The Potential For And Limitations Of A Shift From Animal-based To Plant-based Agriculture And Food Production In England And Wales

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Summary

This study investigates the possibilities for totally plant-based agriculture in England and Wales and assesses the impacts of this shift in food production. The world food situation, increasing pressure on resources for food production, and health problems apparently related to western-style diets all suggest change is necessary. Plant-based agriculture is a possible alternative worthy of investigation.

The general research approach was a technology assessment incorporating a literature review on agricultural and dietary issues; the construction of a novel cropping scheme for England and Wales; a Delphi study on developments in dairy farming; a relevance tree to establish the areas of impact of the shift; and a single farm case study to establish its potential for changing to crop production.

The general conclusions were that plant-based agriculture is a possible alternative for agriculture in this country. The level of self-sufficiency would increase provided the population adopted a vegan diet and the efficiency of resource use in agriculture would improve. The diet is limiting and cannot be wholeheartedly recommended for the whole population. Much agricultural land is released by the scheme providing potential for other forms of land use but it is hard to say whether this would provide any overall economic benefits. Techniques to facilitate dairying in a meatless regime could be developed. The case study indicates that change is possible on farms which might be considered marginal for crop production although the risks involved in farming these holdings increase.

The technological base of agriculture and the economic and social priorities of society were assumed not to change; this tends to make totally plant-based agriculture an unlikely goal although some move away from meat production seems to offer advantages. It is recognised though that if these factors change the conclusions might be different.

Vegetarian

Self-sufficiency

Agriculture

Diet

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CONTENTS

Part 2: A Plant-Based Scheme For Food Production In England and Wales. 188

LIST OF TABLES:

LIST OF FIGURES:

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INTRODUCTION

This study was prompted by a number of considerations and events. It was conceived in 1974/75 at about the time of the first major oil crisis and the United Nation's conference on Food (1974). The problems of food production, distribution and consumption worldwide and Britain's over-reliance on imported food were highly topical. The food production system in this country showed a major imbalance because of the need to import a large proportion of both our food and feedingstuff requirements. This situation, though it is imbalanced, is the result of a multitude of interrelating economic and political factors. The British food supply situation is likely to be threatened, however, in the medium to long-term. Worldwide supplies of oil are decreasing and there is also increasing uncertainty in world food markets as demand for food rises and production has difficulty meeting it. In this country there is considerable strain on agricultural land as demand for other forms of land use rises, as the population increases and society's aspirations change.

There were also other topical problems relating to diets which linked with a study on agriculture. Animal fats and refined carbohydrates, specifically, had been linked with the development of certain diseases virtually peculiar to affluent western societies. The Vegetarian Society (U.K.) was interested in the potential for totally plant-based agriculture in this country. The sort of diet derived from this system would be free of the items implicated in the dieases of affluence and the removal of inefficient animal production should provide better levels of self-sufficiency. There was, therefore, ample incentive for investigating an agricultural system which reduced imports and provided a diet free of ingredients which might lead to degenerative diseases.

The study sought to assess whether or not totally plant-based agriculture was a possible future for agriculture in this country. At a fundamental level it was important to know whether this sort of system was feasible biologically under British conditions. It was also important to determine whether it would increase the possibilities for self-reliance in food and whether the resulting diet could be regarded as a suitable and healthy one for the whole population. It seemed likely that there would be factors both for and against totally plant-based agriculture as a possible alternative for this country's agriculture.

Viewed from the present it is evident that plant-based agriculture must be regarded as a long-term alternative (unless some unexpected catastrophe should occur), even if it proved to be very highly beneficial. This is because of the considerable inertia in the current system and the magnitude of the change suggested. The long time scale involved in the change means that the future constructed cannot sensibly be regarded as a vision of a future situation. Rather it should be regarded as an alternative to the current situation which may or may not be worth pursuing. The scheme elaborated in this study has very strong links with the present because it is bound by specific goals and assumptions which though pertinent and relevant today may not be so at some point in time, years in the future. This rootedness in the present might be regarded as a limitation, particularly if there were no room for a certain amount of imagination as to what the future may hold. It is hoped that the study, though it attempts to construct an alternative methodically, does so with some imagination.

Another aspect of the study of this particular alternative is that it appears very restrictive both agriculturally and in terms of diet. Totally plant-based agriculture does offer an extreme future. It is tempting, therefore, to dismiss it as totally unrealistic. There is merit, however, in investigating the improbable, as extreme situations can highlight effects which occur in less restrictive circumstances but which go unnoticed until the effect becomes critical. Improbable futures are also not necessarily impossible ones. They may offer a real alternative for us or future generations.

The work has been done within the Technology Policy Unit, a research unit interested in many aspects of technology and its impacts. An investigation into totally plant-based agriculture is relevant to such a Unit for two reasons. First, the study has been attempted partially in response to perceived social concern over the direction and effects of current technology in agriculture and food production. If concern is justified, there is a case for encouraging changes in policy to provide a more desirable outcome. The alternative constructed may not provide the most desirable alternative, even in the long-term, if change is necessary. However all conceivable alterative possibilities should be examined if change is considered at all. This then provides a second justification for studying this particular area within the Technology Policy Unit.

The hypothetical system of totally plant-based agriculture assumes a constant level of technology but a change in the mode of application. The approach used in the study had a strong similarity with technology assessment but rather than assessing the effects of past or new technologies it attempts to assess current technology applied in a novel way to meet different goals. A sister project to this one is investigating the effects of changes in technology in the current system and in the alternative constructed in this thesis. Technology assessment is a form of interdisciplinary research, drawing on a variety of disciplines. The assessment of the impact of new technologies, or in this case altered approaches to the application of technology, incorporates an historical background to the area studied or to a very similar technology and an up-to-date examination of the state of the art in the technology. The first part of the thesis provides this background and also develops the rationale for the study.

In the second part of the thesis a model was constructed. This represents a cropping scheme for the country under a plant-based system and the sort of diet derived. It was hoped that the model could be used to assess some of the impacts of change and this was indeed the case, although the extent to which it could be used for this was less than had been hoped. Ideally models should be flexible to allow variations on the original to be generated by manipulating the constraining variables. Unfortunately, the model has very limited flexibility because there is insufficient biological and physical data available in a usable and countrywide form to act as reliable constraints. It was, however, possible to optimise the model for food energy and protein output by imposing cautious, and hopefully sensible artifical constraints on the cropping pattern.

The study did not wish to be confined to establishing what could be grown and what sort of diet would emerge; it also sought to identify the range of impacts likely under the shift. In order to do this in a systematic way, a relevance tree was constructed. This provided a useful supplement to the model as it gave a much wider perspective to the study. There are of course few areas of life which would not be affected by this change to a plant-based system of food production. The relevance tree was, therefore, also used to elucidate those areas which would be explored further in the study. Certain areas such as released land and the Dairy Industry were to receive more attention, and an attempt was made to compare agricultural energy and labour use under the novel and current systems. The impacts noted in the relevance tree extended beyond farming and the diet, which were the areas most closely studied in this thesis, so two projects were instigated to tackle the effects of change on the food industry and the Economy, and to determine the scope for the introduction of new crops and technologies under a plant-based regime.

