peas, together with 58.5 acres of ryegrass following the peas. This meant the 60 acre "pea maximum" was redundant. By this procedure the number of crop maximum restrictions was reduced from 8 to 3.

The basic matrix therefore included 578 coefficients, comprising 17 real activities and 34 restrictions. The initial matrix is presented in Table 7.6. The disposal activities allowing for the non-use of resources are omitted.

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14. "Linear Programming Methods," E.O. Heady and W.V. Candler, Iowa State University Press, Ames, Iowa, Chapter 5, p.151, 1958.

BASIC MATRIX

TABLE 7.6

Restrictions	Level	Relationship	P_1 Corn-Rgs$_1$ (W)	P_2 Peas Rgs$_1$ (W)	P_3 Wheat Rgs$_1$ (W)	P_4 Barley Rgs$_1$ (W)	P_5 Corn Rgs$_1$ (d)	P_6 Peas Rgs$_1$ (d)	P_7 Wheat Rgs$_1$ (d)	P_8 Barley Rgs$_1$ (d)	P_9 Broad Beans Corn Rgs$_1$ (d)	P_{10} Dwarf Beans Rgs$_1$ (d)	P_{11} Tomatoes Rgs$_1$ (d)	P_{12} Mangolds Broad Beans Rgs$_1$ (d)	P_{13} Rgs$_2$ (W)	P_{14} Rgs$_2$ (d)	P_{15} Grazing (W)	P_{16} Grazing (d)	P_{17} Lucerne (d)
Net Revenue (£)			113.75	101.76	91.07	82.00	123.75	111.76	94.07	85.00	158.02	140.46	210.51	168.93	58.56	62.65	17.73	14.21	16.25
(1) LAND (d)	67 acres	≥					2	2	2	2	2	2	2	3		1		1	1
(2) LAND (W)	117 acres	≥	2	2	2	2									1		1		
(3) TOMATOES MAX	20 "	≥											1						
(4) LUCERNE MAX	37 "	≥																	
(5) CORN MAX	40 "	≥	1				1				1								1
(6) LAND TRANSFER (W)	0 "	≥	-1	-1	-1	-1									1		1		
(7) LAND TRANSFER (d)	0 "	≥					-1	-1	-1	-1	-1	-1	-1	-1		1		1	
(8) LABOUR Jan$_1$	430.0 hours	≥	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	2.21	1.38	2.38	1.38	1.38	0.08	0.09	0
(9) Feb$_1$	422.0 "	≥	0.38	2.40	0.08	0.08	0.04	2.42	0.10	0.10	1.42	0.10	4.60	0.10	0.08	0.10	0.05	0.06	2.25
(10) Feb$_2$	450.0 "	≥	0.08	1.73	0.08	0.08	0.10	1.75	0.10	0.10	1.42	7.60	9.70	1.42	0.08	0.10	0.09	0.11	2.25
(11) Feb$_4$	373.6 "	≥	2.72	0.08	2.68	2.73	2.74	0.10	2.70	2.75	0.40	0.10	10.70	0.10	0.08	0.10	0.14	0.17	0
(12) Mar$_1$	370.0 "	≥	1.02	2.52	0.02	0.02	1.04	2.54	0.04	0.04	2.21	0.71	10.64	1.36	0.02	0.04	0.07	0.09	0
(13) Mar$_2$	389.8 "	≥	0.69	2.92	0.69	0.69	0.71	2.94	0.71	0.71	2.68	3.21	4.54	1.29	0.02	0.04	0.10	0.12	0
(14) Mar$_3$	239.8 "	≥	3.19	0.02	3.19	3.19	3.21	0.04	3.21	3.21	1.71	2.94	0.04	0.04	0.02	0.04	0.10	0.12	0
(15) Mar$_4$	280.0 "	≥	3.16	0.26	3.16	3.16	3.20	0.30	3.20	3.20	2.80	0.30	0.30	0.30	0.26	0.30	0.12	0.14	0
(16) Apr$_2$	406.0 "	≥	0.34	0.34	0.34	0.34	0.38	0.38	0.38	0.38	2.03	0.38	3.55	0.38	0.34	0.38	0.07	0.09	0
(17) Apr$_3$	400.0 "	≥	0.30	0.30	0.30	0.30	0.34	0.34	0.34	0.34	0.34	0.34	3.24	0.34	0.30	0.34	0.12	0.14	0
(18) Apr$_4$	400.0 "	≥	0.34	0.34	0.34	0.34	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.34	0.38	0.07	0.09	0
(19) May$_1$	390.4 "	≥	0.18	0.18	0.18	0.18	0.22	0.22	0.22	0.22	1.07	0.22	0.22	24.54	0.18	0.22	0.12	0.14	0
(20) May$_4$	334.0 "	≥	0.14	0.14	0.14	0.14	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.14	0.18	0.07	0.09	0
(21) June$_1$	389.0 "	≥	0.18	0.18	0.18	0.18	0.22	0.22	0.22	0.22	0.22	0.22	0.22	2.54	0.18	0.22	0.22	0.24	0
(22) Aug$_3$	388.0 "	≥	0.32	0.32	0.99	0.32	0.34	0.34	1.01	0.34	2.14	0.34	0.34	1.34	0.32	0.34	0.02	0.03	0
(23) Sept$_1$	414.0 "	≥	0.53	0.53	3.03	0.53	0.55	0.55	3.05	0.55	0.55	0.55	0.55	1.22	0.53	0.55	0.02	0.03	0
(24) Sept$_2$	411.6 "	≥	0.12	2.64	2.62	0.79	0.14	2.66	2.64	0.84	0.14	0.14	0.14	0.81	0.12	0.14	0.02	0.03	0
(25) Oct$_1$	280.8 "	≥	2.48	0.16	0.16	0.16	2.50	0.18	0.18	0.18	0.18	0.18	3.03	2.68	0.16	0.18			2.25
(26) Oct$_2$	321.0 "	≥	1.81	2.66	0.16	2.66	1.85	2.68	0.18	2.68	0.18	0.18	0.18	0.18	0.16	0.18			0
(27) Oct$_3$	420.0 "	≥	0.16	0.56	0.32	1.01	0.18	0.58	0.34	1.03	0.18	0.85	3.29	1.18	0.16	0.18			0
(28) Oct$_4$	420.0 "	≥				0.04				0.04		0.67	6.11	0.20					
(29) Nov$_1$	280.0 "	≥	2.66	0.16	0.16	0.16	2.66	0.16	0.16	0.16	0.16	1.81	4.41	0.16	0.16	0.16			0
(30) Nov$_2$	256.0 "	≥	2.90				2.90					2.50							2.25
(31) Nov$_3$	424.0 "	≥		0.16				0.16			6.00	1.25	1.90						2.25
(32) Nov$_4$	424.0 "	≥									7.00		1.25	5.80					
(33) Dec$_1$	420.0 "	≥									3.17		0.65	5.00					
(34) Dec$_4$	420.0 "	≥	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	2.63	2.04	1.38	1.38	3.66	3.67	2.25

The B column shown in Table 7.6. indicates the labour supplies which include permanent labour and for four extra men which turned out to be "unrestricted" labour.

The linear program was fun four times to provide solutions under four different labour hire situations. The four B columns with the actual labour supplies available are presented in Table 7.7.

7.5. The Results

Simplex solutions were obtained[15] from four situations relevant to the amounts of labour which could be hired for farm number 23. However, for the purposes of discussion, the solution to the linear program containing an upper limit of four extra men on the amount of available hired labour is presented in this section. This closely approximates the farmer's real situation. Solutions to the remaining linear programs are given in Appendix D. Note that as no labour restrictions were effective in the "four hired men" plan the solution to this plan will remain optimum for any number of hired men exceeding four.

7.5.1. The Farm Plan. Table 7.8. provides details of crops, livestock numbers, numbers of hours of hired labour required, the total farm net revenue provided in the program solution allowing hiring of a maximum of four extra labour units at any period of the year.

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15. Using an IBM 1620 computer and program 10-1-002.

TABLE 7.7:

REPLACEMENT LABOUR SUPPLIES FOR TABLE 7.6: (HOURS)

Restriction	Period	Perm.Lab. + 4 Hired	Perm.Lab. + 3 Hired	Perm.Lab. + 2 Hired	Perm. Lab. + 1 Hired.
7	Jan_1	430.0	360.0	290.0	220.0
8	Feb_1	422.0	352.0	282.0	212.0
9	Feb_2	450.0	380.0	310.0	240.0
10	Feb_4	373.6	303.6	233.6	163.6
11	Mar_1	370.0	300.0	230.0	160.0
12	Mar_2	389.8	319.8	249.8	179.8
13	Mar_3	239.8	169.8	99.8	29.8
14	Mar_4	280.0	210.0	140.0	70.0
15	Apr_2	406.0	336.0	266.0	196.0
16	Apr_3	400.0	330.0	260.0	190.0
17	Apr_4	400.0	330.0	260.0	190.0
18	May_1	390.4	320.4	250.4	180.4
19	May_4	334.0	264.0	194.0	124.0
20	$June_1$	389.0	319.0	249.0	179.0
21	Aug_3	388.0	318.0	248.0	178.0
22	$Sept_1$	414.0	344.0	274.0	204.0
23	$Sept_2$	411.6	341.6	271.6	201.6
24	Oct_1	280.8	210.8	140.8	70.8
25	Oct_2	321.0	251.0	181.0	111.0
26	Oct_3	420.0	350.0	280.0	210.0
27	Oct_4	420.0	350.0	280.0	210.0
28.	Nov_1	280.0	210.0	140.0	70.0
29	Nov_2	256.0	186.0	116.0	46.0
30	Nov_3	424.0	354.0	284.0	214.0
31	Nov_4	424.0	354.0	284.0	214.0
32	Dec_1	420.0	350.0	280.0	210.0
33	Dec_4	420.0	350.0	280.0	210.0

TABLE 7.8:

PROGRAM SOLUTION

HIRING A MAXIMUM OF FOUR MEN

A. LAND UTILIZATION (acres)

	LAND (d)	LAND (w)
SWEET CORN		26.50
RGS_1 after SWEEN CORN		26.50
PEAS		12.50
RGS_1 after PEAS		12.50
*BROAD BEANS *SWEET CORN after Broad Beans	13.50	
RGS_1 after SWEEN CORN after B.B.	13.50	
TOMATOES	20.00	
RGS_1 after TOMATOES	20.00	
RGS_2		39.00
	67.00	117.00

*Two crops in the one year. Land must only be counted once. The reader may remember that in addition to the land utilization above, there are 7 acres of very wet, stony land suitable for grazing only, and that this was not included in the program.

B. LIVESTOCK

	LAND (d)	LAND (w)
BUYS 5yr & 6yr EWES and 4th WETHERS (Feb/Mar) (SELLS all less losses by June)	268	780
BUY WETHER HOGGETS (Mar/Apr) (SELLS all less losses by Oct_3)	536	1560

C. HOURS OF LABOUR HIRED

PERIOD	TOTAL HOURS	NO. of MEN HIRED
Jan_1	3.87	1
Feb_1	12.36	1
Feb_2	70.04	1
Feb_4	251.60	3 or 4
Mar_1	211.95	3
Mar_2	72.55	1 or 2
Mar_3	149.45	2 or 3
Mar_4	140.93	2
Oct_1	135.99	2
Oct_2	52.48	1
Nov_1	169.09	3
Nov_2	100.85	2
Dec_4	38.87	1

Total hours hired = 1410.04 hours

D. NET REVENUE

Linear program net revenue =	£12,914
PLUS net revenue calculated for 60 acres lease land =	3,196
	£16,110
LESS Allowance for 1410 hours of hired labour at 7/- per hour	493
∴ NET REVENUE	£15,617

The net revenue shown in Table 7.8. may be compared with two other estimates of net revenue to indicate that the resource restrictions used in the linear program allowed a "sensible" maximum net revenue to be obtained. The three estimates of net revenue are:

(i) The linear program net revenue:

This amounted to £12,914. An additional £3,196 could be made from 60 acres of lease land to bring the total to £16,110. After making an allowance for 1410 hours of hired labour at 7/- per hour[16/] to operate the farm plan plus the 60 acres of lease land, the final net profit is £15,617.

(ii) The farmer's estimate of his net revenue.

The farmer stated during the third interview that he was actually making between £12,000 and £13,000 per year, say an average of £12,500. He also estimated an extra £3,000 could be made from the 60 acres lease land. This would bring the farmer's estimate of net revenue to total of approximately £15,500.

16. The farmer actually obtains labour at 7/- per hour. This can be described as the result of good labour management, which in turn allowed this farmer to keep his costs below the 8/6 an hour for labour used in the cost accounting calculations for farming in general.

(iii) Net revenue for the 1961-62 season's actual farm plan estimated from the basic linear program matrix.

This estimate is only a guide to what the farmer is actually making under his present farming system. It was not possible to obtain an accurate assessment of net revenue from his financial records. This was ~~however~~ because the farmer earned extra income from sources other than the farm. The various sources of income were not clearly specified in the financial records which were kept primarily for taxation purposes.

The net revenue calculated for 58 acres of sweet corn, 61 acres of ryegrass seed, 35 acres of tomatoes and 30 acres of peas was £13,138. Allowing for 1305 hours of hired labour at 7/- per hour the net profit is reduced to £12,681. This is slightly higher than the previous two estimates of net revenue from the farm alone. However, it would not be possible to achieve this return and operate 60 acres of lease land as well, without reorganizing the farm plan. The estimate of £12,681 can therefore only be considered alone, and no account be taken of returns from 60 acres of extra leased land. It does indicate, however, that the figures used for the linear programme are probably of the right general order of magnitude.

A comparison of the amount of labour hired as estimated for the 1961-62 farm plan with the linear program plan illustrates the point. The comparison is shown in Table 7.9.

Table 7.9. indicates that in order to operate 60 acres of lease land some labour would have to be released from the periods of Feb_4 and Mar_1 and possibly from Feb_2 of the 1961-62 plan. This is considered in terms of the labour restrictions imposed in the linear program. The release of this

TABLE 7.9:

LABOUR HIRED FOR 1961-62 FARM PLAN
AND THE LINEAR PROGRAM PLAN.

PERIOD	TOTAL HOURS		NO. OF MEN.	
	PROGRAM	1961-62	PROGRAM	1961-62
Jan_1	3.87	-	1	1
Feb_1	12.36	19.84	1	1
Feb_2	70.04	170.94	1	3
Feb_4	251.60	327.06	3 or 4	5
Mar_1	211.95	280.28	3	4
Mar_2	72.55	47.64	1 or 2	1
Mar_3	149.45	35.14	2 or 3	1
Mar_4	140.93	34.18	2	1
Oct_1	135.99	104.13	2	2
Oct_2	52.49	40.52	1	1
Oct_4	-	73.85	-	1 or 2
Nov_1	169.09	153.51	3	2 or 3
Nov_2	100.85	18.20	2	1
Dec_4	38.87	18.20	1	-

labour would necessitate a change in the farm plan. Hence estimated returns from 60 acres of lease land can only be added to an amount less than the £12,681 net revenue obtained from the plan being operated in 1961-62.

From the comparison of the farm net revenues above, it seems likely that the farmer is operating at or near the point of maximized farm revenue.

It is now necessary to discuss in detail the information provided on the computer print-out sheets, for the simplex solution,[17] concerning the "four hired men" program.

7.5.2. Activities in the Final Plan. The computer print-out identifies the activities in the final plan, the levels of these basic activities, and the price range of each activity over which the plan is optimum. The non-basic activities which would come into the plan, together with the level at which they would enter, are given for both the upper and lower price stability limits. The basic activity leaving the plan at each of the two price limits is also specified.[17]

The upper and lower critical price borders, at which some other plan becomes optimum, are calculated in the following manner.[18]

(i) The Upper price Limit.

Let the new shadow price of the jth non-basic activity resulting from an increase in price (c_{ij}) of the ith basic activity be $z_j - c'_j$. Let all other prices remain constant. We wish to find for each basic activity, $\Delta c_{ij} > 0$ such that:

$$z_j - c_j' = (z_j - c_j) + \Delta c_{ij} r_{ij} = 0$$

or

$$\Delta c_{ij} = \frac{-(z_j - c_j)}{r_{ij}} \quad ; \quad r_{ij} < 0.$$

where r_{ij} is the coefficient in the row corresponding to the ith basic activity and column corresponding to the jth non-basic activity in the final tableau.

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17. The print-out sheets for the four linear programs, the final matrix of "one", "three" and "four hired men" plans, together with all the basic data of this study have been lodged with the Department of Agricultural Economics and Farm Management, Massey University of Manawatu, Palmerston North.
18. The notation here and through the rest of this chapter, corresponds to "Linear Programming Methods", E.O. Heady and W.V. Candler, Iowa State University Press, Ames, Iowa, p.275, 1958.

The minimum price rise Δc_i, required to cause just one $z_j - c_j' = 0$ is:

$$\Delta c_i = \min_j \Delta c_{ij}$$

or

$$\Delta c_i = \min_j - \frac{(z_j - c_j)}{r_{ij}} \quad ; \quad r_{ij} < 0 \qquad (1)$$

$\min_j$ refers to the limiting variable, while $c_i + \Delta c_i$ provides the upper price limit.

(ii) The Lower Price Limit.

In a similar manner to (1) above, the minimum price decrease is given by:

$$\Delta c_i = \min_j - \frac{(z_j - c_j)}{r_{ij}} \quad ; \quad r_{ij} > 0 \qquad (2)$$

These upper and lower price levels define the limits of the range over which the per unit net revenue of the ith basic activity may vary without causing the optimum plan to change; provided the prices of all other activities remain constant.