The study on the Dairy Industry was considered important because dairy foods constitute an important dietary item. What is more, dairy foods are acceptable dietary consitituents in some vegetarian diets. There are problems with integrating dairying into a meatless agricultural system however. The investigation of the Dairy Industry took the form of a forecasting study to determine the necessary technical developments needed to enable dairying to be carried out without accompanying meat production. The forecasting method used was the Delphi technique. This uses a committee approach to achieving a prediction. Speculative technical developments necessary for dairying in a meatless system were suggested and put to a committee of experts for comment and a forecast of development times. It was hoped that the forecasts could provide an estimate of the possible transition period for a change to a system devoted entirely to food crops.

The study also acted as a useful sounding board for opinions on the ideas of dairy farming without accompanying meat production and of totally plant-based agriculture.

The study is largely concerned with examining the country-wide potential for totally plant-based agriculture as it is impossible to reliably cover the effects at the individual farm level. Every farm will have its own characteristics and these will affect the possibilities for change. Nevertheless, it was considered important to look at the potential for change on at least one farm. A case study example was therefore attempted. The farm chosen was at the time pursuing a mixed system of dairying, sheep, pigs and a small amount of arable cropping for feedstuffs. It seemed a good choice as many might consider it of marginal suitability for an all arable system. The added bonus with this farm was ready access both to farm data and to the farmer, for consultation and opinion as to the scope for change. The case study concentrated on establishing what the farm could produce in terms of crops; how much of the currently farmed land could continue in production and what adjustments would be necessary to make an efficient viable unit.

The model of the cropping plan is complemented by the Dairy farming and single farm studies as well as by the work on vegetarian diets, uses for released land,etc. Overall there emerges a fairly comprehensive account of the potential for and limitations of a shift to totally plant-based agriculture. In the conclusion every attempt is made to assess the workability of the scheme objectively. The scheme is intentionally cautious and conservative as it has to depend on biological and physical criteria for its construction. The economics of the changed situation at a country-wide or an individual farming level are virtually impossible to predict as the market for food would be so altered under a strict vegetarian dietary regime. The lack of an economic framework need not detract from the validity of the whole exercise because if change comes it will result from alterations in economic and social factors. Current economic and social opinion, although it is concerned about the food and agricultural situation, does not suggest the need for such radical change but that is not to say that the occasion may never arise. It seems likely that if the need to change farming so radically arose then at least one can say that there is potential for the change although the solution to a number of very complex problems would have to be found. The technological framework of the study is not examined as it is assumed to be as it is at present. There appear to be only a few technical constraints on the achievement of totally plant-based food production and these are more likely to be found at the food processing end of the chain. Advances in agricultural technology, even in an era of increasing resource scarcity, are likely to improve the potential for totally plant-based agriculture.

Briefly, then, this project consists of a review of relevant agricultural and nutritional issues which provide the background for the construction of a cropping plan for agriculture under a totally plant-based food production system. The Plan is complemented by smaller studies on dairy farming, and an individual farm, and by discussions on the use of released land and the comparitive merits of the present and alternative system.

PART 1

THE CURRENT AGRICULTURAL SYSTEM AND PRESENT DAY DIETS IN BRITAIN

Introduction

Part 1 deals with the current system of agriculture and present day diets in Britain. It is important when proposing an alternative system to examine the existing one thoroughly. It is, however, difficult, if not impossible, to cover every possible area relating to the current situation which is relevant to the construction of an alternative. The obvious approach is, therefore, to be selective about the areas covered. The reasons for examining the present system in this study are threefold. First, an investigation of the present system in terms of both its current state and its historical development may reveal the points of weakness that exist and therefore provide the rationale for the development of an alternative. Current opinion on aspects of agriculture and the diet also helps to establish where change may be necessary and it also helps to illuminate the areas of controversy where the justification for change is less clear cut. Second, a comprehensive study of the current system for agriculture and the present diet in Britain can act as a basis for comparing the present with the alternative system. This enables conclusions to be drawn about the merits or faults of the alternative. Third, an investigation of the present system can help to establish constraints both physical, biological, economic and social, likely to affect the development of the hypothetical alternative. The full discussion of assumptions made concerning these constraints occurs in Part 2. Part 1 does, however, help to identify where the constraints might occur.

The areas covered in this part include an historical discussion of agriculture in Britain since the beginning of this century, a study of the type of farming practised, a detailed account of the meat and livestock industry as this is the major enterprise sector which would be absent from the alternative; the present diet, in terms of the range of foods eaten, the nutritional content of the diet and possible effects of the diet on health; and finally the criticisms that have been made about British agriculture and the food it provides.

1.1 Historical Development of Agriculture in this Century

It is probably time to say that the roots of British farming practice and pattern are found way back in time before the beginning of this century. However, developments prior to this time will only receive a cursory mention here. For one thing, even though there is no shortage of space in which to investigate events prior to the beginning of the century, it might be more beneficial to concentrate on a shorter period in more detail, as developments in this period would seem to provide greater immediate insight into the situation farming finds itself in today. Without wishing to denigrate the important role played, for instance, by enclosures in the shaping of agricultural practice, it is also important not to fuzz the picture with too much historical detail. The study will, therefore, be limited to this century in the hope that some clear understanding of the present agricultural system and the lead up to it, will be achieved. The more recent political decisions that have been made, which impinge on or directly affect agriculture, also directly affect the course of development it takes. It is important to see both the benefits that may have emerged along the way and the costs that have been incurred. Only within the boundaries of the present system, both historical and current, can the root causes of any discontent over that system be identified. The rationale behind the project is dependent to a large extent on the identification of areas for concern evident in the current situation. If the situation were such that there was no cause for concern then there would be little incentive for identifying alternatives. However, assuming the system is innocent until proven guilty, an historical case has to be drawn up to give reasons for a study of tbis nature. It is then the purpose of the project to put the alternative on trial, as it were, and compare it with that which currently exists.

1.11 British Agriculture in the Last Century

Many changes occurred in agriculture in the last couple of centuries which set the tone for this century. In the mid-eighteenth century there was a revolution in agricultural practice, new land reclamation methods, improved crop varieties, rotational systems, new machines and improved methods of livestock breeding were all developed. The enclosure of land made the application of these new methods easier and as a result many people were displaced from the land. This pool of labour was absorbed, however, by the factories of the industrial revolution. Britain changed within the century from an agrarian country to an industrial one. It is often suggested that without agricultural progress there could not have been industrial development. The reason for this is that industry needed labour and food for the workers and their families; agricultural progress provided both by releasing labour and increasing output.