To illustrate the effect of a price change above and below the particular price limits, it is necessary to consider some further information provided in the solution for the non-basic activities, which is discussed in detail in the next section. Table 7.10 which is taken directly from the print-out of the "four hired men" solution provides all the information necessary to follow the effects of price changes for the activity tomatoes-ryegrass seed (P_{11}).

TABLE 7.10:

EFFECTS OF PRICE CHANGES ON ACTIVITY P_{11}.

	BASIS					
Activity	Price	Level	Lim.Var.	Lower Limit	Lim.Var.	Upper Limit
P_{11}	£210.51	20.00	(03)*	£146.03	(34)	£00
	NON-BASIS					
Restriction	Shadow Price		Lim.Var.	Lower Limit	Lim.Var.	Upper Limit
(03)	£64.48		(10)	-6.03	P_{11}	20.00

* Bracketed numbers refer to restrictions.

From Table 7.10 the net revenue of the rotation activity tomatoes-ryegrass seed is £210.51 per unit, and this activity is in the basis at a level of 20 units, i.e. 40 acres. If the per unit price of this activity falls from £210.51 to £146.03 then the tomatoes maximum restriction (03) will just come into the plan. (This drop of £64.48 in the price of the tomatoes-ryegrass seed activity may be considered as a drop in tomato price with ryegrass seed price remaining constant). If the price drops below £146.03 then tomatoes maximum restriction (03) with a shadow price os £64.48 will enter the basis at a positive level of 20 units against the tomatoes-ryegrass seed activity P_{11}. Any rise in price above £210.51 for P_{11} will not cause any change in plan.

It must be emphasized that these price limits hold only when all other prices remain unchanged. Consequently the price stability limits given for say, peas-ryegrass seed activity on wet land (P_2), hold only if it is assumed that the price of peas-ryegrass seed activity on dry land (P_6) remains constant. Similar criticism applies to the price stability limits given for the basic activities P_1, P_9 and P_{13} in the "four hired men" solution.

As activities P_2 and P_6 give peas of the same yield and quality we wish to investigate the situation where any change in pea price affects simultaneously the net revenue for peas in both rotations. It is assumed that the respective contribution of ryegrass seed to the net revenue of a unit of P_2 and of P_6 is constant.

Under these conditions the effective minimum drop in pea price just necessary to cause a change in plan is:[19]

$$\text{Min}\left[\min_j\left(\frac{-(Z_j-c_j)}{r_{2j}}\right) \;,\; \frac{-(Z_6-c_6)}{(r_{26}-1)}\right]; \quad r_{2j}>0, \;\; r_{26}>1. \qquad (3)$$

Similarly the effective minimum increase in pea price just necessary to cause a change in plan is:

$$\text{Min}\left[\min_j\left(\frac{-(Z_j-c_j)}{r_{2j}}\right) \;,\; \frac{-(Z_6-c_6)}{(r_{26}-1)}\right]; \quad r_{2j}<0, \;\; r_{26}<1 \qquad (4)$$

For each plan, these upper and lower effective price limits for peas are shown in Tables 7.15 and 7.16. Table 7.15 gives the limits in terms of net revenue per unit of rotation, and Table 7.16 gives the limits in terms of gross price of peas per pound.

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19. For details of derivations, see Appendix F.

7.5.3. Labour Rows in the Basis. In the "four extra men" program there were no effective labour restrictions. All labour was priced at zero to give the linear program the opportunity of selecting the optimum farm plan with labour a free resource, subject only to the land and crop maxima restrictions. As none of the labour restrictions were effective no shadow prices or marginal value products for labour were obtained. Information was provided however on the upper and lower price limits for labour.

Table 7.11. provides an illustration of the information contained in the print-out solution.

TABLE 7.11.

LABOUR PRICES

RESTRICTION	Price	Level	Lim.Var.	Lower Price Lim.	Lim.Var.	Upper Price Lim.
(31)Nov_4	0	304.5	(3)	-£11.2139	P_{10}	£.7957

The method for obtaining upper price limits was indicated in 7.5.2. The upper price limit of £0.7957 per hour for labour before the plan changes is obtained from the activity P_{10} column of the final matrix for the four hired man plan as:

$$\Delta c_i = \min_j \Delta c_{ij} = \min_j - \frac{(Z_j - c_j)}{r_{ij}} \quad ; \quad r_{ij} < 0.$$

Here $\Delta c_i = \frac{-(5.57)}{-(7.0)} = £0.7957.$

This price limit gives the price (16/- per hour) to which the price of labour in the fourth week of November could rise without a change in plan provided the labour price in all other weeks remained at zero. This illustrates that the maximum price change for labour, for any individual week, necessary to cause a change in plan, can be derived. This is not really very useful information because the price for labour does not alter for each week.

The reader may be reminded that there are two types of labour. Firstly the permanent labour may be considered as a fixed cost, and from the point of view of profit maximization, this labour will be used even if the marginal cost falls to zero. Thus for periodswhen no labour is hired (for example, Nov_4 above) the upper limiting price (£0.7957 per hour) derived for permanent labour in this period is not very useful information.

The second type of labour is hired labour. This will be used so long as the marginal value productivity exceeds the cost of hiring labour. In practice the same price is paid for labour for all weeks in the year. Fortunately from the final print-out sheets and the final matrices from the "one" "Three" and "four" hired men plans it was possible to calculate the amount of hired labour being used for each weekly period. Then assuming the same labour price acting on all weeks, the smallest rise in hired labour price from zero which would bring about a change in plan, was calculated from each final matrix.[20]

20. "Linear Programming Methods," E.O. Heady and W.V. Candler, Iowa State University Press, Ames, Iowa, p.275, 1958.

Let the minimum labour price increase which causes $Z_j - c_j$ (where j is any non-basic activity) to become zero, be Δc_j.

Hence for the jth non-basic activity we require:

$$(Z_j - c_j) + \sum_i \Delta c_j \, r_{ij} = 0$$ where the summation over i is over all weeks in which labour was purchased.

$$\therefore \Delta c_j = \frac{-(Z_j - c_j)}{\sum_i r_{ij}} \quad ; \quad \sum_i r_{ij} < 0$$

The effective minimum labour price rise consistent with only <u>one</u> $Z_j - c_j$ going to zero is:

$$\min_j \Delta c_j.$$

When the above calculations were done for the "one," "three" and "four" hired men plans it was found that the price of hired labour in each case, could rise above £1 per hour before any of the plans would change. Table 7.12. provides the actual smallest price changes in hired labour price which were required to bring about changes in each of the linear program plans.

TABLE 7.12.

PARAMETRICALLY VARIED HIRED LABOUR PRICES FOR 3 SOLUTIONS

PROGRAM	ORIGINAL PRICE	SMALLEST PRICE INCREASE FOR CHANGE OF PLAN
"4 hired men"	£0	£1.45
"3 hired men"	£0	£1.32
"1 hired man"	£0	£1.86

The final matrix for the "two hired men" program was not obtained, hence the labour price could not be calculated. As the market price for labour is 7/- per hour it was thought unnecessary to parametrically vary the labour price further.

<u>7.5.4. Activities Not in the Plan</u>. The activities not in the plan have a shadow price or marginal value product imputed to them. The shadow price is given by the term:

$$\sum_i c_i r_{ij} - c_j$$

where $\sum_i c_i r_{ij}$ is the opportunity cost or the value of the basic activity sacrificed in order to produce another alternative. The revenue per unit of the jth non-basic activity is given by c_j. Hence if $\sum_i c_i r_{ij} - c_j$ is positive, the amount by which it is positive indicates the "opportunity cost" of increasing the jth non-basic activity by one unit. This also indicates the price rise necessary to just bring the jth non-basic activity into the plan. These shadow prices for crop activities are, however, subject to the same criticism concerning the price stability limits for some basic activities. That is, the shadow prices do not provide very useful information for some non-basic activities because the shadow prices only refer to the <u>independent</u> non-basic activities. That is, where a crop occurs in more than one activity, then the shadow price cannot provide useful information on critical price changes of that crop.

The marginal value products for the non-basic activities are given in Table 7.13.

TABLE 7.13.

NON-BASIC ACTIVITIES

Rotation Activity	Price	Shad.Price	Lim.Var.	Upper Limit to Entry if forced in
P_3 Wheat-RGS_1(w)	£ 91.07	£10.69	P_2	12.5
P_4 Barley-RGS_1(w)	82.00	19.76	P_2	12.5
P_5 Corn-RGS_1 (d)	123.75	34.27	P_9	13.5
P_6 Peas-RGS_1 (d)	111.76	34.27	P_2	12.5
P_7 Wheat-RGS_1(d)	94.07	51.96	P_2	12.5
P_8 Barley-RGS_1(d)	85.00	61.03	P_2	12.5
P_{10} D.Beans-RGS_1(d)	140.46	5.57	P_2	12.5
P_{12} Mangolds-B.Beans -RGS_1(d)	168.93	50.12	P_2	8.3
P_{14} RGS_2 (d)	£62.65	10.36	(6)	22.33
P_{15} Grazing (w)	17.73	40.83	P_{13}	39.00
P_{16} Grazing (d)	14.21	58.81	(6)	22.33
P_{17} Lucerne (d)	16.25	56.76	P_2	25.00

Activity P_7 will be used as an example of the meaning to be attached to the data in Table 7.14. If the per unit price of activity P_7 (£94.07), was increased by its shadow price (£51.96), then P_7 would just enter the plan by coming in against activity P_2. At most, 12.5 units of P_7 could come into the plan without a further basis change.

The upper limit is defined as:

$$\min_i \frac{b_i}{r_{ij}} \quad ; \quad r_{ij} > 0$$

Where $\min_i$ gives the limiting basic variable of all i basic variables, and $\frac{b_i}{r_{ij}}$ gives the upper limit at which the jth non-basic activity will come into the plan against the ith basic activity.

The print-out solution also provides the lower limiting variable for the jth non-basic activity which may be defined as:

$$\min_i \frac{b_i}{r_{ij}} \quad ; \quad r_{ij} < 0$$

These are all negatives and have no clear economic interpretation in the present situation.

7.5.5. Effective Restrictions. Effective restrictions appear amongst the non-basic variables. In the case "four extra men", none of the labour restraints were effective. The marginal value products, or shadow prices, of effective restrictions are of interest since they indicate the marginal value products of the resources. That is, these shadow prices give the increase in income which could be obtained if the farmer had an extra unit of the resource. By the same token they give the upper limit of the amount that the farmer could pay for the use of an extra unit of the resource.

Table 7.14. indicates the important information for the effective restrictions.

TABLE 7.14.

EFFECTIVE RESTRICTIONS

RESTRICTION	PRICE	SHAD. PRICE	LIM. VAR.	UPPER LIM.
(1) Land (d)	£0	£73.0	P_2	25.0
(2) Land (w)	£0	£53.4	P_2	37.5
(3) Tomatoes max. (d)	£0	£64.48	P_{11}	20.0
(4) Land transfer (w)	£0	£5.12	P_{13}	58.5
(34) Corn max (w)	£0	£11.9	P_1	26.5

The shadow prices from Table 7.14 indicate the value of an additional unit of land at the margin. They indicate the decrease in income for a unit of each resource which is allowed to go unused.

The shadow prices for land also indicate how much the farmer could afford to pay as rent on an additional acre of each class of land. As indicated in 7.5.4. the derivation of the shadow prices is given by

$$\sum_i c_i r_{ij} - c_j.$$

The upper limiting variable for an effective restriction is defined as $\min_i \frac{b_i}{r_{ij}}$; $r_{ij} > 0$, which provides the level at which the jth non-basic variable would enter the plan. The minimum limiting variable is defined as $\min_i \frac{b_i}{r_{ij}}$; $r_{ij} < 0$ which gives the maximum level at which the jth non-basic variable may enter the plan at a negative level.

The shadow prices for land can also indicate how much a farmer should pay for additional land. Consider for example restriction (2), the wet land restriction with its shadow price of £53 per unit. Then provided the farmer continued with the plan indicated by the solution of "four extra men", it can be shown that he could afford to pay £53 for an extra acre of land.

The shadow price (£53) may be considered as a rough estimate of the return to capital invested in an extra acre of land. If the farmer required a return of 15% on invested capital, then he could afford to pay:

$$\frac{15}{100} \times X = £53 \quad ; \quad X = \text{capital invested in land}$$

$$\therefore X = \underline{\underline{£353}} \text{ per acre.}$$ [21]

The information discussed above indicates the sort of information which can be derived from a linear program. As this study is concerned with the financial returns to process pea growing, the place of peas in the farm plan for the "four extra men" situation is now discussed.

<u>7.5.6. The Place of Peas in the Farm Plan.</u> From the foregoing discussion it is now possible to identify the factors which will effect the level of peas in the final solution. The effects listed below, concerning the "four hired men" plan, may occur provided all prices except the ones being discussed remain constant.

(i) The upper and lower price stability limits of P_2 & P_6.

These limits, derived from (3) and (4) are shown in Table 7.15, assuming that the changes in price accrue only from peas. That is the ryegrass seed contribution to the per unit net revenue of these activities is constant.

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21. The market prices for land in the area surveyed are of this order, and a return to capital on farms in this area of over 10% is achieved by many farmers.

TABLE 7.15.

UPPER AND LOWER PRICE STABILITY LIMITS
OF THE PEAS-RYEGRASS SEED
ACTIVITIES.

PLAN.	FOUR HIRED MEN		THREE HIRED MEN		ONE HIRED MAN	
Activity	P_2	P_6	P_2	P_6	P_2	P_6
Price	£101.76	£111.76	£101.76	£111.76	£101.76	£111.76
Lim.Var.	P_{10}		(03)		P_1	
Lower Limit	£96.19	£106.19	£100.30	£110.30	£ 71.64	£81.64
Lim.Var	(34)		(10)		P_6	
Upper Limit	113.75	£123.75	£113.75	£123.75	£166.18	£176.18
Range	£17.56		£13.45		£94.54	

The upper and lower price stability limits of peas, in terms of gross pea price/lb. is shown in Table.7.16.

TABLE 7.16:

UPPER AND LOWER PRICE STABILITY
LIMITS OF GROSS PEA PRICE/LB.

PLAN	Four hired men	Three hired men	One hired man
Lower limit	3.2d.	3.6d.	1.0d.
Actual price	3.7d.	3.7d.	3.7d.
Upper limit	4.8d.	4.8d.	9.5d.
Range	1.6d.	1.2 d.	8.5d.

From Table 7.16 it is seen that with ryegrass seed and livestock prices remaining constant, the price stability limits for the "four hired men" plan correspond to prices of 3.2d. and 4.8d. per lb. gross. From Table 7.15 we see that above a price of 4.8/lb. the "corn maximum" restriction (34) enters the plan. From Table 7.14 we see that (34) enters against corn-ryegrass activity (P_1) at a maximum 26.5 units. From the solution matrix it can be seen that a unit increase in the "corn-maximum" will supply one unit of the peas-ryegrass activity (P_2). Thus an increase in the price of peas above 4.8d./glb. gross will allow an additional 26.5 units of peas-ryegrass on wet land (P_2) to be grown, or an extra 26.5 acres of peas.

If however, the price of peas falls from 3.7d. lb. gross to just below 3.2d. lb. gross, the dwarf beans-ryegrass activity (P_{10}) will come into the plan, forcing peas-ryegrass on wet land out. Thus if the price of peas falls by more than .5 lb. gross, the 12.5 units of P_2 (12.5 acres of peas and 12.5 acres of ryegrass) will be replaced by 12.5 units of dwarf beans ryegrass rotation.

(ii) The effect on pea production of price changes in other crops.

(a) Corn Price.

As corn appears in three different activities, the price stability limits for corn rotations derived by the computer are subject to the criterions mentioned in sections 7.5.2., 7.5.3., and 7.5.4. Consequently corn price limits (assuming the prices of other crops in the rotations remain constant) were calculated from (3) and (4) after modification to allow for the fact that two corn rotations are in the basis and one in the non-basis. The two basic rotations are corn-ryegrass activity on wet land (P_2) and the broad beans - corn - ryegrass activity (P_9). The non-basic corn rotation is corn-ryegrass activity on dry land (P_5). The resulting minimum corn price changes necessary to just cause a change in plan are, a drop in price of £11.99 per unit of activity, and an increase in price of £4.00. In terms of gross corn price per ton[22] this means that corn price can fall from £12.04 ton gross to £10.00 ton gross without causing a change in the optimum plan. Below £10.00 ton gross, corn maximum restriction (34) enters the plan against corn-ryegrass activity on wet land (P_1) at a level of 26.5 units. From the final matrix, this supplies an additional 26.5 units of peas-ryegrass (P_2). An increase in corn price above £12.04 ton gross has no effect on the activities in the final plan.

(b) Wheat Price.

Wheat occurs in activities P_3 and P_7, both of which are non-basic in the final solution. Again as the yields and prices of wheat per unit of each activity are the same, and no wheat rotation is in the final plan, the minimum rise in wheat price just necessary to bring wheat into the plan is the minimum of the two respective shadow prices, or £10.69 per unit of activity. This rise is equivalent to an increase from £725 bushel gross to £.939 bush gross. Above a price of £.839 bush.gross, wheat-ryegrass activity on wet land will enter the plan against peas-ryegrass (P_2) at a level of 26.50 units. That is, above a wheat price of £.939 bush.gross 25.5 acres of wheat replaces 12.5 acres of peas in the plan.

(c) Barley Price.