The industrial revolution also resulted in a shift in political power. Prior to this time most of the political muscle was in the hands of landowners, most of whom had farming interests. Policies relating to agriculture were invariably of a protectionist nature, as it was not in the interest of these politicians to undermine their own position. As the industrial revolution progressed the increasingly powerful industrialists began to enter government. The balance began to swing away from the landowner with his agricultural interests. The industrialists were more interested in increasing their output and keeping their costs down. One of their major costs was labour, despite some degree of mechanisation industry was still labour intensive. One way of discouraging efforts to increase wages was to keep the price of food down. To the average worker in those days the purchase of food was his major expense (anything from 60 per cent to 80 per cent of a worker's income was spent on food(1)). If people were to be fit to work, and relatively contented with their lot, they had to have food. They also had to have it at a price they could afford. It was, therefore, very much in the interests of industrialists that food was cheap.

In 1846 the corn laws were repealed, these measures had originally been enforced to maintain the price of grain. Farmers now found themselves without protection. However, agricultural output continued to expand up until the 1870's. At about this time the produce from vast new lands in the world, particularly the countries of the Empire, was beginning to reach Britain. Initially mostly grain was transported but refridgeration was not long in coming and this meant that meat and other perishable goods could be shipped long distances. Even more important, that the capability to transport food great distances, was the fact that food produced overseas, on virgin land farmed extensively, was very cheap. The British farmer could not compete with the flood of cheap food reaching the market. British agriculture, as a result, went into decline. The single advantage that the British farmer had, his proximity to large expanding urban markets, he was slow to appreciate. The traditional farming patterns based on grain and meat as the major outputs would have to change. From a general economic standpoint the free market was advantageous to Britain. It had a ready market for its manufactured goods and was the principal market for food produced around the world. Strong political and trading links were forged at this time and they depended on this food - manufactures exchange. British agriculture having lost its political power was slow to reorganize itself politically and even if it had it is unlikely that any action would have been taken to protect agriculture from a situation which, on the whole, benefited the economy.

At the beginning of this century agriculture was in a declining state. In the previous century, landowners had seen their political power hopelessly diluted and had been unable to recuperate. The majority of farmers were tenants to large landowners and their political voice was negligible, their rights minimal. Despite this, concern was beginning to be shown about the nation's agriculture and its health. A Board of Agriculture was set up in 1889 which was to become the Ministry of Agriculture and Fisheries in 1919. It was set up to encourage education and research in agriculture as well as to formulate legislation. Government was beginning to become involved in agriculture even if only tentatively. Coupled with this was a growing concern over the nation's health. Advances in medicine and nutrition began to show the importance of food in the maintenance of health. A medical examination of recruits for the Boer War showed that forty per cent of them had to be rejected on the grounds that they were not fit to fight(2). This weakliness was attributed, in part, to poor nutrition.

1.12 From World War One to the Present

In the past sixty-five years, considerable changes have occurred in most areas of agriculture and food production. The industry has moved from a state of decline into one of relative prosperity. Resource use in agriculture has changed and new methods and equipment have been developed and adopted. The pattern of farming has altered and the political importance of agriculture has gone through numerous changes. It was noted above that during the last century Britain changed from being an agrarian country into an industrial one. This change has continued, at least in the sense that agriculture becomes of relatively less importance to the economy every year. In 1871 agriculture contributed an estimated 20 per cent to Gross Domestic Product, this fell to 4 per cent by 1958 and is now running at about 2.5 per cent(3). These figures do not, however, indicate the growing significance of agricultural support industries and further down the chain, the food processing, distribution and catering industries, all of which have become important sectors in the economy over this century. Agriculture's economic role is strengthened by this inter-relationship between it, and the other industries.

The amount of land farmed in this country has also delined since the beginning of the century. Currently, approximately seventy-five per cent of the land area of the United Kingdom is in agricultural use(4) (this percentage includes the contribution made by rough grazing and woodlands on agricultural holdings). The percentage was once greater than this, for the amount of agricultural land has shrunk by nearly a million hectares in the past century. In 1935, 19.3 million hectares were in agricultural use, this fell to 18.37 million hectares in 1975(5 & 6). Similarly, changes have occurred in the use of agricultural land. The arable area which includes tillage and temporary grass, reached a maximum of 7.36 million hectares in 1872. This fell to 5.72 million hectares in 1915 and rose briefly to 6.32 million hectares during the later part of the First World War(6). The decline continued again after the war to reach 4.76 million hectares by 1938(6). The area fluctuated between six and seven million hectares in the 1950's and 1960's and currently stands at around about seven million hectares(5). The relative balance of crops to grass has changed too over the years. As farm management techniques became more sophisticated during this century, the percentage of arable land increased at the expense of permanent pasture. This can be seen in Table 1.1 overleaf which refers to the situation in England and Wales only.

TABLE 1.1

Proportion of Crops and Grass Area Devoted to Arable and Permanent Grass in England and Wales

[Source: calculated from data from "Century of Agricultural Statistics: 1866-1966" (1968) HMSO and "Agricultural Statistics for England and Wales" HMSO]

Permanent pasture had declined in relative importance, presumably because of the increased emphasis being placed on good grassland management which has encouraged moves towards ley systems for grass rather than traditional permanent pasture in grassland areas. As various informed bodies keep stressing that grass is still an under-utilised resource[7 & 8], it is probable that the area of permanent pasture will continue to decline. The proportion of tillage is also increasing which indicates the increasing profitability of, and emphasis on, arable cropping in recent years.

There have also been marked changes in the number of holdings and the type of farming practised, the total number of holdings, the form of tenure on holdings and the type of farming practised. The total number of holdings in 1875 was 470,000. This had fallen to about 261,000 in 1977[6 & 9]. The average size of holdings in the United Kingdom which are considered to be full-time businesses (i.e. provide at least 275 standard man days (SMD's) of work in a year) is currently about 113 hectares[9]. This figure has continued to rise gradually over recent years. Larger farm businesses are becoming more and more important with respect to their contribution to total farm output for the country. Fifty per cent of farm output in 1977 was produced by the 10 per cent of farm businesses that were considered large scale concerns (i.e. provide 1000 SMD's of work or more in a year)[10]. The majority of the remaining output was produced by the remaining full-time businesses. Nevertheless, 10 per cent of total farm output is still produced by part-time farms which means that these concerns are far from insignificant.

Until relatively recently, the majority of farmers in England and Wales were tenants and most of the agricultural land was tenanted. The situation now is that more holdings are owner-occupied than tenanted. The proportion of agricultural land that is owner-occupied is also signficantly greater than that which is tenanted. The decline of tenanted holdings started at the beginning of the century but accelerated between 1920 and 1950 when the price of agricultural land was relatively low and many landowners were selling up. The current balance for Great Britain is 62 per cent of holdings owner-occupied, compared with 38 per cent tenanted[9]. In 1908, 87 per cent of holdings were rented, or mainly so[6].