Barley occurs in activities P_4 and P_8 both of which are non-basic. The yields and prices of barley per unit of each activity are the same, and

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22. Corn yields and prices per unit of each of the three corn activities are the same.

the minimum price rise necessary to just cause a change in plan is the maximum of the two respective shadow prices. This is an increase of £19.76 per unit of activity. Thus an increase in barley price from £.5 bush.gross to £.869 bush.gross will just allow barley-ryegrass activity (P_4) to enter the plan against peas-ryegrass activity (P_2) at a level of 12.5 units. That is above a barley price of £.889 bush.gross, 12.5 acres of peas is replaced by 12.5 acres of barley.

(d) Broad Beans Price.

Broad beans occur in the basic activity (P_9) and the non-basic activity (P_{12}). Thus the price stability limits per unit of activity are given by (3) and (4); as the yields and prices of broad beans in the two activities are the same. These price stability limits per unit of activity are given by a drop of £5.57 and an increase of £64.48. In gross terms, the present price of broad beans of £42 tons gross may decrease to £39.21 ton gross and increase to £74.24 ton gross without a change in plan. Below £39.21 ton gross, Dwarf beans-ryegrass activity (P_{10}) enter against peas-ryegrass activity (P_2) at a level of 12.5 units. Above £74.24 ton gross the tomatoes maximum restriction (03) comes into the plan against tomatoes-ryegrass activity (P_{11}) at a level of 20 units, increasing the level of peas-ryegrass activity (P_2) by 20 units.

(e) Dwarf Beans.

As dwarf beans appear only in the non-basic activity P_{10}, the shadow price given in the print-out applies to dwarf beans price increases. The increase in price of dwarf beans necessary to just bring P_{10} into the plan is £5.57 per unit of activity. This represents an increase in gross price of dwarf beans from £46.65 ton gros to £48.51 ton gross. Above this price dwarf beans-ryegrass activity (P_{10}) enters the plan against peas-ryegrass activity (P_2) at a level of 12.5 units.

(f) Tomatoes.

As tomatoes appear only in the basic activity P_{11}, the stability limits given in the print-out apply. These are given as £146.03 and £$+\infty$ per unit of activity. The lower price limit is equivalent to a drop in price from £13.23 ton gross to £8.59 ton gross. Below this price tomatoes maximum restriction (03) enters the plan against tomatoes-ryegrass activity (P_{11}) at a level of 20 units, and supplies an additional 20 units of peas-ryegrass activity (P_2). A price increase above £13.23 ton gross has no effect on the activities in the plan.

(g) Mangolds.

Mangolds appear only in the non-basic activity P_{12} and hence the shadow price applies. An increase in mangold price of £50.11 per unit of activity will just allow P_{12} to enter the plan.against peas-ryegrass (P_2) at a level of 8.33 units. This upper price limit corresponds to a price increase in mangolds from £2.5 ton gross to £3.5 ton gross.

(ii) The effect of a labour price rise.

If the price per hour of labour rose above £1.45, the "Tomatoes maximum" restriction would enter the plan against the tomatoes-ryegrass rotation up to a limit of 20 units. This would release resources from the tomatoes-ryegrass rotation to be used for an increase in production of an extra 20 units of peas-ryegrass.

(iii) Reduction of crop maximum restrictions.

If the "corn maximum" restriction was reduced from 40 units, then for every unit reduction, the peas-ryegrass rotation would be increased by one unit up to a maximum of 26.5 units; or from the 12.5 acres of peas and

12.5 acres of ryegrass in the "four man plan", to a maximum of 39.0 acres of peas and 39.0 acres of ryegrass.

A summary of the influence of changes in gross crop prices on the 12.5 acres of peas in the final plan is shown in Table 7.17. This table gives the upper and lower gross price stability limits and shows the effect on the pea acreage if these limits are just exceeded.

TABLE 7.17:

SUMMARY OF THE EFFECT OF CHANGES IN GROSS PRICES OF CROPS ON PEA PRODUCTION FOR THE "FOUR HIRED MEN" PLAN

Crop	Price	Lower Limit	Effect(acres)	Upper Limit	Effect (acres)
Peas	3.7dlb.	3.2dlb.	-12.5	4.8d.lb	+26.5
Corn	£12.04 ton	£10.00 ton	+26.5	∞	0
Wheat	£.725 bush	$-\infty$	0	£.939bush.	-12.5
Barley	£.50 bush	$-\infty$	0	£.869 bush.	-12.5
Broad beans	£42.00 ton	£39.21 ton	-12.5	£74.24ton	+20.0
Dwarf beans	£46.65 ton	$-\infty$	0	£48.51 ton	-12.5
Tomatoes	£13.23 ton	£8.59 ton	+20.0	∞	0
Mangolds	£2.50 ton	$-\infty$	0	£3.50 ton	-12.5

From the point of view of price changes, the most sensitive competition with peas appear to be:

(i) A drop in pea price of .5d. lb. gross.
(ii) A drop in broad bean price of £2.79 ton gross.
(iii) An increase in dwarf bean price of £1.86 ton gross
(iv) An increase in mangold price of £1.00 ton gross.

All four of these changes cause peas to be eliminated from the final plan.

All price changes necessary to bring about an increase of pea acreage in the plan appear to be extensive; except perhaps for a drop in corn price of £2.04 ton gross. However, any lowering of the corn maximum restriction (say through a smaller acreage contract) will increase pea acreage.

The results discussed above refer to the solution of the "four hired men" program. Similar information is also obtainable from the print-outs and matrix solutions for plans concerning "one hired man," "two hired men," and "three hired men."

The farm plans provided in each of these solutions are illustrated in Fig. 7.2. and Table 7.18 which express output as a function of farm labour input.

The relevant numerical information for figure 7.2. is provided in Table 7.18.

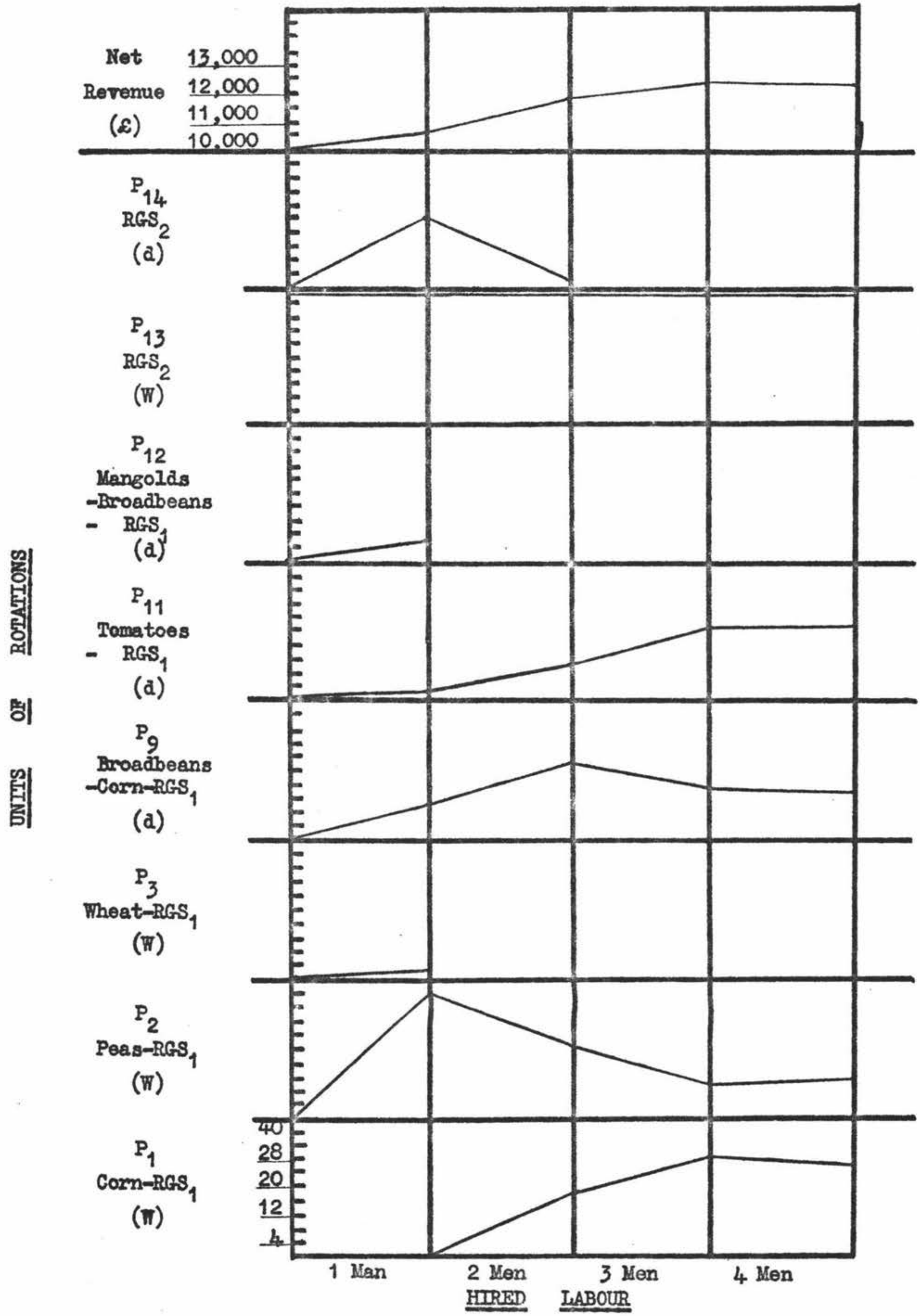

FIGURE 7.2. FOUR FARM PLANS ACCORDING TO LABOUR INPUT

TABLE 7.18

NUMERICAL DATA FOR FIG. 7.2.

		LABOUR		PLANS
	1 man	2 men	3 men	4 men
* Net Revenue	£10,748	£11,921	£12,448	£12,420
Activity Rotations	Levels of Rotations			
P_{14} RGS_2 (d)	20.33	3.41	-	-
P_{13} RGS_2 (W)	39.00	39.00	39.00	39.00
P_{12} Mangolds-Broad Beans Rgs_1 (d)	6.02	-	-	-
P_{11} Tomatoes-RGS_1 (d)	3.16	10.63	20.00	20.00
P_9 Broad Beans-Corn-RGS_1 (d)	11.15	21.16	13.50	13.50
P_3 Wheat-RGS_1 (W)	2.52	-	-	-
P_2 Peas-RGS_1 (W)	36.48	19.60	9.47	12.50
P_1 Corn-RGS_1 (W)	-	19.40	29.53	26.50
Total Hours Hired Labour	558	1,028	1,435	1,410
Labour From zero to Change the Plan	£1.86	-	£1.32	£1.45

* Net revenue is the programme net revenue less the cost of hiring labour. The cost of hiring labour is given by the total hours of hired labour at a price of 7/- per hour.

7.5.7 Discussion of Farm Plans

The farm plans illustrated in Figure 7.2 and Table 7.18 refer to the allowable maximum labour which may be hired at any period of the year. This hired labour is additional to the permanent farm labour staff of the farm and his permanently employed men.

The first point to notice in Table 7.18 is that the net revenue for the "three hired men" plan is slightly higher than that of the "four hired men" plan. This was evident even before the cost of hiring labour was deducted. For example the programme net revenue for "three men" was £12,950 and the net revenue for "four men" was £12,914. The reason for this was that an error occurred when placing the punched cards into the computer. As a result, the "corn maximum" restriction was left out of the "three men" plan. Unfortunately time did not permit to re-run this programme. The effects of this error is illustrated by an increased corn-ryegrass acreage and a decreased pea-ryegrass acreage for the "three men" plan. This plan specifies a total of 43.03 acres of sweet corn per year. From the final matrix it was seen that had the "corn maximum" restriction been imposed, corn-ryegrass would have been reduced by 3.03 units and peas-ryegrass would have increased by 3.03 units to give a plan similar to the "four hired men" situation.

From Table 7.18 it is clear that each plan is insensitive to variations in the price of hired labour from zero to an amount in excess of 26/- per hour.

The general pattern of farm organisation illustrated in the Figure 7.2 and Table 7.18 shows firstly that as the amount of available hired labour is reduced, so are the levels of labour-intensive crops. Rotations such as tomatoes-ryegrass and corn-ryegrass are reduced. The combination of crops for the lower labour hire situations have avoided peak periods of labour use where possible by including winter and spring harvested crops such as mangolds and broad beans.

Comparing the situations of "one", "two" and "three hired" men indicates the plans are sensitive to the amounts of labour available for hiring. As the number of hired men increase there is a marked increase in the amounts of labour-intensive crops of tomatoes and sweet corn. In spite of this trend there is a difference of only £1,672 in net revenue (after deducting the cost of hiring labour) between the "one hired man" situation and the "4 hired men" situation. The major factor contributing to this effect is the crop maximum restrictions imposed on tomatoes and sweet corn production.

With reference to the peas-ryegrass rotation which has relatively low labour requirements, there is a marked trend from large areas when labour is scarce, to small areas as labour becomes less limiting.

The sensitivity of peas to changes in price for all plans is indicated in Tables 7.15 and 7.16. The information in those Tables has been derived from the solution print-out sheets and assumes that all prices except for peas, remain constant.

Table 7.16 shows that where labour is scarce and peas are included in the plan, the price of peas is insensitive to price changes. However, where labour is freely available at any time of the year, and where peas are grown in combination with other specified crops, the average gross price of peas is at a level where 0.5 lb. decrease, would force them out of the plan. Thus peas would be fairly sensitive to a price decline where profitable labour intensive alternatives were being considered, but are less sensitive to a price increase.

7.5.8 Review of the Situation For Farm No. 23

The situation of farm No. 23 is one in which the amount of labour that can be hired is flexible. By means of linear programming it was possible to examine this situation over a wide range. It has been shown that although the plans hiring one and two men are feasible and stable, they are not the most profitable plans. Hiring one man can achieve a net revenue of £10,748 after allowing for the cost of hiring the man. Further the marginal value productivity of hiring two men is high, and adds £1,173 to net revenue after allowing for the cost of hired labour. Increasing the hired labour force above two men, however, causes a marked decline in the marginal productivity of labour.

With the crop restrictions imposed by the farmer, the linear programming results suggest that he should produce the allowable maximum acreage of those labour intensive crops and hire three or even four men to get the work done. Less labour-intensive crops such as peas, and ryegrass seed which are harvested just prior to the labour intensive crops of tomatoes and sweet corn "fit in" well with the labour resources available. Similarly a winter-grown, spring harvested crop such as broad beans, "fits in" well with the labour pattern.

7.5.9 Summary

Chapter 7 has dealt with the application of linear programming to derive optimum farm plans under various situations for hiring farm labour, for the survey farm number 23. The farm was described and the method of developing the linear programme model was given. The results of the programme concerned with the "four hired men" situation was presented and discussed in detail. Examples illustrating pertinent points arising from the solution were given with reference, where possible, to peas. Finally the production plans for the five linear programmes were compared illustrating the place of peas in each plan, and the sensitivity of price changes for peas in relation to the other activities was considered.

Additional information in the form of the complete farm plans for "one hired man", "two hired men" and "three hired men" appears in Appendix D. Appendix E shows the budgets for the livestock.

The farmer's comments on the linear programme plans are given in Chapter 8.

CHAPTER 8

FARMER'S COMMENTS ON THE LINEAR PROGRAM RESULTS.

This Chapter presents the farmer's comments on the initial linear program derived for his farm. This program was run after the first two farm visits and the results were taken back to the farmer for his comments. This Chapter is essentially concerned with the third interview. The farmer's comments obtained at this interview allowed modification to be made to the programming matrix; the final form of which was shown in Table 7.6. As stated in the previous Chapter, the time available for this study prevented the author from visiting the farmer on a fourth occasion to obtain his comments on the final programming results.[1]

Section 8.1. will show the errors which occurred in the initial program. The form in which the results from this program were actually presented to the farmer is shown in 8.2. and the farmer's comments appear in 8.3. and 8.4.

8.1. Errors in the Initial Program.

The initial program contained two types of errors.

8.1.1. Technical Mistatement of the problem by the author.

These were technical errors made by the author when deriving the coefficients. The first of these errors appeared in the land requirement coefficients for the rotation activities wheat-ryegrass and broad beans - ryegrass respectively. The respective per unit requirements of these rotations for

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1. A final visit to the farmer is planned, and his comments on the final program will be published.

land appeared as +3 in the land rows, but as they were both two-year rotations the coefficients should have been +2.

The second technical error occurred when the resource requirements for 20 units of the pea-ryegrass rotation activity were being deducted from total resource supplies.[2] When subtracting 20 units of the rotations from the wet land (w) supply of 117 acres, only 20 acres instead of 40 acres were subtracted from this land supply.

Other errors which occurred in the initial program were due to the author misunderstanding the problem.

8.1.2. Misunderstanding of the problem by the author. These errors occurred because some aspects of the farm management system were not stated clearly during the course of the first two interviews. The first problem was an error of omission. The author was not fully aware that crops grown on wetter land (w) could also be grown on the drier land (d). Hence no rotation activities of corn-ryegrass, peas-ryegrass, wheat-ryegrass, and barley-ryegrass were defined for the use of drier land.

Another problem arose in defining two of the rotation activities. A two-year rotation of broad beans - fallow - ryegrass was defined. The other rotation activity was a three-year rotation of mangolds - fallow - dwarf beans - ryegrass. It can be seen that both of these activities contain a fallow period. This period was thought to be necessary in order to correctly specify the time sequence of the cropping enterprises within each activity. At the third interview the farmer said that no land should lie idle; accordingly, he suggested, changes in the rotation activities

2. Resources for 20 units of the peas-ryegrass rotation were subtracted from the initial supplies since the author understood that at least twenty acres of this activity were to be produced.

including broad beans and mangolds respectively. These changes are discussed further in 8.3.2.

The author also gained the wrong impression from the farmer concerning the peas-ryegrass rotation. It was wrongly understood that <u>at least</u> 20 acres of peas were to be grown each year. Accordingly, account was taken of this by subtracting the requirements for 20 units of the peas-ryegrass rotation activity from the resource supplies.

In the initial programme provision was made for labour hire activities, allowing the purchase of hired labour at 7/- per hour, each weekly period, to augment permanent labour supplies. A labour hire row was also incorporated to put an upper limit on the total amount of labour that could be hired during the year. Unfortunately, the extra rotation activities revealed during the third interview prevented there being space in the computer for labour hire activities in the final form of the problem. This has already been discussed in Chapter 7.

Finally, a restriction on the amount of working capital was included in the initial linear program. The farmer pointed out that this was redundant.

Due to the errors described above, the initial "plan" was not entirely realistic. The technical errors were realized by the author when he checked the plan, and cut-and-try improvements were made to the programming results. For example the actual level of second year ryegrass in the program solution was 45.67 acres. This was 20 acres too much and violated the actual land (w) supply by 20 acres. The error occurred when 20 units of the peas-ryegrass activity were subtracted from the resource supplies. Thus instead of reducing the land (w) supply from 117 acres to 77 acres, the actual (w) supply was reduced to 97 acres. Hence the land (w) "supply" appearing in the

B column of the first simplex tableau was 20 acres greater than it should have been. The <u>correct</u> adjustment however was made to the land (w) transfer row by increasing the supply in the B column from zero to 20, to make allowance for the 20 acres of the first year ryegrass already deducted from the plan. This land is "optionally" available for second year ryegrass(w). The effect of having an extra 20 acres of land (w) "out of ryegrass 2" available was to allow an extra 20 acres of second year ryegrass to come into the plan. Thus leading to a plan which required 20 acres more land than was actually available.

A cut-and-try improvement was made by reducing the level of second year ryegrass from 45.67 acres to 25.67 acres to achieve the correct land balance. Similarly the net revenue of 20 acres of second year ryegrass was deducted from the program net revenue to reduce this from £11,899 to £10,578. No other adjustments were made although it was realized that there would be other effects on, for example, the amount of labour hired.

After making these corrections the results of the initial linear program were presented to the farmer at the third interview. It was necessary to interpret the results in the form of a budgetary analysis which could be readily understood by the farmer. In addition to the budget, the form of the results actually presented to the farmer included a farm production pattern detailing the land use and amounts of labour hired by weeks, and farm sketch plans showing how the acreages of crops specified by the program would fit in with existing fence-lines on the farm. The basic matrix was also shown to the farmer to let him see how the model was actually set up.

8.2. Presentation of Results

The presentation of the results to the farmer is discussed in the next three sections.

8.2.1. The Budget. A simple budget was constructed from the information on the computer print-out sheets. From the levels of activities in the plan, and the net revenue per unit of each activity, it was possible to show the farmer how the linear program total net revenue figure was obtained. The following budget was readily understood by the farmer after a brief explanation of some of the terms used. For example the meaning of each Activity, the level in units, and the meaning of the net revenues were all explained.

Activity	Level (Units)	Net Revenue Per Unit	Net Revenue From Activity
Sweet corn - RGS_1	25.67	£115.50	£2964.49
* RGS_2	25.67	65.56	1682.70
Tomatoes - RGS_1	20.00	205.57	4110.20
Dwarf beans - RGS_1	10.28	135.46	1393.00
Mangolds - D.Beans - RGS_1	2.14	199.70	428.20
Linear Program Net Revenue			£10578.59
LESS Allowance for 1004 hours of hired labour at 7/- per hour			351.35
Revenue Net of Hired Labour			£10,227.24
PLUS Net Revenue Calculated for 20 units Peas - RGS_1 Rotation			2,235.20
∴ Total Farm Net Revenue			£12,462.44

*Corrected as described in 8.1.2.

It was explained to the farmer that the costs which had been deducted from the enterprise gross revenues were the costs of seed (or plants), fertilizer, spray materials, tractor fuel and oil, cartage, sacks and gang labour.[3] These are the costs that a farmer thinks of when he is assessing the profitability of a crop. The "profit" of £12,462 had to go to meet the cost of permanent labour, repairs and maintenance costs of tractor and implements, building and fencing repairs and maintenance, general farm expenses and other farm "overheads."

8.2.2. The Farm Production Pattern. The farm production pattern detailed from the budget and actually presented to the farmer was as follows:

A. LAND UTILIZATION

Wetter Land

25.7 acres sweet corn
25.7 acres RGS_1 after sweet corn
25.7 RGS_2 (that is RGS_2 follows RGS_1 after sweet corn)
20.0 acres Peas (not included in the linear program)
20.0 acres RGS_1 after Peas (not included in the linear program)
7.0 acres Grazing only (" " " " " ")
124.1* acres wetter land

* The additional 0.1 acres of land (w) is due to computational rounding errors.

Drier Land

20.0 acres Tomatoes
20.0 acres RGS_1 after Tomatoes
10.3 acres Dwarf Beans
10.3 RGS_1 after dwarf beans
2.1 acres Mangolds
211 acres Dwarf Beans after Mangolds
2.1 acres RGS_1 after D. beans after Mangolds

66.9* acres Drier land.

* The deficiency of 0.1 acres of land (d) is due to computational rounding errors.

3. The actual complete budgets presented to the farmer have been lodged with the Department of Agricultural Economics and Farm Management, Massey University of Manawatu. The farmer, however, was mainly concerned with the summarized budget shown above once he had seen how the net revenues for each crop had been calculated.

B. HIRED LABOUR[4]

The amounts of hired labour specified by the program for certain weeks in the year were as follows:

PERIOD	TOTAL HOURS	NO. of HIRED MEN
Jan_1	39.5	1
Feb_1	71.2	1
Feb_2	71.2	1
Feb_4	200.6	3
Mar_1	130.4	2
Mar_2	130.4	2
Mar_3	130.4	2
Mar_4	177.8	3
Nov_1	24.6	1
Nov_2	27.8	1

Additional to the numerical information provided by the budget, and the farm production pattern, sketch maps of the farm were drawn, showing how the linear program plan would work on the farm.

8.2.3. Sketch Farm Plans. Sketch farm plans were drawn with rough paddock sizes, and also showing the approximate demarkation fence lines between the two types of land. The linear program rotation pattern was transferred to these sketch farm plans, to show the farmer how he could work the crop rotations for the next three years, keeping as far as possible within existing fence lines. Figures 8.1; 8.2; and 83, indicate the farm land utilization for a three year period.

4. Hired labour in this sense does not include gang labour. Gang labour for harvesting tomatoes, mangolds and dwarf beans was allowed for in calculating the respective activity net revenues.

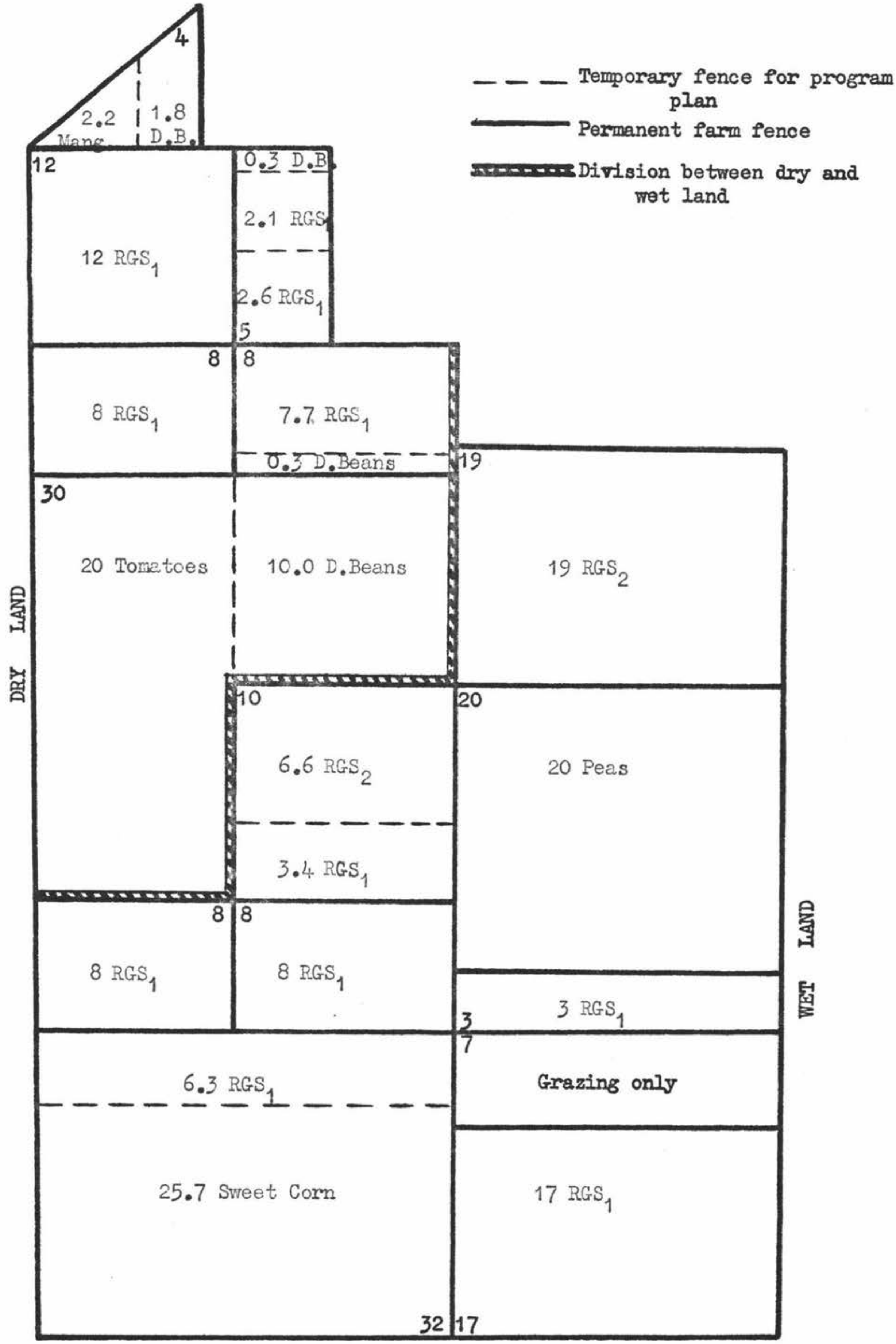

FIGURE 8.1. LAND USE FOR YEAR I

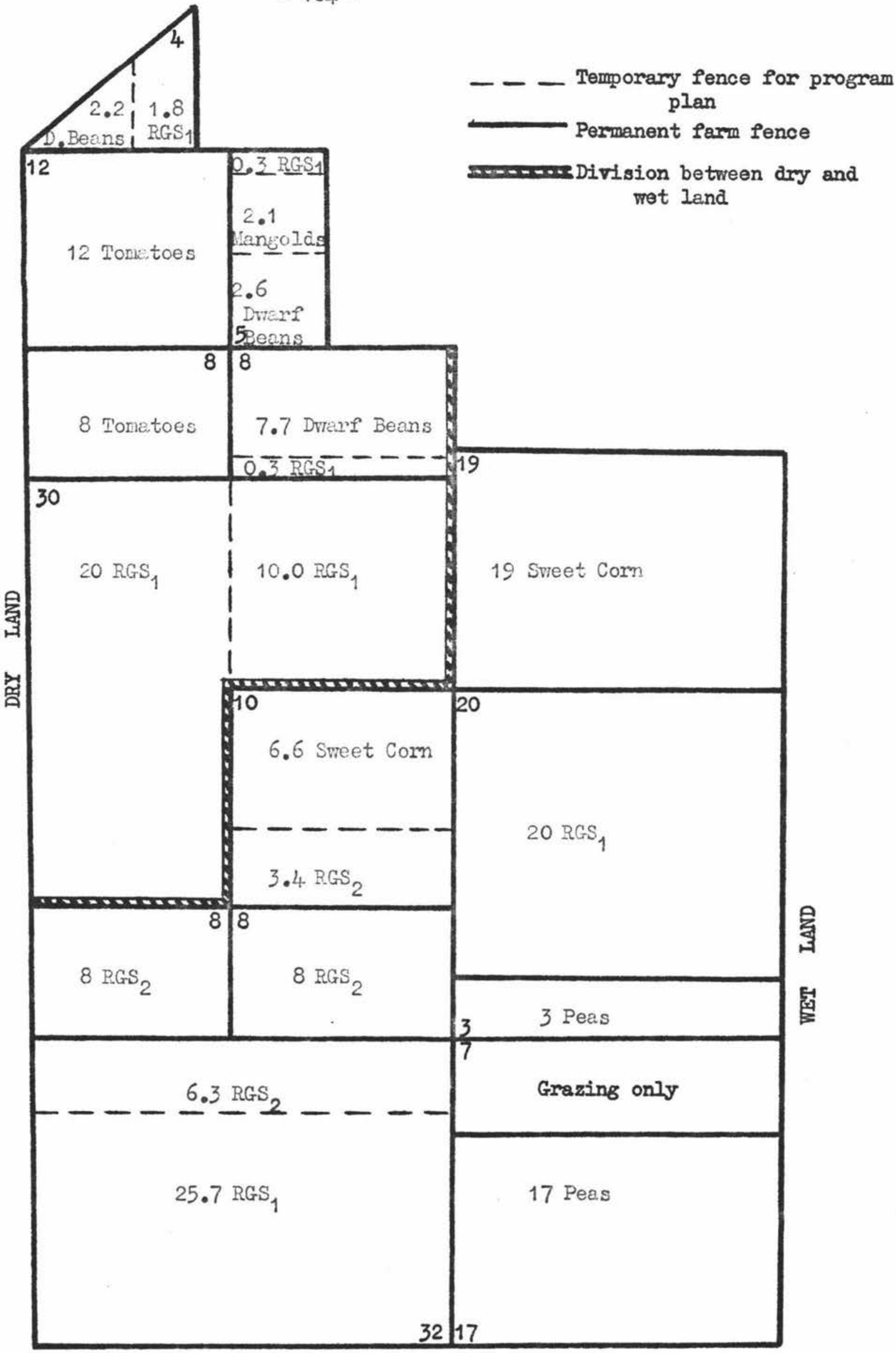

FIGURE 8.2. LAND USE FOR YEAR II

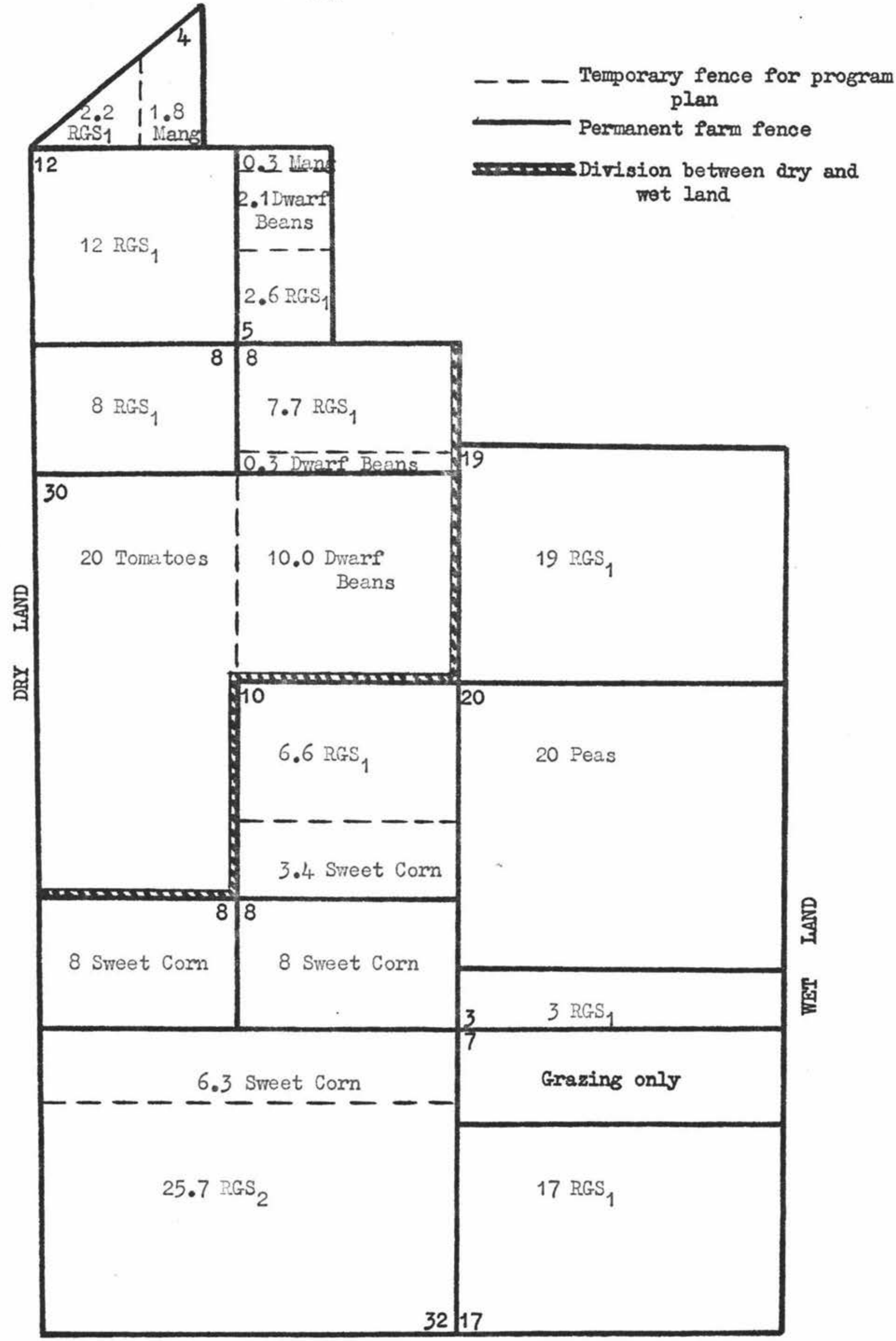

FIGURE 8.3. LAND USE FOR YEAR III

The pattern of land use illustrated in Figures 8.1. to 8.3. indicates that there are basically five short-term rotations which succed themselves. These rotations are:

(i) Mangolds - dwarf beans - ryegrass (3 years)

(ii) Tomatoes - ryegrass (2 years)

(iii) Dwarf beans - ryegrass (2 years)

(iv) Peas - ryegrass (2 years)

(v) Sweet corn - first year ryegrass - second year ryegrass (3 years)

The actual areas occupied by the specific levels of these rotations could of course be rotated about each class of land, but this would necessitate further (temporary) subdivision of paddocks. The plans presented minimise the further subdivision necessary. Where a farm plan had large acreages of all crops, planning the land use pattern would be simplified.