Changes in type of farming indicate a movement away from mixed enterprises and towards greater specialisation. This can be seen most clearly with dairying and cereal cropping. The number of farms on which 50 per cent of output is in the form of milk or dairy products rose from 26,677 in 1963, to 30,192 in 1973[5 & 11]. The figure for 1975 is 29,274[11], which could indicate a decline in specialisation but for the fact that the total number of farms on which dairying is an important enterprise had fallen by 21,500 from 1963 to 1975. The percentage of all holdings that were in specialist dairying (over 50 per cent output as milk) has also risen from 8.8 per cent in 1963 to 14.1 per cent in 1975 while those classified as mainly dairy (over 25 per cent output as milk, but less than 50 per cent) had fallen from 10.4 per cent to 6.6 per cent in the same period. Milk production in this period rose, and average herd size increased, compensating for the reduced number of holdings and implying even greater specialisation. For cereals, the number of farms on which this was the major enterprise rose from 6,345 in 1964 to 8,280 in 1975[5 & 11]. The percentage change in importance was 2 per cent to 5.9 per cent of holdings. Mixed farming enterprises were practised on 22,667 holdings in 1963 but on 8,004 in 1973[5 & 11].

Considerable changes have also occurred in the numbers of the different types of farm livestock, and in their rate of growth and yield of by-products. Crops too have shown increases in yields over the century, and changes in their relative importance compared with each other. Numbers of poultry, cattle and pigs have increased dramatically. For example, the size of the poultry flock increased from 54 million in 1930 to 137 million in 1977, cattle numbers rose from 7 million in 1922 to double that in the 1970's and the pig herd has virtually doubled in size from 4 million in 1922 to 7 million in 1977[5 & 6]. Most of these increases have been possible because livestock production, with these three types of animal, has been revolutionised by the development of new, often intensive methods of husbandry and new or improved breeds of livestock. In the 10 years between 1960 and 1970, average milk yield per cow rose by 325 litres and the number of eggs laid per hen increased by 31 eggs(9). Sheep numbers have not shown such dramatic increases although in 1922 there were 23 million and in 1977 there were 28 million(5 & 9). The proportionally smaller increase in the size of the sheep flock is due in part, to the fact that sheep have been slow to adapt, so far, to intensive methods.

Although there has been little change in the range of crops grown over the past century the importance of some has changed. The main cereals grown are still wheat, barley and oats but the relative importance of each of these has altered. Barley, in acreage terms, is by far the most important cereal now, whereas in the early part of the century it was definitely in third place. Oats have declined in importance because of the reduction in the number of working horses. Most fodder crops are of less importance now because of a shift in the nature of over-winter feeding for stock, which is now more dependent on cereals and conserved grass than formerly. Table 1.2 gives some indication of the changing importance of the various crops by showing the percentage of crops and grass acreage occupied by the various crops in 1866, 1938 and 1975.

TABLE 1.2

The Proportion Of The Crop And Grass Acreage
For 1866, 1938, 1966 and 1975 Occupied By Various Crops

/Source: data taken from "A Century of Agricultural Statistics 1866-1966" HMSO (1968) and CSO "Annual Abstract of Statistics 1977" HMSO/

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* Figures for 1866, 1938, 1966 apply to whole of Great Britain. Figures for 1975 apply to United Kingdom.

Crop yields have changed and so has the total output for some crops. The increase in total output is partly due to greater acreages of these crops being grown but is also a result of improved varieties coupled with increased use of fertilisers, weed and pest controlling chemicals and improved harvesting techniques. The output of wheat increased from 2.5 million tonnes in 1942(6) to 5.25 million tonnes in 1977(9), in the same period the area under wheat only increased by about 7 per cent, so much of the extra output was due to improved yields. Many crops follow similar patterns especially barley and sugarbeet. Potatoes on the otherhand have fallen in output but this is due to a decrease in acreage as yields have increased. The demand for crops will also govern whether output increases or decreases, thus it can be presumed that demand for potatoes has declined. Wheat and potatoes provide good examples of the extent to which yields have been improved, in the period 1935 to 1976, average wheat yield per hectare rose from 2.25 tonnes to an expected average of 4.4 tonnes and potato yields increased from 15 tonnes per hectare to about 26.5 tonnes(6 & 10).

The extra output achieved as a result of improved farming methods, for livestock and crops, has increased the levels of self-sufficiency over this century. Immediately before the Second World War, 30 per cent of the country's food supplies was home produced(12), in 1955 this rose to 47.8 per cent and in 1977 the figure was 53.5 per cent(6 & 9). In terms of indigenous foodstuffs, Britain was 62.1 per cent self-sufficient in 1955(5), and is now 64.8 per cent self-sufficient(9). Output has kept pace with rising population and increasing demand in certain areas. This situation is highly laudable from the point of view of output and the preservation of a productive healthy industry.

1.13 The Political and Historical Background to Agricultural Change 1914 to 1970

Many changes, other than those in farming techniques, use of land etc, which are covered above, have also occurred. These too have shaped the current farming situation. In the preamble to this section it was noted that home agriculture was not receiving very much attention politically at the turn of the century, but that with increasing concern over the nation's health, tentative moves were being made by Government to improve the agricultural situation. The importance of a healthy productive home agricultural industry was brought into focus in this century by the First World War. In the early part of the war, the possibility that naval blockades could disrupt supplies of imported food, so crucial to the United Kingdom, was only considered by a few. Home agricultural output did not therefore receive any stimulation until the import situation deteriorated. Rapid measures were then taken by Government to boost home output. A guaranteed price system for cereals was introduced and efforts made to increase the area of tillage. After tbe war, government involvement in agriculture lapsed, the guaranteed price measures were repealed in 1921 and British farmers again found themselves competing in a free market with cheap imported food. This resulted in a decline in the state of the industry.

During the late 1920's when the whole economy was suffering from a severe depression, government had to step in to help out a group of basic industries such as coal, steel, textiles and agriculture. All these industries suffered from similar problems, the worst being an inability to compete with the increasing competition from overseas. The free market conditions surrounding food in the United Kingdom had resulted in a shift in emphasis in home agricultural production. Farmers were producing greater quantities of bulky perishable foods, particularly milk, rather than maintaining the more traditional pattern of meat and cereal production. This shift resulted in a glut of milk, in excess of market requirements. In order to control the market situation, the government passed the Agricultural Marketing Acts of 1931 and 1933 which called for the setting up of Marketing boards for milk, potatoes and hops. The purpose of these boards was to control the marketing of these commodities, protecting the producer, stabilising prices to the consumer and regulating supply to meet demand.

As well as setting up the Marketing boards at this time, the government also agreed on import quotas with overseas suppliers of bacon, ham, mutton and beef. It even introduced price subsidies for sugarbeet, wheat, barley, oats and fat cattle. The subsidy for wheat was financed from a levy on imported flour. This pinpoints one of the dilemmas in agricultural support policies, where to raise the money to finance them. The burden of support falls on the Exchequer and for widespread and consistent support of agriculture a country has to weigh the benefits of maintaining a healthy agriculture against the very high costs of supporting a high risk industry. Support is likely to be considered as a burden if the commitment by the State to agriculture is not wholesale. In the 1920's it was not, and semi-self financing schemes like the wheat subsidy - flour import levy were favoured. The government were still committed to the cheap food policy which meant that to an extent home agriculture would have to manage with piecemeal protective measures. The depressed condition in the industry did not become much better as a result of government action at this time, though some did receive benefit, particularly the arable farmers of Eastern England.

At the start of the Second World War immediate control of food production was assumed by the State. It was known that imported supplies could be severely restricted by blockade and every attempt had to be made to save shipping space. Food was an obvious choice as an area in which economies could be made. Guaranteed prices for certain agricultural products were reintroduced and farmers were required to plough up as much land as possible and plant what was required in return. County War Agricultural Executive Committees were set up to organize and advise on production at a local level. Livestock numbers were run down and the production of edible crops was given priority. The machinery of control for each essential foodstuff was ready on the first day of the war, according to Hammond(13), but there was no agreed "feeding policy" for the population. Not until later on in the war when rationing became essential did scientific considerations concerning an individual's food needs become important. When rationing occurred, it was first applied to proteinaceous and fat foods, for which either a distinct and definite need existed in the community or, in the case of fats, alternative and easier to produce calorie sources were available. Carbohydrate foods were not rationed initially as the energy need of individuals varied so much depending on their energy expenditure.

After the war, State control of food production did not cease immediately because of a world-wide shortage of food. Normal trading conditions were slow to return. Certain things were apparent though after the war, which were to affect agriculture, most particularly it became obvious that Britain had been considerably weakened as a trading nation. This change created a need to maintain home output of food. Agriculture had contributed greatly to the war effort in keeping the Nation fed. Farmers too had seen the advantages of some measure of protective State control. Even if they had not prospered excessively in wartime they certainly had not become destitute. There was a mood of eagerness, therefore, to put forward future plans to consolidate the position of the industry. Agriculture was seen as an important factor in a healthy economy even an industrial one. Self and Storing(14) describe the fervour for post-war agricultural planning in this way.

> "Thus there were motives enough for offering a "new deal" to British agriculture. It must be admitted that these motives contained a large admixture of loose idealism and generalised benevolence which grew easily out of the wartime atmosphere of shared sacrifices and suspended competition. This mood nourished by admiration of the farmers' wartime achievements and by somewhat loose inferences about the strategic and economic value of keeping agriculture prosperous."

There was a great deal of activity between 1943 and 1945 from many groups, both political and agricultural, as many policy proposals were drawn up. Eventually, a joint policy statement drawn up by a number of organisations, including the National

Farmers Union, Country Landowners Association, National Union of Agricultural and Allied Workers, Royal Agricultural Society of England, and others, advocating a revised system was released(4). It called for a system of guaranteed prices to ensure reasonable returns to the producer and on capital invested, which would secure a standard of living in agriculture on a par with that of urban workers. The disparity in incomes between the urban and rural worker had been increasing since the middle of the previous century. In 1870, incomes for both were roughly equal, by 1900 the agricultural wage was only 63 per cent of the industrial wage, and in 1930, it had fallen to 61 per cent(3). The policy statement also covered such issues as the need for owners and occupiers of rural land to maintain it in good productive heart, and the need for controls on the import and marketing of foodstuffs. This statement, although never adopted in total by Government, gave clear indication of the mood and expectations of the farming community. It was still not entirely clear how these policy goals would be achieved and the main political parties had different ideas about the methods which could be used. Some, such as the Conservatives, favoured import levies on food to raise money for state support of home agriculture. The Labour Party preferred a guaranteed price system similar to that used in the War as it did not care for direct taxes on food.

All this activity concerning the future of agriculture eventually led to legislation. In 1947, the then Labour Government passed the Agriculture Act. This proposed that a yearly review of the economic conditions and prospects of agriculture be made and, in the light of this, economic guarantees would be set for a stated list of commodities. Precisely which products were to be included on the list was governed by the famous statement limiting it to, "such part of the nation's food and other agricultural produce as in the national interest it is desirable to produce in the United Kingdom." The Act also stipulated that guaranteed prices should provide proper remuneration and living standards for farmers and workers in the industry as well as an adequate return on invested capital. The Act promoted a mood of optimism in agricultural circles and output increased rapidly. The direct political involvement of farmers was also strengthened as the annual review had to be conducted by the Ministers (responsible for agriculture) in consultation with the National Farmers Union. Between 1947 and 1951 rationing was still enforced, the supply situation was unsettled and the cost to government of the guaranteed price system proved to be very high.

The method of farm support was changed in 1951 in an attempt to cut the Exchequer bill. International trade had now settled down after the Korean War and supplies of imported food were more forthcoming. The government did not wish to abandon home agriculture to the free market again, so it set a target for an increase in output of sixty per cent by 1956 and introduced the deficiency payment scheme. This scheme involved setting a minimum price for each commodity and only paying out to farmers if the average market price fell below the minimum price. As all farmers would receive payment in such a situation this was supposed to encourage an individual farmer to go for the best price he could get, thereby reducing the possibility of the market price falling below the minimum price.

If this worked, the cost to the Exchequer would be kept to a minimum. The market price of commodities was, however, vulnerable to the price of imported supplies and surplus home production, the cost of agricultural support to the Exchequer remained large. Britain was a net food importing nation and supplies from overseas were still cheap, so the country stood to benefit from continuing to import food. British agricultural policy was therefore presented with a dilemma, how to preserve a healthy home agriculture and maintain cheap food supplies.

In 1957 the cost to the Exchequer of agricultural support had become huge and farmers were urged by government to be economical and cut costs. The industry had to become efficient and competitive. The Agriculture Act 1957 set out a scheme for protective grants and long-term assurances on guaranteed prices (which were to be maintained at not less than 96 per cent of that set out in the previous year for each commodity considered). "Standard quantities" were introduced for milk, eggs, and potatoes to prevent over-prduction, control the market, and cut the Exchequer Bill. This system was organized through the marketing boards and excess output, above the "standard quantity", received reduced payment. Despite these controls agricultural production continued to increase rapidly. Expansion was encouraged by the arrival of new technologies especially for milk, cereal and poultry production (commodities which also had attractive guaranteed prices). The move away from mixed farming systems and towards greater specialisation also got underway at this time.

The expansion in agricultural output continued until the mid 1960's when it began to level out. The cost of support was high and this was giving rise to considerable concern, so change was not far away. In 1965 the government began to show an awareness of the integrated nature of agriculture and the problems of rural areas. Certain sectors of farming, such as hill farming, were at a financial disadvantage to the rest but necessary to the overall pattern of the industry. In recognition of this, grants for specific problem areas were introduced. Imports of food were costing the country much money and acting against the balance of payments, in the National Plan, released in 1965, agriculture's role was identified as one of import-saving. A target of a five per cent improvement in home output within five years was suggested. The efforts to increase self-sufficiency by this much proved unsuccessful, their impact being watered down by a number of factors including bad weather and a shortage of quality labour. Cereal production remained on target until 1968 when it began to slide and livestock production was constrained by the availability of feedingstuffs, much of which had to be bought in from abroad, as there were insufficient home-grown supplies. This undermined any attempts to reduce imports. Selly[15] suggests that the promotion of agriculture's import saving role was not, as was commonly held, an attempt to encourage import substitution, but an attempt to contain imports at a steady level. This was the old dilemma of how to balance home production against imported supplies, considering the political and trading importance of the latter.