The above farm budget, land and labour "profiles", and sketch farm plans were readily understood by the farmer. These three different "perspectives" on the proposed plan allowed the farmer to grasp easily what was proposed. This in turn enabled him to point out deficiencies in the proposed farm plans. After discussion of these deficiencies with the farmer, to identify just what was wrong, the author was able to modify the programming matrix to provide a better description of the farmer's problem. The next section gives examples of the farmer's comments on the above plan.

8.3. The Farmer's Comments

From the above farm plans and budgets the farmer was able to suggest modifications to the statement of the problem so that it would represent more closely, the real life situation on his farm. The suggested modifications were of several kinds.

8.3.1. Improvements in Crop Land Use. After observing the initial basic matrix and discussing it with the author, the farmer's first criticism concerned the crop rotations requiring the two types of land. He pointed out that crops grown on wet land could be grown equally well on dry land. He suggested that new activities for corn-ryegrass, peas-ryegrass, wheat-ryegrass and barley-ryegrass should be defined for the drier land. Although the resource requirements and yields of corn, peas, wheat and barley were considered the same for both classes of land, this was not so for ryegrass seed. The differences for ryegrass seed in the rotation activities were evident in higher labour requirements and higher net revenues on the drier land.

8.3.2. "Inefficient Rotations." The farmer considered the broad beans - fallow - ryegrass rotation and the mangolds - fallow - dwarf beans - ryegrass rotation to be "inefficient." He was not keen to let land lie idle. He therefore suggested re-defining the broad beans - fallow - ryegrass rotation again as a two-year rotation, but to replace the fallow period with a third cash crop. According to the farmer it is possible to grow a third cash crop from the end of harvest of broad beans (Nov_4) until cultivation begins for a ryegrass pasture (Mar_3). Sweet corn was suggested as the replacement crop.

The mangolds - fallow - dwarf beans - ryegrass rotation was also changed. The farmer suggested a change of this three-year rotation to mangolds - broad beans - ryegrass. In this rotation, the broad beans would follow on immediately after the mangolds are harvested in mid-June. The late planting of broad beans would mean later harvesting of this crop in Dec_1; although the cultivation prior to sowing down pasture after broad beans would begin earlier than usual (Jan_4), the intervening period (Dec_1 - Jan_4) would of necessity be a short fallow period. The farmer considered that this latter rotation was more efficient than the one including dwarf beans. Although he was "not entirely happy" with it, the farmer considered the mangolds - broad beans - ryegrass rotation as being "satisfactory."

8.3.3. Crop Maximum and Crop Minimum Restrictions. Contrary to the author's impression, the farmer has no set ideas about growing a specified minimum acreage of peas each year. He uses the pea crop to "fill in the gap" if contracts for growing other crops are reduced. He suggested that the minimum restriction of 20 units for the peas-ryegrass rotation should be deleted from the program.

Consideration was then given to including a "corn maximum" restriction. At the time of the third interview with the farmer, he had recently acquired sixty acres of level land on which he intended to grow sweet corn for the next three successive seasons. As the food processing factory had guaranteed at least this sixty acres of corn contract; the farmer considered that he could not handle any more than 100 acres of sweet corn per season. Hence he suggested imposing a limit of 40 acres of sweet corn on the linear program for the "home" farm. After discussion with the author it was decided to subtract the labour requirements for 60 acres of a one-year rotation of sweet corn - stock green feed from the farm labour force, and let the linear program select the farm plan from the remaining resources. Any sweet corn entering the plan would be restricted to a maximum of 40 acres. The farmer considered this would provide him with a much more realistic picture of the actual farm situation.

8.3.4. Labour Requirements. "Labour is not much of a problem," and "Casual labour is easy to get" are two quotations from the farmer. He maintained that he could hire all the casual labour he required for any farm system. For this reason he paid very little attention to the amounts of hired labour specified in the program.

However, at a later stage in the interview, when the farmer was asked to check some of the labour requirement coefficients, he was eager to do so. Although he said he could get as much casual labour as he needed, he suggested an upper limit of 70 hours per week per hired man for any period during the year.

The remaining suggested changes for labour, concerned the individual coefficients for harvesting periods for broad beans, dwarf beans, and tomatoes, and the labour spent buying and selling livestock. These modifications are listed below:

(i) The coefficients for harvesting broad beans:

Nov_3 4 hours/acre (farmer) + 2 hours/acre (permanent man)
This was a change from 7.4 hours/ac. to 6 hours/ac.

Nov_4 4 hours/ac. (farmer) + 2 hours/ac. (permanent man)
This was a change from 8 hours/ac. to 6 hours/ac.

(ii) The coefficients for harvesting dwarf beans.

Feb_2 5 hours/ac. (farmer) + 2.5 hours/ac. (permanent man)
This was changed from 8 hours/ac. to 7.5 hours/ac.

(iii) The coefficients for harvesting tomatoes (based on 20 acres).

Jan_3 First pick takes 2 days.

But farmer spends 3 days @ 9 hours/day =		27 hours
Permanent man spends 2 days @ 9 hours/day	=	18 hours
Total		45 hours

= 2.25 hours/acre

Feb_1 Second pick takes 4 days

But farmer spends 5 days @ 9 hours/day	=	45 hours
Permanent man spends 5 days @ 9 hours/day	=	45 hours
Total		90 hours

= 4.5 hours/acre

This was a change from 9.00 hours/acre to 4.5 hours/acre.

Feb_2 and Feb_3 Third pick takes 8 days.

Farmer spends 8 days @ 12 hours/day	=	96 hours
Permanent man spends 8 days @ 12 hours/day	=	96 hours
Total		192 hours

= 9.6 hours/acre

This was a change from 9.0 hours/ac. to 9.6 hours/ac.

Feb_4 and Mar_1 4th pick takes 8 days

But farmer spends 8 days @ 12 hours/day	=	96 hours
and " " 1 day @ 10 hours/day	=	10 hours
Permanent man " 8 days @ 12 " "	=	96 hours
and " " 1 day @ 10 " "	=	10 hours
Total hours		212

= 10.6 hours/acre

This was a change from 9 hours/acre to 10.6 hours/ac.

Nov_2	5th pick takes 4 days	
	But farmer spends 5 days @ 9 hours/day =	45 hours
	Permanent man " 5 days @ 9 hours/day =	45 hours
	Total hours	90

= 4.5 hours/acre

This was a change from 8.0 hours/ac to 4.5 hours/acre.

(iv) The coefficients for buying and selling livestock.

The farmer suggested the following changes in information for deriving the labour coefficients for buying and selling all stock:

Buying stock 2 hours/week instead of 8 hours/week
Selling stock 2 hours/week instead of 5 hours/week

8.3.5. Other Resource Supplies. The farmer suggested that the capital restriction should be delted from the program after being questioned by the author as to the large amount of capital remaining unused in the program, and reconciling this with the farmer's actual situation. The farmer mentioned he could obtain a short-term loan of £5,000 at any period in the year if he required it. He said, "The availability of capital is no restriction."

8.3.6. Changes in Crop Revenues. The gross price of sweet corn from which net price was calculated for the initial linear program was £53.75 per acre. The farmer suggested this price be increased to £62 per acre. He considered the average gross price per acre of £53.75 he had given the author during the first interview was lower than is actually achieved.

Similarly he suggested changes in the gross returns of ryegrass seed (at £1 per bushel) for the different types of land. The suggested changes reflect modification of the estimates of average yields of ryegrass seed per acre, as the author's estimates were also based on the average gross price of £1 per bushel.

	Author's Gross Price Per Acre.	Farmer's Gross Price per Acre
RGS_1 (W)	£45	£35
RGS_1 (D)	£40	£45
RGS_2 (W)	£37	£30
RGS_2 (D)	£35	£40

All other aspects of the initial linear program including all the labour coefficients except those mentioned above, were thought to be satisfactory by the farmer. In addition to the specific comments above he was asked to comment generally on the initial program as it applied to his farm.

8.4. General Comments.

Disregarding some of the errors which were made, the general farm pattern which was presented to the farmer "looked very good" to him. He was very keen on the idea of settling down to a stable farm plan which the program provided. The problems of achieving a stable plan in practice however is not easy. The annual production pattern is governed to a large extent by the amounts of crops that the food processing factory requires. Because the farmer is a large producer of sweet corn, and whole tomatoes for canning, the farmer stated that he had to work in with the factories "and keep them a little bit happy." In other words there must be some "give and take" between the farmer and the factory each year, on contracts for growing vegetable crops.

The "stable plan" idea greatly appealed to the farmer. If he could be assured of stable crop contracts each year he would "become very efficient at producing the crops." "Operations would become routine," he could "plan the year's operations with certainty," and he maintained he "could increase crop yields by quite a bit through increased efficiency of production methods." However, as the problem of obtaining stable contracts each year remains, and as he is not prepared to forgo growing vegetable crops, the farmer said he would probably be able to operate "a set plan in some sort of way," but he certainly could not rely "rigidly" on any one plan. This is borne out by the fact that since the farmer has been on the farm (four years) he has not had the same acreage of any one crop, because the demands of the factory fluctuate.

The farmer then turned his attention to considering the plan in view of the acreage of sweet corn grown, and mentioned how this crop tends to govern his present farming pattern.

He considered the income from sweet corn more stable than from any other crop. For this reason, and because he has produced sweet corn for a number of years, he is "looking after" his corn contract. Hence the farmer is inclined to view all other crops grown on the farm in relation to the area of sweet corn. This is especially true with reference to permanent labour supplies. "Corn is a lot of work." "The corn contract is the labour bottleneck." That is, the large area of corn grown requires most of the permanent labour supply during the harvesting period of corn in Feb_3 and Feb_4. Thus the farmer views this period as the critical time of the year. He viewed the acreages of crops specified by the initial linear program, in relation to this period, and was very "happy about them." In other words he could adequately manage the linear program plan.

However, despite these remarks concerning sweet corn, the farmer said he would "stop growing corn" if he had to. "With this sort of cash cropping set-up (which concerns obtaining contracts to grow food processing crops) it is either in or out of any particular crop." For these reasons the farmer was not prepared to place any minimum restriction on the acreages of crops grown on the farm.

The farmer concluded his general comments about the program with reference to the sketch plans and the actual farm paddock sizes in relation to acreages of crops specified. Where crop acreages did not conform to paddock sizes, he considered this no problem. Where a paddock had to be subdivided for two different crops, "in most cases, the whole paddock could be cultivated at the same time before planting the two crops." This comment was made with reference to summer-grown crops such as peas and sweet corn, and tomatoes, dwarf beans and mangolds.

As accurately as possible the comments and modifications made by the farmer on the initial linear program, were all carried out by the author. In addition to these modifications, permanent labour supplies and hired labour supplies were combined for all weeks of the year, for different situations of hired labour availability. (A detailed discussion of how this was done was provided in Chapter 7). The modifications of the initial linear program resulted in the final basic matrix as shown in Table 7.6.

This Chapter emphasizes the fact that to achieve a representation of the real world situation when applying linear programming to help a farmer maximize his farm profits, it is essential to check and discuss the results with him several times, and take note of any suggested improvements to the plan he might make. There were no difficulties encountered in communicating with farmer No. 23 in carrying out this aspect of the study. It has been shown, however, that the author felt it necessary to translate the programming results into an easily understood form before attempting to discuss them with the farmer. At each interview he was willing to give his comments and pick out any mistakes that the author might have made when recording information. Without the enthusiastic co-operation, and helpful criticism on the initial linear program by the farmer, it is doubtful whether the linear programming section of this Thesis could have been carried through to its conclusion.

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CHAPTER 9.

A COMPARISON OF THE RESULTS OBTAINED FROM COST ACCOUNTING AND LINEAR PROGRAMMING

In Chapter 5 the theoretical concepts of cost accounting and linear programming were compared. Chapter 6 presented the cost accounting results for a number of farms, and the results obtained by linear programming for a single farm were presented in Chapter 7. This Chapter is concerned with a comparison of the results obtained by cost accounting and linear programming.

The profitability of crops in terms of gross margins as derived by the cost accounting analysis was shown in Table 6.6. As pointed out in Chapter 6, the gross margin is the most useful information obtained from a cost accounting analysis.

9.1 Using Cost Accounting Results:

A list of crops in the order of their gross margins alone, does not provide very useful information. However, when this information is used with additional "extraneous" technical information about the farm, cost accounting results can provide interesting information which may be used to help farmers explore profitable farm plans. For example, Table 6.6 showed that tomatoes, with a gross margin of £120, was the most "profitable" crop of all those considered. If this was suggested to a farmer, he might say that he could grow tomatoes, but only up to a maximum of 20 acres. When questioned about this maximum limit he might say that sweet corn is his main enterprise and that if he grew more than twenty acres of tomatoes, the harvesting period of these two crops would clash in Feb_3 and Feb_4. In other words he would be offering the information that a restriction on the availability of labour at this time would prevent him from increasing tomatoes above 20 acres, while still growing his specified annual sweet corn average.

Turning again to Table 6.6, it is shown that sweet corn is listed fourth [1/] in the order of profitability with a gross margin of £38. This would provide an interesting point for discussion, because from the cost accounting results it would appear questionable as to why the farmer considered sweet corn as his main enterprise. He may suggest that he has always grown a large area of sweet corn, and that he has all the specialized machinery and knowledge for efficient corn production. These may be the main contributing factors to relatively high and stable returns from sweet corn on his farm. But if an analysis of the farmers' returns from sweet corn showed that despite this efficiency, his gross margin was only £38 per acre, it would be worth budgetting plans which allowed some substitution of tomatoes for sweet corn.

Accepting the information that a maximum of 20 acres of tomatoes could be grown together with sweet corn, it may then be suggested that the farmer should include dwarf beans in his farm plan. This crop was the second [1/] most profitable crop with a gross margin of £71.65 per acre.

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1 Potatoes may be disregarded for the purposes of this discussion, as this crop was not considered as an alternative in the linear programme.

If the farmer had only limited knowledge on the resource requirements for dwarf beans he may be mislead into growing this crop. He may not know, and the cost accounting results would not show, that when grown in combination with tomatoes and sweet corn, the profit per unit of labour for dwarf beans during the harvest period in Feb_3 and Feb_4 is comparatively low. This point is brought out by the linear programme results. Sweet corn and tomatoes were in the plan, but dwarf beans was excluded by other crops which had higher returns to labour at this period. The cost of including dwarf beans in the linear programme would have been £70. The examples above illustrate that the cost accounting results in terms of gross margins, may provide meaningful results when additional technical information is also used. However, for any single farm, where the objective is to maximize farm profits, the "profitability" of crops derived by cost accounting may in fact lead to sub-optimum farm plans. This is of course, due to the fact that the cost accounting procedure does not take the availability of farm resources into account. On the other hand this information is included explicitly in linear programming.

9.2 Useful Information From Linear Programming

In linear programming all resources which are liable to limit production of any activity are specified explicitly. Within these resources, the full range of production possibilities open to the farm are examined, and a feasible, optimum farm plan is derived. The "profitability" of crops is examined in terms of marginal values and opportunity costs. The crops with the highest marginal values are included in the plan. The nearest approach to this concept which can be achieved by cost accounting, is to assume that the difference in gross margins between two crops will give the marginal value of substituting an acre of the more profitable crop for an acre of the less profitable crop.

The fact that linear programming examines the whole farm organisation (compared with cost accounting which examines crops as independent entities) means that much more useful information can be obtained. The actual acreages of crops in the plan are specified (Table 7.8), and the price stability limits for each crop may be derived (provided prices of all other crops remain constant) giving the minimum price increase or decrease of each crop necessary to just cause a change of plan (7.17). The net revenue for the optimum farm plan is also given (Table 7.8, and Table 7.18). Shadow prices indicate possible gains in income by acquisition of scarce resources (Table 7.14). Thus linear programming can give a "complete picture" of the optimum farm plan.

9.3 General Comments

One of the main disadvantages of linear programming applied to agriculture is that it takes considerable time to achieve results for a single farm. However, once the results are obtained they are of far greater value to the farmer, and provide much more accurate information than can ever be derived from the results of a cost accounting study. On the other hand, where a full analysis such as linear programming is impossible, then cost accounting procedures will provide interesting information, which, when used in conjunction with technical and other extraneous information, may help farmers to formulate a more profitable farm plan.