Towards the end of the 1960's new murmurings were heard concerning reapplication for entry into the Common Market (the first application having been turned down in 1963). Before continuing with discussion on the effects and working of the Common Market with respect to agriculture, and on the current political thinking connected with agriculture in this country, full consideration of changes in the input base and resource use in farming will be covered.

1.14 The Changing Input Situation in Agriculture over this Century

The changes in political thinking, farmers' economic position and the use and organisation of land over the century have been covered in the previous section. Remarks have also been made about improvements in farming technology and the overall level of output and self-sufficiency. The interaction of all these factors and others has resulted in a substantial change on the input base for farming. The next few paragraphs will examine some of the obvious changes.

First, it is helpful to look at the changes in the pattern of expenditure on the National Farm. Table 1.3 shows the percentage composition of expenditure in agriculture for selected years. At present, the major item on the list is feed. This situation has persisted since before the Second World War, except for the period during and immediately after the war when livestock numbers were severely reduced.

TABLE 1.3

Composition Of Farm Expenditure For Selected Years Since 1938

Aston University

Illustration removed for copyright restrictions

[Source: Metcalf D (1970) "The Economics of Agriculture" Penguin page 39, and "Annual Review of Agriculture 1978" HMSO]

The situation with regard to feed is worsening, in 1977, an estimated 35 per cent of the cost of inputs was for feedingstuffs. Feed is costly and often has to be bought in on to farms. Some feedingstuffs are produced and eaten on farms, but a large proportion of home produced feed is traded internally. The self-sufficiency situation is improving in animal feedingstuffs but there is little production of high protein feeds in this country, consequently much of the requirement for this type of feed has to be met from imported supplies. Considerable effort is being put into developing competitive home produced supplies of protein for animal feedingstuffs[7 & 16] The intensification of livestock farming and increased specialisation with respect to the type of farming practised have altered the requirements for animal feedingstuffs. Intensive production of monogastric animals such as pigs and poultry requires compounded feedingstuffs made up of cereal meal mixed with some high protein substance such as soya or fish meal which balance the amino acid content. The needs of the ruminent are simpler but yields in terms of milk output or weight gain can be boosted by supplementing the normal diet of grass or some other fodder with other feedingstuffs, which may be either a readily available energy source like cereal meal or a compound feed containing additional protein. Barley beef was an intensive system of beef production developed in the 1960's, which depended on the feeding of cereals to beef animals and resulted in rapid growth to marketable weight(14). However, such systems, in the current climate of rapidly rising feed prices and a fluctuating market for beef, have become less economically viable(7). Nevertheless even though it may not be wise to use this sort of method for the whole rearing process many beef animals are still finished off on high energy feedingstuffs before marketing.

Labour is the second most important individual item on the list as far as cost goes ("other" accounts for a greater percentage but includes numerous inputs). Labour costs have increased substantially over the years but their relative contribution to expenditure on farms has declined. The rise in wartime was due to the increased number of people working the land at the time. Agriculture currently employs only a small proportion of the country's working population, 2.7 per cent in 1976(9). This is a highly significant reduction from the 1871 figure of 19.1 per cent of the working population engaged in agriculture(3). If numbers are examined the agricultural work force fell from 810,000 in 1932 to 377,000 in 1976(18 & 9). These figures include full and part-time workers as well as casual workers but not the farmer and his wife. The number of farmers has not declined so much. An interesting situation now exists in which full-time working farmers outnumber full-time hired workers(19). The importance of the farmer and his immediate family has become of far greater significance in recent years. Casual worker numbers have not fallen as rapidly as the number of full-time workers. Other types of employment in farming have gained in importance. The number of salaried managers, for instance, rose by 7.6 per cent in the five years between 1971 and 1975(19). There is greater demand for contractor services and relief workers than there was. As labour on some farms is cut to a bare minimum for most of the year, there is a need for extra specialist help in busy periods. The numbers quoted above do indicate a definite move away from agricultural work however, even though there has been an expansion in peripheral labour services. Many factors have contributed to this decline not least high labour costs relative to other items of expenditure, technical progress and the low level of agricultural wages when compared with those in the non-agricultural sector.

Machinery is the third most important contributor to overall farm expenditure in the current breakdown. This has not always been so. In 1938/39 it accounted for only 9.5 per cent compared with the current figure of 16.5 per cent. This indicates the increased importance of mechanisation on the farm which to a large extent has replaced labour. The number of tractors on the National Farm illustrates the magnitude of the change in use, in 1932 there were 10,000 tractors in the United Kingdom compared with 490,000 in 1972(18). Prior to the boom in mechanisation it would be foolish to imagine there was no machinery but most of this, although more time saving than when the operation was done manually, still required a large work force and the power came from horses or, to a lesser extent, steam traction engines. Horses were the main source of power on farms in the early part of the century. In 1932 there were 780,000 working farm horses and by 1972 this number had fallen to 10,000[18]. Mechanisation on farms has not, of course, just been a question of replacing horses with tractors, but also the introduction of machines to do most jobs on the farm. The number of milking machines installed increased from 29,510 in 1942 to 120,140 in 1961[20]. Combine harvester numbers rose from 1,000 in 1942 to 62,038 in 1964[20]. The fundamental change has been in the power capacity on farms, enabling the work to be done quickly and with substantially less physical effort on the part of the work force. The increased costs of buying and fuelling machinery were offset by the decreased need for expenditure on labour.

Next on the expenditure list is fertiliser, currently absorbing 8 per cent of costs. In 1938/39 this percentage was only 3.8 per cent.

Table 1.4 shows the changes in the quantities of chemical fertiliser used in the United Kingdom since the mid 1940's.

TABLE 1.4

Fertiliser Usage In The United Kingdom:
Thousands of Tonnes

Aston University

Illustration removed for copyright restrictions

/Source: Metcalf, D (1969) "The economics of agriculture" Penguin page 56, and Cooke, G.W. (1976) page 15 in "Energy Use and British Agriculture" Reading University Agricultural Club7

The use of chemical fertilisers started on arable land but has since spread to grassland. Fertilisers use follows the law of diminishing returns after a certain level of application, which raises questions about the usefulness of increasing use for only marginal increases in output when wastage, environmental problems and extravagant use of energy can result. Britain is not self-sufficient in chemical fertilisers and the extra use of fertiliser to provide greater output will have to be weighed against the burden on the balance of payments incurred by importing supplies, the possible environmental damage caused by fertiliser run-off, and the drain on energy resources.

Energy use in agriculture is an area of considerable change in this century. The oil crisis of 1973/74 brought to the public eye, the vulnerable situation in which we live with regard to energy. Much of what is now an accepted part of life is highly dependent on fossil fuels, most particularly oil. Agriculture is no exeption. The increase in mechanisation, the use of chemical fertilisers and the many petrochemical inputs, such as pesticides and herbicides, have all increased the industry's dependence on oil. Prior to this change the main source of energy was manual labour and horses, buth of which were fuelled with food which roughly speaking could be envisaged as part of cyclical renewable energy scheme. What was not produced and eaten on the farm was sold to feed others, the energy cycle on the farm was essentially internal. This is a simplification as not all inputs even in the early part of the century were derived from the farm, so energy still had to be brought into the system. For argument's sake though the concept can be taken as true; the "fuelling" of horses was achieved by growing fodder for them on the farm, but the arrival of widespread mechanisation and other fossil fuel based inputs, which could not be fuelled with grass and oats, uncoupled the internal farming energy cycle. The production potential of farms was reduced by keeping horses of course. Leach[21], suggests that something like 30 per cent of the lowland farm area was devoted to providing fodder for the nation's working horses. The result of introducing increasing amounts of energy not derived from the farm was to boost production and increase self-sufficiency by improving the efficiency of farming in terms of labour and land utilisation. The increase in gross energy consumption to achieve these efficiencies, from 1952 to 1972 was of the order of 70 per cent, rising from 241 to 410 mega giga joules (MGJ)[22]. The efficiency of energy use, measured as a ratio of energy input to energy output, in terms of food energy, has decreased in this same period, according to

Leach[23], falling from a calculated 0.46 to 0.35. Energy use seems also to show adherence to the law of diminishing returns. However, if only small decreases in the amount of support energy used in British agriculture were brought about, it has been calculated that the result would be a drastic fall in output[24]. This situation is of critical importance if it is remembered that supplies of oil, the most widely used energy source, are rapidly running out. Much influential attention has been directed at the problems of energy use in agriculture and what sort of future can be expected. Even so, after a brief steadying in consumption after the oil crisis, consumption has again started to rise.

The changes that have occurred in farming have generated criticism from certain sectors and problems within the industry. Radical changes in animal husbandry and specialisation of farming practice have generated problems of waste disposal. Continuous cropping of cereals and other crops has resulted in increased problems with weeds, particularly grass weeds, and diseases, which has meant that controlling chemicals have to be developed and used, in quantity. Some problems of farming, such as the weather, remain very much as they always have done, although the discomfort is probably reduced these days, but mechanisation, the use of agrochemicals, intensive husbandry and increasing public awareness of rural areas, even if only at holiday time, have created problems unknown to farmers at the beginning of the century. British farming has moved from an essentially craft based situation to virtually full mechanisation within this century.

1.15 The Agricultural Situation In The 1970's

The first few years of the 1970's were a time of expansion and generous government aid to agriculture. The weather was also good. In 1973, Britain became a member of the European Economic Community (EEC). This meant adopting the Common Agricultural Policy (CAP), and its regulations. However, a period of transition was envisaged during which time Britain would come into line with European prices and become fully integrated. Britain attained full membership of the EEC in January 1978.

The objectives of the CAP as set out in the Treaty of Rome (1957) are:-

1) Increased agricultural productivity.
2) The assurance of a fair standard of living for farmers.
3) The stabilisation of agricultural markets.
4) The guarantee of regular supplies of food.
5) The maintenance of a reasonable price for food.

The policy was formulated to protect European agriculture from outside price fluctuations and gradually to reorganize the structure of European farming within the protective net of the policy. This was, therfore, a policy of protectionism designed to create a situation in which farmers had assurance of reasonable income, food supplies were forthcoming and agricultural rationalisation could take place. The idea of protectionism manifested in the CAP was part of a trend evident in the agricultural policies of most western European countries, even those not of the Six, in the late 1960's. What differentiated the CAP from other policies was, according to Ojala[26], the fact that it was, "the most integrated and powerful manifestation of the general determination on the part of industrialized countries to preserve more of their agricultural markets for their own farmers, at a high level of cost to consumers and taxpayer". Britain's policy prior to entering the EEC had been to attempt to achieve greater self-sufficiency and a healthy home agriculture but to balance this with low food prices to the consumer. This latter requirement, cheap food, has been a major stumbling block to a happy integration into the Common Market. However, as Marsh[27] points out in a recent report, "the underlying reality is that the cost of food to the UK consumer depends principally on the productivity of the exporting sectors of the UK economy as a whole. If this compares favourably with other economies food will seem reasonably priced in relation to spending power". If this is held to be true, then the problem is not so much a matter of the high price the consumer will have to pay for food under EEC conditions but how soon our standard of living can be raised to a level in which the cost of food seems relatively small, and this maybe dependent on other sectors of the economy, as well as agriculture.

The protection of European agriculture is achieved using two main methods. First the internal community market is protected from outside competition by a system of variable levies on imported produce. Second, there is an internal price support system. This works by setting an upper and lower limit on the market price of a commodity, which is regularly reassessed to encourage orderly marketing. The upper price limit is known as the target price and the lower price is the intervention price. If community produce on the market falls below the intervention price level it is bought up and stored by the individual government. Produce bought into intervention can be reintroduced into the market when appropriate. Cheap imported produce entering the EEC is penalised by the levies imposed, these vary and are the difference between threshold prices set by the EEC and the prevailing world market price. The levy usually raises the price of an imported commodity to a level near the internal target price which makes it less competitive. Not all agricultural produce is governed as yet by EEC market organisation, sheep meat for instance has still to be integrated.

Differences in the economic growth rates of the member states have complicated market operations. Prices still vary considerably between the various countries of the EEC. In order to overcome the problems this might cause, with trade and with respect to the cost of produce to the purchaser, a monetary compensation scheme was introduced. This was an attempt to level out the price of commodities traded between countries in the EEC using a system of levies and subsidies, called monetary compensation amounts (MCA's). If produce passes from a country in which its price is low to a country in which it is higher, because of the price differential created by differences in the currencies of the two countries, a levy is made. In the reverse situation the produce would be subsidised. In order to make the workings of this system easier an artificial exchange rate was introduced, called "green" money, it is related to the "real" value of the EEC currencies but does not suffer so severely from short term fluctuations in value. It is evident from all this that the workings of the CAP are complicated by the great differences exhibited in the strengths of the individual member countries' currencies. The organisation of the market in the way described above has proved very expensive to the Community. The cost to the Community taxpayer in 1977 was reckoned to have been £3,025 million, about seventy-six per cent of the total Community budget for all its policies(28). Other objectives of the EEC have been neglected because of the cost of the CAP. This has generated discussion on ways of reforming the CAP and ways of stabilising European currencies through more rapid progress to economic unity.