It is sometimes said that cost accounting has the advantage that farmers can understand the results. In so far as the analyst himself frequently has great difficulty in interpreting his results, it would probably be more accurate to say that "farmers think they can understand the results". The author has shown, in the last chapter that if the programming results are carefully interpreted before being shown to the farmer, there need be no "communication barrier" associated with the use of linear programming.

Probably the most important finding from a comparison of the two different types of results achieved by cost accounting and linear programming, is the rediscovery of the well known fact that there is no one "cost of producing" or "profit from" one particular crop. Rather, as shown in Table 7.17 there is a supply function. The cost accounting results provide one average figure for each crop, giving the impression that this is the "cost of" or "profit from" a crop. As illustrated in Table 7.17 this is not in fact, the case. Within any farm plan, there is a price range for a crop, considering prices of all other crops constant, over which the price, or profit, or costs, or yield, may vary and that crop will remain in the optimum farm plan. For the case on a particular farm where this price range was large and a substantial price drop would still allow a crop to remain in a linear programme plan, the cost accounting results at the lower price may show that the crop had fallen say, two places in the order of profitability. On the basis of these latter results the crop would no longer be considered "profitable". Thus the supply function concept illustrates the fact that the price of a crop necessary to maintain a given output depends on the quantity of the crop produced and the prices of all other crops.

SUMMARY

A survey was made of 28 Hawkes Bay farmers growing peas for food processing. The farms were classified according to four main groups of farming system. A cost accounting analysis was completed for eight major crops which included tomatoes, sweet corn, peas, potatoes, broad beans, dwarf beans, wheat and ryegrass seed. A definition was offered for what is meant by an acceptable cost accounting convention. The author suggested, however, that for some farm situations, some costs must be "synthesized" in order to derive costs which could be charged to each enterprise. The difficulties of allocating fixed costs were discussed and some errors which had been made were pointed out. The results of the cost accounting analysis were given in table form, showing the order of profitability of crops according to gross margin, and the average net returns per acre.

A full linear programme analysis was made for one of the survey farms. Three interviews with the farmers were required to achieve the final programme. The first two interviews were solely concerned with collection of information. The third interview enabled the initial linear programme to be checked; this programme was modified in accordance with the farmer's comments. The final revised linear programme is presented and discussed in this Thesis. Farm plans were obtained for a wide range of labour availability. These

included plans for "one-", "two-", "three-" and "four" hired men" which were additional to the permanent farm labour force of two men.

Some problems of defining activities as rotations for two classes of land were encountered. These problems mainly concerned reconciliation of price changes for rotations defined for different types of land, but which included the same crops. As a result of this much of the information on the computer print-out sheets was redundant, and had to be calculated from the final matrix.

A pea supply function was derived illustrating the minimum pea price increase and decrease, necessary to change the plans for the "one, "three" and four hired men" plans.

A comparison of the results derived by cost accounting and linear programming was given in Chapter 9.

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VOLUME II

APPENDICES TO THE STUDY OF THE FINANCIAL RETURNS TO PROCESS PEA GROWERS IN HAWKES BAY.

January, 1964.

LIST OF APPENDICES

THIS SCHEDULE IS STRICTLY CONFIDENTIAL.

Date: Farm Identification No:-

Questionnaire for the Study of the Financial Returns from Process Pea Growing in the Hastings Area.

Section I.

Characteristics of the Farm.

1. Location:-

Road distance from Hastings:- miles

:- N W E S

District:-

Road Name:-

2. Acreage:

Grazing and cropping			
Grazing only			
Buildings and yards			
Plan tation and waste			
Total acreage			

3. Tenure

Freehold: acs since 19

Leasehold: acs since 19

Details of Lease:

Trust: acs since 19

4. Climate

Av. Rainfall (inches)

Av. Sunshine (hours)

Other Details: -

F.I. No:

7. List of Plant and Equipment

Field	Equipment	Make	Size	Linkage	Age	Yrs in your poss	Original Value	Present value	Use per annum.
Tractors	1								
	2								
	3								
Plough	1								
	2								
Disc	1								
	2								
Harrows	1								
	2								
	3								
	4								
	5								
	6								
Cultivator									
Roller and seed box									
Mower									
Drill									
Trailers	1								
	2								
Leveller									
Side Rake									
Buck rake									
Head Harvester									
Baler									
Forage harvester									
Bale Loader									
Elevator									
Trucks	1								
	2								
	3								
Blade									
Transport Box									

F.I. No: ____________

List of Plant & Equipment (contd...)

	Make	Size	Linkage	Age	Yrs in your poss	Original value	Present Value	Use per annum.
Clover Lifter								
Spray unit 1								
2								
Other:-								
General Plant								
Saw Bench								
Welder 1								
2								
Winch								
Irrigation Plant								
Water Supply								
1								
2								
3								
4								
Sundries:								

F.I. No: ____________

8. List of Buildings and Yards

Buildings		Roof	Walls	Floor	Dimensions Length x Breadth	Age	Original value	Present value
House	1							
	2							
Cottage								
Sheds:-								
1								
2								
3								
4								
5								
6								
7								
8								
Haybarns								
1								
2								
3								
Other:								
Yards:-								
Sheep								
1								
2								
Cattle:								

F.I. No: ______

9. Labour Employed.

Permanent	Age	Vacation	Ill-Health	Worked	Wages Paid.	
a) Family						
Owner						
Manager						
Other						
1						
2						
b) Hired:-						
1						
2						
3						
4						

Special Comments:-

Casual Type of Work.	Nos. Employed Males	Nos. Employed Females	Rate of Payment Males	Rate of Payment Females	Total Wages Paid	Pd. of Employment.

F.I.No: ________

10. Stock Reconciliation:

Cattle:	Nos Purchased	Date Purchased	Age when Purchased	Price Paid	Nos Sold	Date Sold	Price Received	Nos on hand / /62.
Breed								
Cows								
Heifers								
Steers								
Bullocks								
Bulls								
Sheep:								
Breed								
Ewes 2^{th}								
4^{th}								
5 yr								
6 yr								
Lambs:-								
Ewes								
Wths.								
Rams								
Dairy Cattle								
Breed								
Cows								
Heifers								
Calves								
Bulls								
Other Stock								
Breed								
Comments:-								

F.I.No: ________________

1960/61.

	Nos Purchased	Date	Age	Price Paid	Nos Sold	Date	Price Received
Cattle							
Breed							
Cows							
Heifers							
Steers							
Bullock							
Bulls							
Sheep:							
Breed							
Ewes 2th							
4th							
5 yr							
6 yr							
Lambs:							
Ewes							
Wths							
Rams							
Dairy Cattle							
Breed							
Cows							
Heifers							
Calves							
Bulls							
Other Stock							
Breed							
Comments:-							

F.I.No. ____________

1959 / 60.

	Nos Purchased	Date	Age.	Price Paid	Nos. Sold	Date	Price Received
Cattle							
Breed							
Cows							
Heifers							
Steers							
Bullocks							
Bulls							
Sheep:							
Breed							
Ewes 2th							
4th							
5 yr							
6 yr							
Lambs							
Ewes							
Wths							
Rams							
Dairy Cattle							
Breed							
Cows							
Heifers							
Calves							
Bulls							
Other Stock							
Breed							

Comments:

F.I.No. ________

SECTION 2: PATTERN OF FARM OPERATIONS

1. 3 year Calendar for Land use

Padd.	Ao.	1959												1960												1961											
No.		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D

F.I. No.______

13. Comments on Special Features of this Pattern

F.I.No. ________

14. Calendar of Farm Operations - Labour Use.

Operation	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.
Ploughing						
Discing						
Cultivating						
Harrowing						
Rolling						
Sowing						
Spraying						
Harvesting.						
Fat Lamb:						
Lambing						
Weaning						
Shearing						
Dipping						
Footrotting						
Drenching						
Crutching						

F.I.No.________

Operation	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.
<u>Dairying</u>						
Calving						
Milking						
<u>Beef Cattle</u>						
Feeding out						
<u>Other</u>						
Hay						

F.I. No.

Operation	DEC.	JAN.	FEB.	MAR.	APR.	MAY.
Ploughing						
Discing						
Cultivating						
Harrowing						
Rolling						
Sowing						
Spraying						
Harvesting						
Fat Lamb						
Lambing						
Weaning						
Shearing						
Dipping						
Footrotting						
Drenching						
Crutching						

F.I.No. ________

Operation	DEC.	JAN.	FEB.	MAR.	APR.	MAY
Dairying						
Calving						
Milking						
Beef Cattle						
Feeding out						
Other						
Hay						

F.I.No.

15 Tractor, Labour and Machinery useage. (1961/62 Pea Crop)

Operation	Tractor				Labour		Machinery	
	Strokes	Ac/hr.	Total Hours	Costs of Fuel & Oil	Hours	Costs per Hr.	Hours	Total Costs/hr.
Ploughing								
Discing								
Cultivating								
Harrowing								
Rolling								
Sowing								
Spraying								

16. Contract Charges 1961/62 Pea Crop

Operation	Acreas	Rates / hour	Total Cost
Ploughing			
Discing			
Cultivating			
Harrowing			
Rolling			
Sowing			
Spraying			
Harvesting			

F.I.No. ....

17 (a) Do you consider this a "normal" pattern of operations for cultivating the pea crop?

YES NO

(b) If NO do you consider the operations excessive?

YES NO

(c) What in your experience, have been the minimum operations (i.e. under ideal conditions of weather and state of land) required to put in a pea crop?

	Peas out of pasture Strokes	Peas out of crop Strokes
Ploughing		
Discing		
Cultivating		
Harrowing		
Rolling		
Spraying		

(d) What in your experience have been the maximum operations to put in a pea crop?

	Peas out of Pasture Strokes	Peas out of Crop Strokes
Ploughing		
Discing		
Cultivating		
Harrowing		
Rolling		
Spraying		

(e) What would you suggest as to the cause of this excessive cultivation?

18 (a) Would you consider the cultivation practices as outlined in Q.17 as being similar for other crops you grow

YES NO.

(b) If NO where does the difference lie?

F.I.No. ________

19. <u>Tractor,Labour and Machinery useage</u>:

(Other than cultivation operations) 1961/62

Operation	Acreas/hr.	Tractor Total Hours	Costs/hr. Fuel & Oil	Labour Hours	Hourly Rate	Machinery Hours	Machinery Total Costs/hr.
Spreading manure							
Irrigation							

<u>Contract Rates</u>

	Crops	Acreas	Rates /hour	Total Cost
Header Harvesting				
Baling				

Section 3: Peas

20. (a) When did you commence growing peas?
19

(b) Have you grown them each year? | YES | | NO |

(c) If | NO | for what reasons?

21. (a) What acreage did you grow in 19 ?

(b) What acreage did you grow in

1959/60 : acres
1960/61 : acres
1961/62 : acres

22. What variety of peas did you grow in

1959/60 :
1960/61 :
1961/62 :

23. If you have changed varie. es, what is the reason?

24. Of the varieties you have grown, which do you prefer?

For what reasons?

Over/p. 21

25. (a) From which company do you obtain your seed?

(b) How much does it cost?

1959/60 :	/ bush	or	/lb
1960/61 :	/ bush	or	/lb
1961/62 :	/ bush	or	/lb

(c) At what rate do you sow?

bush/ac.

(d) Is the seed treated for pre-emergence attacks by fungi?

YES   NO

26. (a) Do you grow

early,   mid-season,   late maturing,

seed?

(b) Do you make this decision on your own?

YES   NO

If NO for what reasons?

27. What lime or fertilizer do you apply for peas?

(a) <u>Lime</u>

Time of application :

Rate of application :

Cost of material :

Over/p.22

(b) Fertilizer

Type

Time of application:

Rate of application:

Cost of application:

28. (a) Over the past 5 years, what type of pea vine has been used on your crop?

1957/58	:	Mobile / Static
1958/59	:	Mobile / Static
1959/60	:	Mobile / Static
1960/61	:	Mobile / Static
1961/62	:	Mobile / Static

(b) Which do you consider is the most efficient?

MOBILE   STATIC

(c) Which do you prefer ? MOBILE   STATIC

For what reasons?

(d) Is there any direct cost to you for harvesting by the firm?

YES   NO

If YES what are the rates?

Over/p.23

F.I. No.______

29. Do you spray your crop?

YES. NO.

If YES for what?

30. What sprays do you use?

pints/acrea
pints/acrea

31. What is the cost of the spray material?

32. What are the gross returns to peas?

1959/60			1960/61			1961/62		
Acreas	lbs.	£	Acreas	lbs.	£	Acreas	lbs.	£

33. (a) What is your sales outlet for peas?

Watties :

N.Z.Foods :

Fropax :

Thompson & Hill :

(b) Have you changed firms? YES NO

(c) If YES for what reasons?

34. (a) Have you ever had a crop by-passed?

YES NO

(b) In what years? 19

19

19

(c) For what reasons?

F.I.No. ______

35. What did you do with the by-passed crops?

=========================

SECTION 4:

Costs and Returns of Other Enterprises:

36. Wool: (past 3 years)

Shearing Costs	Crutching Costs	Wool Sold Bales	Wgt.	Type	Price / lb.	Gross Returns

37. Milk: (past 3 years)

	1959/60	1960/61	1961/62
gals. @ /gal. lb. B.F. @ /lb.			

F.I.No. ______

38. Crops: (excluding peas)

Enterprise	Acs.	Contact Charges		Seeds		Fertilizer		Spray		Gross Returns	
		Operation	Cost	Rate/ac.	Cost	Rate/ac.	Cost	Rate/ac	Cost	Yield	Price

F.I.No.

39. Fertilizer: (pasture topdressing)

	Type:		
Rate/acrea:			
Cost at farm gate:			
Cost applied:			

40. Hay

		Acs.	Bales	Tedding	Baling	Cartage	Price/bale.
Lucerne	1959/60						
	1960/61						
	1961/62						
Pea	1959/60						
	1960/61						
	1961/62						
Clover	1959/60						
	1960/61						
	1961/62						
Meadow	1959/60						
	1960/61						
	1961/62						
Straw	1959/60						
	1960/61						
	1961/62						

Section 5: The Place of Peas in the Farm Plan

41. Do you consider the pea crop as:

(a) An "extra"

(b) part of the farm plan.

For what reasons?

42. (a) What is the maximum acreage of peas you could grow on the farm ? acs.

(b) What is the minimum acreage of peas you could grow in the farm ? acs.

43. If you didn't grow peas, how would the present pea area be used?

(a) Grow grain crops - wheat
barley
oats

(b) Increase lucerne area

(c) Increase clover area (for seed and hay)

(d) Increase green feed for stock

(e) Other:-

(f) Hadn't thought about it.

44. What fall in price would be necessary before you would consider going out of peas?
(Take average price @ $3\frac{1}{2}$d/lb).

..............pence/lb.

45. Suppose you were forced out of peas and concentrated on the alternative stated in Q43. How would this affect:

(a) Pasture management

(b) Crop rotation

(c) Labour requirements

(d) Machinery useage

46. Would you increase your present pea acreage if there was a price rise?

YES NO

What price would you require ? (av. $3\frac{1}{2}$d.lb)

.... pence/lb.

To what would you increase your acreage?

.... acs.

F.I.No.________

47. (a) If you doubled your present pea acreage, what other enterprises would have to be reduced?

Enterprise		Est. loss in Revenue

(b) How would this affect:

(i) crop rotation?

(ii) labour requirement?

(iii) machinery useage?

48. Do you consider the machinery you own adequate for all field operations?

YES. NO.

If NO for what reasons?

49. Does the amount and type of machinery owned by you influence the acreage of peas grown?

YES NO

If YES in what way?

50. In your present farm plan, do you consider that, at any period, the labour requirements for peas clash with other farm work?

YES NO

If YES with what work?

(go to Q 51)

If NO have you avoided this clash by planning farm operations accordingly?

YES NO

If YES by what plan?

(go to Q 52)

51. What suggestions have you for avoiding the labour clash in Q50?

What is your reason for not putting this into operation?

52. Have you always attempted to use the same methods for growing peas?

YES NO

If NO for what reasons?

If YES what would you say causes the large yearly variations in yield?

53. Do you consider peas before ryegrass essential for good ryegrass-seed yield?

YES NO

If YES for what reasons?

F.I.No.________

SECTION 6: Pea Marketing:

54. Possible terms of contract are:-

(a) Payment in yield. The Company directs times of sowing and harvesting, and advise husbandry practices, but you take all the risks.

(b) Payment of a flat rate regardless of yield, for the use of your land. Otherwise as for (a) above.

(c) Renting the land for cash (i.e. flat rate payment) with the Company undertaking all operations and assuming all risks.

(d) Renting land on a share-basis. The Company or a share-farmer does all operations and pays you a percentage of the crop returns for the use of your land.

Which is your present form of contract?

a	b	c	d

Which is the order of your preference?

a	b	c	d

55. In your view, what are the defects of the less derivable forms of contract?

(a)

(b)

(c)

(d)

56. What do you consider the gross returns per acre must be for peas to be worthwhile?

£ / ac.

57. What gross returns/ac. would you require before you would accept contract form:

(a) £ / ac.

(b) £ / ac.

(c) £ / ac.

(d) : %

Section 7: Advisory Service and the Federation:

58. Can you suggest any shortcomings in the technical advice you receive from the Company Advisory Officers?

YES NO

If YES what are they?

Over/p.36.....

59. Is there any advice you would like that is not available?

YES | NO

If YES what is it?

60. (a) Are you a member of the Vegetable Growers' Federation?

YES | NO

(b) If NO have you any special reason for not being a member?

YES | NO

If YES for what reasons?

61. What do you consider to be its main functions?

62. (a) Does the V.G.F. have any effect in determining the new season's pea prices.

YES | NO

(b) If NO do you think it could?

YES | NO

Over/p.37......

If [YES] what sort of action could be taken?

If [NO] for what reasons?

63. Would you support Federation action to increase prices?

e.g. (a) By subscribing to a "fighting" fund.

(b) Withholding supplies unless the Federation price was paid.

Section 8: Finance

64. Fixed Costs

(a) Rates

(b) Land Tax

(c) Mortgages

Over/p.38....

(d) Capital value.

(e) Unimproved value.

64. Access to Balance Sheets for the past three years.

APPENDIX B

DETAILED COSTS OF FOUR MAIN ENTERPRISES FOR A SINGLE FARM

The method for allocating all costs to a single enterprise was illustrated in Chapter 6. This appendix provides an actual numerical example of the cost accounting procedure. Four crops have been costed for farm 23. This example illustrates how all costs for other survey farms were derived as shown in the Tables of Appendix C.

NOTE: (i) All costs and prices are expressed as decimals of of the pound. For example £9.7.0 = £9.35.

(ii) All costs and prices are taken to the nearest 1/- or £0.05.

(iii) All costs, returns, acreages and yields are average figures taken from the 1959-60, 1960-61 and 1961-62 season's data.

(iv) All costs and prices are expressed per acre of crop grown.

I. DETAILS OF COSTS FOR PEAS

Average Annual Pea Acreage = 46 acres

Gross Returns £72.75

Cash Costs

(i) Seed: 3 bushels sown per acre at 42/6 bush £6.40

(ii) Fertilizer and Cartage:

100lb. bag "Ámophos" per acre at £1.14.0 bag . £1.70

Cartage at £4.4.0 total £0.10 £1.80

(iii) Spray materials:

$1\frac{1}{2}$ pts. 30% D.N.B.P.	£0.80	
$2\frac{1}{2}$ pts. 40% M.C.P.B.	£1.05	£1.85
Total Cash Costs per acre	=	£10.05

Imputed Variable Costs

(i) Contract expenses Nil

(ii) Tractor Running Costs:

Fuel and oil.

Operation	Average hrs/ac.	Diesel/hr.*	Fuel and oil
Plough	0.67	$1\frac{1}{2}$ gals.	£0.10
Disc and Harrow	1.65	" "	£0.24
Cultivate	0.50	" "	£0.07
Harrow	0.85	1 gal.	£0.08
Roll	0.20	" "	£0.02
Drill	0.20	" "	£0.02
Spray	0.16	" "	£0.02
Total Fuel and oil per acre			£0.55

* Oil consumption at the rate of $1\frac{1}{2}$ gallons per 100 tractor hours. This is equivalent to 0.015 gals/hour = 3^{0} per hour.

Repairs and Maintenance

New cost of Tractor = £950

R & M 75% new cost = £713

Econimic service life = 10,000 hours

∴ R & M cost per hour = £0.07

Average tractor hours per pea acre = 3.9 hours

.˙. Average R & M per pea acre = £0.07 x 3.9 = £0.30

.˙. Average Tractor Running Expenses = £0.85

(iii) Implement Running Costs

Machine	Av.Annual Charge % New Cost	R & M per hour	Hours per Acre	R & M per pea Acre
Plough	7.4	0.09	0.67	£0.06
Discs	3.5	0.02	1.65	£0.03
Cultivator	3.8	0.03	0.50	£0.02
Harrows	1.1	0.01	0.85	£0.01
Roller	1.5	0.05	0.20	£0.01
Spray unit	4.0	0.04	0.16	£0.01

Total Implements. Running Costs £0.14

Say £0.15

(iv) Labour costs at 8/6 per hour

Average labour for all operations

5.2 hours/ac. @ 8/6 per hour £2.20

Total Imputed Variable Costs £3.20

.˙. Total Cash Costs £10.05

Total Imputed Variable Costs £3.20

Total Variable Costs £13.25

Hence Gross Returns £72.75

Less Total Variable Costs £13.25

.˙. Gross Margin £59.50

<u>Fixed Costs or "Overheads"</u>

(i) Tractor overheads:

New cost of tractor = £950

Hours worked per year = 1,200 hours

Economic life = 9 years

Average annual depreciation
and interest payment = £131.75

Average depreciation and
interest charge per hour = £0.1098

Average tractor hours per
pea acre = 3.9 hours.

∴ Depreciation and Interest per pea acre = <u>£0.45</u>

Sundries per year at 1.2%
new cost of tractor = £11.40

Sundries per hour = £0.01

∴ Sundries per pea acre = £0.05

Total tractor overheads per pea acre = £0.50

(ii) Implement Overheads:

<u>Plough</u>

Average Annual depreciation
and interest payment = £14.30

Average depreciation and
interest charge per hour = £0.1212

Average plough hours per
pea acre = 0.67 hours

∴ Depreciation and interest per pea acre = <u>£0.10</u>

Average annual sundries

at 2% new cost = £2.95

Sundries per hour = £0.03

Average plough hours

per pea acre = 0.67 hours

∴ Sundries per pea acre = £0.05

Discs

Average annual depreciation

and interest payment = £23.30

Average depreciation and

interest charge per hour = £0.0803

Average disc hours per

pea acre = 1.65 hours

∴ Depreciation and interest per pea acre = £0.15

Average annual sundries

at 2% new cost = £3.35

Sundries per hour = £0.01

Average disc hours per

pea acre 1.65 hours

∴ Sundries per pea acre = £0.05

Cultivator

Average annual depreciation

and interest payment = £8.44

Average depreciation and

interest charge per hour = £0.0959

Average cultivator hours

per pea acre = 0.50 hours

∴ Depreciation and interest per pea acre = <u>£0.05</u>

Average annual sundries

at 2% new cost = £1.50

Sundries per hour = £0.0175

Average cultivator hours

per pea acre = 0.50 hours

∴ Sundries per pea acre = <u>£0.05</u>

<u>Harrows</u>

Average annual depreciation

and interest payment = £6.00

Average depreciation and

interest charge per hour = £0.0400

Average harrows hours per

pea acre = 0.85 hours

∴ Depreciation and interest per pea acre = <u>£0.05</u>

Average Annual Sundries

at 2% new cost = £1.25

Average sundries per hour = £0.0083

Average harrows hours per

pea acre = 0.85 hours

∴ Sundries per pea acre = <u>£0.05</u>

Roller

Average annual depreciation

and interest payment = £10.88

Average depreciation and

interest charge per hour = £0.3109

Average roller hours per

pea acre = 0.20 hours.

∴ Depreciation and Interest per pea acre = <u>£0.05</u>

Average annual sundries

at 2% new cost = £2.24

Sundries per hour = £0.0640

Average roller hours

per pea acre = 0.20 hours

∴ Sundries per pea acre = <u>£0.05</u>

Spray Unit

Average annual depreciation

and interest payment = £9.61

Average depreciation and

interest per hour = £0.1186

Spray unit hours per

pea acre = 0.16 hours

∴ Depreciation and interest per pea acre = <u>£0.05</u>

Average annual sundries at

2% new cost = £1.50

Sundries per hour = £0.0185

Average spray unit hours per acre = 0.16 hours

.˙. Sundries per pea acre = <u>£0.05</u>

.˙. Total Implements' Depreciation, Interest and Sundries per pea acre = <u>£0.75</u>

<u>NOTE</u>: The costs shown for depreciation, interest and sundries have been taken to the nearest £0.05. In many cases the actual costs of sundries were as low as £0.007 per pea acre. Rather than show zero cost in such instances, the cost was entered at £0.05.

(iii) Land Overheads:

Annual rates and Land tax = £981

Rental Value

(Capital Value - £3500)x6% = <u>£3387</u>

£4368

Overheads per farm acre = £20.5

Months land in peas = 4 months

.˙. Land overhead per pea acre = <u>£6.85</u>

(iv) General Farm Expenses:

Average annual general farm expenses = £308.90

General expenses per farm acre = £1.45

Months land in peas = 4 months

∴ General expenses per pea acre = <u>£0.50</u>

(v) "Overhead" Labour:

Gross Farm Income (A) = £16,460

Gross Income from Peas (B) = £ 3,347

Proportion $\frac{B}{A}$ = 0.2033

£900 x $\frac{B}{A}$ = £183

Direct Labour charged to peas = £101

∴ Proportion labour overheads charged to peas = £82

∴ "Overhead" labour per acre of peas = <u>£4.10*</u>

∴ <u>Total Imputed Fixed Costs</u> = <u>£12.70</u>

*This figure is incorrect. It was calculated on the basis of an average of 20 acres of peas instead of 46 acres. It therefore, should have been correspondingly reduced to £1.80.

Final average per unit net profit can now be calculated.

Gross revenue - Total Variable Costs = Gross Margin

£72.75 - £13.25 = <u>£59.50.</u>

Gross Margin - Total Fixed Costs = Average "Net Profit"

£59.50 - £12.70 = <u>£46.80</u>

The details given for peas showing how each cost was obtained are similar for all other crops. The remaining three crops costed for farm number 23 are shown in summary form in succeeding sections of this appendix. Slight variations appear in the subheadings for major cost items. For example, in the costing of tomatoes, under Imputed Variable Costs, fuel oil, labour and contract charges are all shown under the one subheading. Calculation of the individual costs, however, is similar to the method shown in the detailed analysis of peas for the same items.

II. DETAILS OF COST FOR RYEGRASS SEED

Average annual ryegrass seed acreage = 50 acres

Gross returns				£23.55
Cash Costs				
(i)	Seed	£2.60		
(ii)	Fertilizer and cartage	Nil		
(iii)	Spray materials	£0.50		
	Total Cash Costs per acre		£3.10	
Imputed Variable Costs				
(i)	Contract Charges	£2.00		
(ii)	Fuel, oil and labour	£4.90		
(iii)	Tractor running expenses	£0.35		
(iv)	Implement, running expenses	£0.15		
	Total Imputed Variable Costs per acre		£7.40	
∴	Total Variable Costs per acre		£10.50	

Gross returns	-	Total Variable Cuts	=	Gross Margin
£23.55	-	£10.50	=	£13.05

Fixed Costs or "Overheads"

(i)	Tractor overheads	£0.60	
(ii)	Implement, overheads	£0.60	
(iii)	Land overheads	£6.85	
(iv)	General expenses	£0.45	
(v)	Labour overheads	£3.05	
	Total fixed costs per acre		£11.55

Gross margin	-	Total fixed costs	=	Average "net profit"
£13.05	-	£11.55	=	£1.50

III. DETAILS OF COSTS FOR TOMATOES

Average annual tomato acreage - 30 acres.

Gross returns				£328.25
Cash Costs				
(i)	Plants	£18.00		
(ii)	Fertilizer and Cartage	£ 3.15		
(iii)	Spray materials and Labour	£ 7.10		
(iv)	Picking and cartage	£103.90		
	Total Cash Cost per acre		£132.15	

Imputed Variable Costs

(i)	Fuel, oil and labour for cultivation	£11.40	
(ii)	Tractor running expenses	£ 1.15	
(iii)	Implements, running expenses	£ 0.20	
	Total Imputed Variable Costs per acre		£12.75
	∴ Total Variable Costs per acre		£144.90

Gross returns - total variable costs = Gross margin

£328.25 - £144.90 = £183.35

Fixed Costs or "Overhead"

(i)	Tractor overheads	£1.95	
(ii)	Implement, overheads	£0.80	
(iii)	Land overheads	£10.25	
(iv)	General expenses	£0.70	
(v)	Labour overheads	£3.60	
	Total fixed costs per acre		£17.30

Gross margin - Total fixed costs = Average "net profit"

£183.35 - £17.30 = £166.05

IV. DETAILS OF COSTS FOR SWEET CORN

Average annual sweet corn acreage = 50 acres.

Gross returns £55.70

Cash Costs

(i)	Seed	£2.00
(ii)	Fertilizer and cartage	£2.85

(iii)	Spray materials and Labour	£2.20	
(iv)	Crop cartage	£0.75	
	Total cash costs per acre		£7.80

Imputed Variable Costs

(i)	Fuel oil and labour for cultivation and contract charges	£8.75	
(ii)	Tractor running expenses	£0.30	
(iii)	Implements, running expenses	£0.15	
	Total Imputed Variable Costs per acre		£9.20
	∴ Total Variable Costs per acre		£17.00

Gross returns	-	Total Variable Costs	=	Gross margin
£55.70	-	£17.00	=	£38.70

Fixed Costs or "Overheads"

(i)	Tractor overheads	£0.50	
(ii)	Implements, overheads	£0.60	
(iii)	Land overheads	£10.25	
(iv)	General expenses	£0.70	
(v)	Labour overheads	£3.25	
	Total Fixed Costs per acre		£15.30

Gross margin	-	Total fixed costs	=	Average "nêt profit"
£38.70	-	£15.30	=	£23.40

APPENDIX C

SUMMARY OF COMPLETE COST ACCOUNTING RESULTS FOR EIGHT MAJOR CROPPING ENTERPRISES.

The number of survey farms growing each of the major crops summarized in this appendix are presented in Table C.1.

TABLE C.1. NUMBERS OF SURVEY FARMS GROWING THE MAJOR CROPS

Peas	28*
Ryegrass	15
Tomatoes	4
Potatoes	3
Dwarf Beans	4
Broad Beans	3
Wheat	2
Sweet Corn	1

*Results of the 28 farms growing peas have been presented according to the four main classes of farming system. (refer Chapter 3)

Tabulation for all crops except peas, include the corresponding number of farms listed in Table C.1. irrespective of farm classification

For the remaining Tables in Appendix C the following points should be noted:-

(i) F.I. No. refers to the Farm Identification Number.

(ii) All costs and prices are expressed as decimals of the pound.

For example £9.7.0 = £9.35.

(iii) All costs and prices are taken to the nearest 1/- or £0.05.

(iv) All costs, returns, acreages and yields are average figures taken from the 1959-60, 1960-61 and 1961-62 season's data.

(v) All costs and prices are expressed per acre of crops grown.

(vi) The "mean", minimum and maximum figures refer to the average costs and lower and upper range limits of costs respectively for each column in the Tables.

(vii) The codes for the various classes of farms is as follows:-

I is Intensive Stocking and Cropping

II is Sheep and Cropping

III is Dairying and Cropping

IV is Part-time farming

THE SUMMARY TABLES

See pages 54 to 62

I PEAS

TABLE C.2.

CLASS I. INTENSIVE CROPPING AND STOCKING

SUMMARY OF PER ACRE COSTING ANALYSIS FOR PEAS.

F.I. No.	Pea Acres	Gross Returns	Total Variable Costs	Gross Margin	Total Fixed Costs	Net Profit Per Acre.
1	14	48.30	13.75	34.55	21.95	12.60
5	32	45.80	12.35	33.45	10.80	22.65
12	19	49.00	16.50	32.50	21.10	11.40
17	43	50.70	14.55	36.15	16.50	19.65
18	24	45.65	16.25	29.10	17.65	11.45
20	11	31.90	13.65	18.25	17.00	1.25
21	32	31.60	12.95	18.65	8.90	9.75
22	11	41.45	12.70	28.76	9.45	19.30
23	46	72.75	13.25	59.50	12.70	46.80
24	11	45.90	16.25	29.65	12.70	16.95
26	79	44.10	12.35	31.75	14.55	17.20
28	14	37.00	14.80	22.20	15.75	6.45
Mean		45.35	14.30	31.20	14.90	16.30
Min.		31.60	12.35	18.25	8.90	1.25
Max.		72.75	16.50	59.50	21.95	46.80

TABLE C.3.

CLASS II. SHEEP AND CROPPING

SUMMARY OF PER ACRE COSTING ANALYSIS PEAS.

F.I. No.	Pea Acres	Gross Returns	Total Variable Costs	Gross Margin	Total Fixed Costs	Net Profit Per Acre
2	33	50.80	12.05	38.75	7.05	31.70
3	27	24.00	13.90	10.10	7.25	2.85
4	42	46.65	9.40	37.30	6.10	31.20
7	12	44.30	14.35	29.95	7.55	22.40
8	11	43.95	16.95	27.00	6.00	21.00
14	59	42.00	14.90	27.10	4.60	22.50
19	27	54.00	12.10	41.90	7.35	34.55
R_1	17	37.85	13.65	24.20	8.15	16.05
R_3	52	52.00	11.95	40.05	9.90	30.15
R_5	13	53.80	16.50	37.30	10.85	26.45
Mean		44.95	13.60	31.35	7.50	23.90
Min.		24.00	9.40	10.10	4.60	2.85
Max.		54.00	16.95	41.90	10.85	34.55

TABLE C.4.

CLASS III. DAIRYING AND CROPPING

SUMMARY OF PER ACRE COSTING ANALYSIS PEAS.

F.I. No.	Pea Acres	Gross Returns	Total Variable Costs	Gross Margin	Total Fixed Costs	Net Profit Per Acre.
9	55	1.10	13.90	19.80	13.25	6.55
11	59	1.76	15.65	40.70	17.05	23.65
25	12	1.32	18.80	42.75	19.35	23.40
27	24	1.30	15.50	29.80	16.40	13.40
Mean		1.37	15.95	33.25	16.50	16.75
Min.		1.10	13.90	19.80	13.25	6.55
Max.		1.76	18.80	42.75	19.35	23.65

TABLE C.5.

CLASS IV. PART-TIME FARMING

SUMMARY OF PER ACRE COSTING ANALYSIS PEAS.

F. I. No.	Pea Acres	Gross Returns	Total Variable Costs	Gross Margin	Total Fixed Costs	Net Profit Per Acre.
10	10	56.30	15.25	41.05	11.10	29.95
13	16	34.00	15.25	18.75	19.35	0.60*
Mean		45.15	15.25	29.90	15.20	14.70

* Net Loss

II RYEGRASS SEED

TABLE C.6.

SUMMARY OF PER ACRE

COSTING ANALYSIS RYEGRASS SEED

F.I. No.	Farm Class	Rye-grass seed Acres	Gross Returns	Total Variable Costs	Gross Margin	Total Fixed Costs	Net Profit Per Acre.
1	I	17	50.00	14.60	35.40	18.00	17.40
2	II	40	50.00	14.20	35.80	6.95	28.85
5	I	62	40.15	13.85	26.30	9.20	17.10
7	II	12	30.00	15.80	14.20	7.00	7.20
8	II	30	32.10	14.00	18.10	5.10	13.00
9	III	43	33.30	10.95	22.35	9.20	13.15
12	I	12	21.90	15/75	6.15	16.05	9.90*
17	I	42	31.20	14.05	17.15	14.55	2.60
18	I	23	22.00	14.50	7.50	13.15	5.65*
22	I	7	35.00	13.80	21.20	10.85	10.35
23	I	50	23.55	10.50	13.05	11.55	1.50
24	I	24	36.35	10.65	25.70	11.40	14.30
26	I	60	37.00	10.65	26.35	11.25	15.10
27	III	15	38.30	11.45	26.85	13.65	13.20
R_3	II	25	42.00	12.05	29.95	10.70	19.25
Mean			34.85	13.10	21.75	11.25	10.50
Min.			21.90	10.50	6.15	5.10	9.90*
Max.			50.00	15.80	35.80	18.00	28.85

* Net Loss

III TOMATOES

TABLE C.7.

SUMMARY OF PER ACRE

COSTING ANALYSIS TOMATOES

F.I. No.	Farm Class	Tomatoes Acres	Gross Returns	Total Variable Costs	Gross Margin	Total Fixed Costs	Net Profit Per Acre
22	I	7	227.55	97.55	130.00	19.00	111.00
23	I	30	328.25	144.90	183.35	17.30	166.05
24	I	7	207.70	142.10	65.60	22.90	42.70
28	I	3	220.50	118.80	101.70	50.15	51.55
Mean			246.00	125.85	120.15	27.35	92.60
Min.			207.70	97.55	65.60	17.30	42.70
Max.			328.25	144.90	183.35	50.15	166.05

IV POTATOES

TABLE C.8.

SUMMARY OF PER ACRE

COSTING ANALYSIS POTATOES

F.I. No.	Farm Class	Potato Acres	Gross Returns	Total Variable Costs	Gross Margin	Total Fixed Costs	Net Profit Per Acre.
20	I	1	187.50	100.45	87.05	20.15	66.90
22	I	9	175.20	86.15	89.05	27.90	61.15
28	I	5	229.35	95.70	133.65	68.45	65.20
Mean			197.35	94.10	103.25	38.85	64.40
Min.			175.20	86.15	87.05	20.15	61.15
Max.			229.35	100.45	133.65	68.45	66.90

V DWARF BEANS

TABLE C.9.

SUMMARY OF PER ACRE

COSTING ANALYSIS DWARF BEANS

F.I. No.	Farm Class	Dwarf Bean Acres	Gross Returns	Total Variable Costs	Gross Margin	Total Fixed Costs	Net Profit Per Acre.
12*	I	6	65.65	18.05	47.60	19.45	28.15
20	I	2	79.00	31.90	47.10	23.00	24.10
26*	I	16	65.25	18.15	47.10	14.30	32.80
28	I	5	265.65	120.85	144.80	68.45	76.35
Mean			118.90	47.25	71.65	31.30	40.35
Min.			65.25	18.05	47.10	14.30	24.10
Max.			265.65	120.85	144.80	68.45	76.35

* No Harvesting Costs, Machine Harvested by Processing Company.

VI BROAD BEANS

TABLE C.10.

SUMMARY OF PER ACRE

COSTING ANALYSIS BROAD BEANS

F.I. No.	Farm Class	Broad Bean Acres	Gross Returns	Total Variable Costs	Gross Margin	Total Fixed Costs	Net Profit Per Acre.
20	I	4	68.00	43.60	24.40	28.25	3.85*
24	I	3	72.70	51.85	20.85	12.35	8.50
26	I	10	132.10	57.10	75.00	26.65	48.35
Mean			90.95	50.85	40.10	22.40	17.65
Min.			68.00	43.60	20.85	12.35	3.85*
Max.			132.10	57.85	75.00	28.25	48.35

* Net Loss

VII WHEAT

TABLE C.11.

SUMMARY OF PER ACRE

COSTING ANALYSIS WHEAT

F.I. No.	Farm Class	Wheat Acres	Gross Returns	Total Variable Costs	Gross Margin	Total Fixed Costs	Net Profit Per Acre.
4	II	68	28.25	8.00	20.25	5.80	14.45
5	I	11	28.80	8.95	19.85	9.25	10.60
Mean			28.50	8.50	20.05	7.55	12.55

VIII SWEET CORN

TABLE C.12.

SUMMARY OF PER ACRE

COSTING ANALYSIS SWEET CORN

F.I. No.	Farm Class	Sweet Corn Acres.	Gross Returns	Total Variable Costs	Gross Margin	Total Fixed Costs	Net Profit Per Acre.
23	I	50	55.70	17.00	38.70	15.30	23.40

APPENDIX D

Appendix D provides the linear programming solutions for farm number 23, for the situations of hiring "one extra man", "two extra men", and "three extra men" at any time of the year.

NOTE:

(i) Dry land is designated by (d)

(ii) Wet land is designated by (W)

(iii) RGS_1 refers to first year ryegrass seed

(iv) RGS_2 refers to second year ryegrass seed

(v) The weekly periods are designated, by for example

Jan_1 = The first week in January

Oct_4 = The fourth week in October

I. PLAN FOR HIRING "ONE EXTRA MAN"

A. Land Utilization (Acres)

	LAND (d)	LAND (W)
WHEAT		2.52
RGS_1 after WHEAT		2.52
PEAS		36.48
RGS_1 after PEAS		36.48
RGS_2		39.00
*BROAD BEANS } *SWEET CORN after BROAD BEANS }	11.15	
RGS_1 after SWEET CORN after B.B.	11.15	
TOMATOES	3.16	

RGS_1 after TOMATOES	3.16	
MANGOLDS	6.02	
BROAD BEANS after MANGOLDS	6.02	
RGS_1 after B.B. after MANGOLDS	6.02	
RGS_2	20.32	
	67.00	117.00

* 2 crops in the one year .˙. land must only be counted once. In addition to the land utilization above, there are 7 acres of very wet stony land suitable for grazing only. This was not included in the programme.

B. Livestock

	LAND (d)	LAND (W)
BUYS 5 yr and 6 yr EWES and	325	780
4th WETHERS (Feb/Mar.)		
(SELLS all less losses by June)		
BUYS WETHER HOGGETS (Mar/Apr)	650	1560
(SELLS all less losses by Oct_3)		

C. Hours of Labour Hired

PERIOD	TOTAL HOURS	NO. OF MEN HIRED
Jan_1	19.76	1
Feb_4	9.67	1
Mar_1	70.20	1
Mar_2	51.84	1

PERIOD	TOTAL HOURS	NO. OF MEN HIRED
Mar_3	69.80	1
Mar_4	67.66	1
May_1	68.78	1
Oct_1	42.84	1
Oct_2	70.00	1
Nov_1	32.40	1
Nov_2	24.00	1
Dec_4	31.66	1

Total Hours Hired = 558 hours

D. <u>Net Revenue</u>

Linear programme net revenue	=	£10,943
PLUS net revenue calculated for 60 acres lease land	=	£ 3,196
		£14,139
LESS allowance for 558 hours of hired labour at 7/- per hour		£ 195
∴ NET REVENUE		£13,944

II. PLAN FOR HIRING "TWO EXTRA MEN"

A. Land Utilization (acres)

	LAND (d)	LAND (W)
SWEETCORN		19.40
RGS_1 after SWEET CORN		19.40
PEAS		19.60
RGS_1 after PEAS		19.60
RGS_2		39.00
*BROAD BEANS } *SWEET CORN after BROAD BEANS }	21.16	
RGS_1 after SWEET CORN after B.B.	21.16	
TOMATOES	10.63	
$R.G.S_1$ after TOMATOES	10.63	
RGS_2	3.42	
	67.00	117.00

* 2 crops in the one year .˙. Only count land once. In addition to the land utilization above, there are 7 acres of very wet stony land suitable for grazing only. This was not included in the programme.

B. Livestock

	LAND (d)	LAND (W)
BUYS 5 yr and 6 yr EWES and 4th WETHERS (Feb/Mar) (SELLS all less losses by June)	282	780
BUYS WETHER HOGGETS (Mar/Apr) (SELLS all less losses by Oct_3).	564	1560

C. Hours of Labour Hired

PERIOD	TOTAL HOURS	NO. OF MEN HIRED
Jan_1	6.22	1
Feb_2	2.11	1 or 0
Feb_4	136.03	2
Mar_1	140.00	2
Mar_2	66.53	1
Mar_3	139.80	2
Mar_4	140.00	2
Oct_1	93.12	2
Oct_2	58.83	1
Nov_1	111.80	2
Nov_2	80.25	2
Nov_3	6.31	1
Nov_4	17.42	1
Dec_4	29.52	1

Total Hours Hired = 1028 hours

D. Net Revenue

Linear programme net revenue	=	£12,281
PLUS net revenue calculated for 60 acres lease land	=	£ 3,196
		£15,477
LESS allowance for 1028 hours of hired labour at 7/- per hour		£ 360
∴ NET REVENUE		£15,117

III. PLAN FOR HIRING "THREE EXTRA MEN"

A. Land Utilization (acres)

	LAND (d)	LAND (W)
SWEET CORN		29.53
RGS_1 after SWEET CORN		29.53
PEAS		9.47
RGS_1 after PEAS		9.47
RGS_2		39.00
*BROAD BEANS } *SWEET CORN after BROAD BEANS }	13.50	
RGS_1 after SWEET CORN after B.B.	13.50	
TOMATOES	20.00	
RGS_1 after TOMATOES	20.00	
	67.00	117.00

* 2 crops in the one year .˙. Count land only once. In addition to the land utilization above, there are 7 acres of very wet, stony land suitable for grazing only. This was not included in the programme.

B. Livestock

	LAND (d)	LAND (W)
BUYS 5 yr and 6 yr EWES and 4th WETHERS (Feb/Mar) (SELLS all less losses by June)	268	780
BUYS WETHER HOGGETS (Mar/Apr) (SELLS all less losses by Oct_3)	536	1560

C. Hours of Labour Hired

PERIOD	TOTAL HOURS	NO. OF HIRED MEN
Jan_1	3.87	1
Feb_1	6.24	1
Feb_2	65.04	1
Feb_4	210.00	3
Mar_1	207.40	3
Mar_2	65.79	1
Mar_3	159.06	2 or 3
Mar_4	149.72	2
Oct_1	143.02	2
Oct_2	49.91	1
Nov_1	176.67	3
Nov_2	109.64	2
Dec_4	38.87	1
	1435 hours	

D. Net Revenue

Linear programme net revenue	=	£12,950
PLUS net revenue calculated for		
60 acres lease land	=	£ 3,196
		£16,146
LESS allowance for 1435 hours		
of hired labour at 7/- per hour		£ 502
		£15,644

NOTE: The total sweet corn average for this plan is 43.03 acres.

No "Corn maximum" restriction was imposed.

The three plans given in Appendix D are illustrated in summary form in Table 7.18.

APPENDIX E

Appendix E presents the budgets for deriving the net profit per acre for livestock on both classes of land.

I. Net returns from 5 yr and 6 yr old ewes and 4th wethers.

Calculations are based on:

50 acres	2nd yr	pasture	(W)*	10 ewes and wethers/Ac.
15 acres	" "	"	(d)**	8 " " "

* Wetter land = (W)

** Drier land = (d)

EXPENSES (*)

Buy 400 5 yr and 6 yr fattening ewes @ 23/- net av. (Feb/Mar)	£460
Buy 220 4th wethers @ 38/- net av. (Feb/Mar)	£418
Total Expenses	£878

RETURNS

Allow stock losses say 1.5% say 9 sheep @ 7/6	£ 3. 7. 6
Sell 393 5 yr and 6 yr ewes (May/June) fat to works @ 33/- net average	£648. 9. 0

Sell 218 4th wethers (May/June) fat to butchers @48/- net average	£ 532. 1. 0
Total Returns	£1183.17. 6
LESS Total Expenses	£ 878. 0. 0
Total Net Profit	£ 305.17. 6

(*) Does not include "running expenses". Very little expense is incurred on these sheep. They are bought in to clean up the aftermoath of harvesting ryegrass seed paddocks and sweet corn paddocks, fattened quickly and are all sold by mid June.

Net profit per sheep bought $= \frac{£305.17.6}{620} =$ £0.4933

At 10 sheep/Ac on land (W) net profit from 5 yr and 6 yr and 4th wethers on land (W) = £4.93/Ac

At 8 sheep/Ac on land (d) net profit from 5 yr and 6 yr ewes and 4th wethers on land (d) = £3.95/Ac

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II. Net returns from wether hoggets.

Calculations are based on:

50 acres	1st year pasture land (W)*	20 Hgts/Ac
15 acre	1st year pasture land (d)**	16 Hgts/Ac

* Wetter land = (W)

** Drier land = (d)

EXPENSES

Buy 1240 hgts (Mar/Apr) @	
average net price of 40/-	£2480. 0. 0
Stock stores at 1/- sheep	£ 62. 0. 0
Crutching expenses @ £2.5.0/100	£ 27. 7. 0
Shearing expenses @ £10/100	£ 121.10. 0
Total expenses	£2690.17. 0

RETURNS

Stock losses, say 2%	
25 Hgts @ 7/6 each	£ 9. 7. 6
Wool : 7.5lb. wool/hgt.	
9112.5lbs wool @ 38d lb. net	£1442.16. 0
Sell 1215 hgts (Oct$_3$) @ 45/- net av.	£2733. 0. 0
Total returns	£4185. 3. 6
Less Total expenses	£2690.17. 0
Total net profit	£1494. 6. 6.

Net Profit per sheep bought = $\frac{£1494.335}{1240}$ = £1.2374

At 20 Hgts/Ac on land (W), net profit from Hgts on land (W) = £24.75/Ac

At 16 Hgts/Ac on land (d) net profit from Hgts on land (d) £19.80/Ac

∴ Total Net profit from sheep on land (W) = <u>£29.68/Ac</u>

and Total Net profit from sheep on land (d) = <u>£23.75/Ac</u>

NOTE: The stock carrying capacities for this farm are high. The stocking rates used above, for the linear programme, are slightly less than those actually carried for seasons 1960-61 and 1961-62.

The broad stock policy is to buy old sheep in Feb/Mar, to "clean up" paddocks harvested for ryegrass seed and sweet corn. These older stock are kept on the "harder" feed and second year pasture. They are sold in lots fat to the works and the butchers in May and June.

By June the young grass paddocks are due to be grazed. The hoggets are brought at this time and stocked very heavily on the young grass right up until the paddocks for ryegrass seed are due for closing in the third week of October. The pasture must be kept "close grazed" otherwise the farmer says he can't control the growth in the September/October period. All hoggets are shorn and sold one month later in the third week of October.

APPENDIX F

DERIVATION OF THE EFFECTIVE MINIMUM CHANGE IN PEA PRICE NECESSARY TO CAUSE A CHANGE IN PLAN

It is required to find the minimum upper and lower changes in the price of peas for activities P_2 and P_6 necessary to change the optimum plan. Pea yields and quality are the same for both P_2 and P_6. It is assumed that the ryegrass yields and prices remain constant in both P_2 and P_6, and that yields and prices for all other crops remain constant.

For the j^{th} column

$$z_j - c_j = \sum_i c_i r_{ij} + c_p r_{pj} - c_j$$

Where p refers to the row corresponding to the pea activity in the basis (P_2),

and the summation over i is over all <u>other</u> basic activities.

Let p = 2 and j = 6 refer to the P_2 row and P_6 column respectively.

Then

$$z_6 - c_6 = \sum_i c_i r_{i6} + c_2 r_{26} - c_6$$

Now let both c_2 and c_6 increase by Δc, where Δc is the minimum change in pea price necessary to change the optimum plan.

Hence $z_6 - c_6' = \sum_i c_i r_{i6} + (c_2 + \Delta c) r_{26} - (c_6 + \Delta c)$

$$= \sum_i c_i r_{i6} + c_2 r_{26} - c_6 + \Delta c r_{26} - \Delta c$$

$$= z_6 - c_6 + \Delta c r_{26} - \Delta c.$$

$$z_6 - c_6' = z_6 - c_6 + \Delta c\,(r_{26} - 1)$$

$z_6 - c_6' = 0$ when

$$\min \Delta c = \frac{-(z_6 - c_6)}{(r_{26} - 1)}$$

$\therefore$ for $\min \Delta c$ positive, $r_{26} < 1$

and for $\min \Delta c$ negative, $r_{26} > 1$

Having derived this minimum upper or lower price change necessary to cause a change in the optimum plan, it must then be compared with the other minimum upper or lower price changes as derived in 7.5.2 equations (1) and (2), to find the minimum minimorum of the price increase and price decrease respectively for peas, to change the optimum plan.