Britain is still self-determining about aspects of agricultural policy, despite membership of the EEC, particularly with regard to agricultural structure. The government still, therefore, produces policy documents on agriculture. For instance, in 1975 a white paper "Food From Our Own Resources" was published(8). This was a restatement of the need for increasing Britain's self-reliance in food stuffs. The paper was to an extent prompted by the inflationary situation Britain found itself in at the time, which was aggravated by dramatic rises in the price of oil and consequently most other areas. Food prices were pushed up by this situation and rapidly rising food prices are one factor leading to demands for higher wages, because of the proportion of individual incomes spent on food, this therefore encouraged the inflationary spiral. One factor in limiting inflation is the control of food prices. Cheap food was once obtainable from world markets and in this sort of situation would have been bought in rather than produced at home. However, the white paper concluded that we could no longer expect to buy cheap food from the rest of the world and that we must therefore seek to expand home agricultural output, even though we were now members of the EEC and part of a protected market extremely prone to producing surpluses. A number of areas, sugarbeet, cereals, milk, beef from the dairyherd and sheep, were identified for expansion. Other areas should expand to keep up with demand only. The rate of growth hoped for was 2½ per cent a year until 1980. For one reason or another output has not kept pace with this projected target. Poor weather and the rapidly rising cost of inputs which have resulted in increasing food prices, forcing consumers to economize, have no doubt contributed to the shortfall.

The Economic Development Council (Agriculture) published a series of studies in 1977 which were to act as a back up to the 1975 White Paper[7, 29, 30, 31 & 32]. Their objective was to assess whether any restrictions on expansion existed as a result of foreseeable limitations on resource use and availability in agriculture. The study covered finance, taxation, labour, land use and animal feedingstuffs. It suggests that the efficiency of resource use should continue to improve and in consequence should not limit expansion potential[29], neither should the availability of resources hinder expansion. Nevertheless, expansion could be inhibited by low levels of liquidity in the industry coupled with concern over taxation[30], both of which it was thought might severely reduce the motivation to expand output. Despite the fact that the report is hopeful about improvements in the efficient use of resources, this is surely a fundamental problem when considering expansion in output without enormous increases in costs.

The current situation is therefore that British agriculture is being asked to expand selectively, even within the overall frame-work of the EEC. Government is going to re-emphasise the need for greater self-reliance when it publishes an expected revised version of "Food From Our Own Resources". The range of products produced on British farms, where the restrictions on pursuing a variety of enterprises are not great, probably depend more on the possible financial returns from an enterprise than on any loose political statement. Consequently, the areas in which expansion will occur are still unclear and will depend on the home and European market as well as political controls and support.

1.2 Present Day Farming

Having reviewed the historical changes in Britsh agriculture since the turn of the century, we now turn to present day agriculture and cover aspects of it in greater detail than was possible in Chapter 1. The object of this section is to give a geographical breakdown of farming by examining the distribution of different types of agricultural land and the different farm enterprises in England and Wales. Some aspects of the business side of agriculture are also covered, such as the size of individual farms, how productive they are in output terms and what differences exist between businesses with the same or similar enterprises. The overall output from farms in Britain is also examined to establish the relative importance of each output sector in monetary terms. This will give a much better picture of the structure of farming in this country by detailing the relative importance of various enterprises in economic terms, the distribution of types of farm and land throughout the country and by examining some of the reasons for differences in productivity. The project's proposed alternative may well require substantial changes to be made in the structure of farming, so knowledge of the current system is important as is the realisation that to an extent some relatively fixed factors, such as land, control the shape of the farming structure.

1.21 Agricultural Land - Use and The Pattern Of Farming

The total land area of England and Wales is about 15,028,996 hectares (excluding water)(1), this land has to be used for food production, forestry, living space, industry, roads, recreation, water storage space and potentially for more of all these things. Statistics on the exact breakdown of land use in England and Wales are confused but roughly the situation is as shown in Table 1.5.

TABLE 1.5

Land Use In England And Wales 1976

[Source: Calculated from Agric EDC (1977) "Agriculture into the 1980's: Land-use" NEDC, page 5]

The demands on land from all these areas are high and as the biggest percentage is occupied by agriculture, this land is the most likely to be reduced through the development of other uses. In the previous section it was noted that there are considerable losses of land from agriculture to other uses, a figure of 32,000 hectare average annual loss of agricultural land is given by the Ministry(1). The major shift to forestry is much less although plantings in other parts of the UK, especially Scotland, account for a large part of the loss of agricultural land. The loss to urban development is not spread

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* Urban includes industrial land and roads.

evenly throughout the country but seems to centre on the London area, the West Midlands and North Eastern England as well as to a lesser extent South Wales and the Central Lowlands of Scotland. Older industrial urban areas are the ones which seem to be expanding into agricultural areas at the fastest rate presumably because of demands for greater living space in these areas, as standards of living rise low density housing becomes very desirable(4). The future demands for urban development are forecast as being in the region of 6,000 to 18,000 hectares per annum over the next 25 years(3). If this occurs on agricultural land it would amount to a considerable loss. One answer that has been suggested to ease the problem is the development of derelict land which currently accounts for an estimated 60,000 hectares of Great Britain. The reclamation of some 45,000 hectares of this is considered justifiable(3). Much of the derelict land is found in urban and industrial areas and to a small extent development of some of it is already underway. However, even bearing this in mind, the availability of land for food production in Britain is liable to come under increasing pressure as demand for food grows and if the level of self-sufficiency is to be maintained or increased in line with government policy(2 & 3). These comments on the availability of agricultural land are relevant to the future of the present system of farming if it is to produce the same range of output and meet demands for increased self-sufficiency, they do not take into account the possibilities for change which might exist to relieve the pressure on land.

The type of farming practised in England and Wales varies considerably from area to area as a result of variations in soil type, rainfall, altitude etc. There are a number of ways of identifying the overall pattern of farming in this country. The method used can give a broad picture or one in more detail. If the areas of rough grazing, permanent pasture and arable are taken as a simple guide to agricultural land use and as indicators of likely type of farming practised a reasonable assessment of the pattern of farming can emerge. Rough grazing, is poor quality grazing usually containing a high content of gorse, bracken, mosses and rushes. It is primarily located on poor soils in upland areas and its use for farming purposes is confined to sheep, and to a lesser extent beef farming. About 16 per cent of the agricultural land area is rough grazing. The majority of it is found in Wales, the North and Yorkshire and Lancashire, where 36.6 per cent, 28 per cent and 21 per cent respectively of the agricultural area is rough grazing*. It is extremely likely therefore that these areas have a high dependence on sheep farming and beef production. Rough grazing areas do have some potential for alternative use or for grazing improvement. The possible alternatives are forestry and recreation. Improvement, in some cases, is possible usually this will involve drainage, subsoiling, liming, fertiliser applications etc, to improve the pasture and thereby enable the farmer to increase his stocking densities. In some areas where grazing improvement is a possibility there has been strong opposition to this sort of action, for conservation reasons, this is particularly so in the National Parks(5). There is no doubt that extensive pasture improvement incorporating the removal of gorse, heather and bracken would drastically alter the accepted appearance of the landscape in many of

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* Calculated from MAFF "Agricultural Statistics for England and Wales" HMSO

Britain's upland areas. The problem is a difficult one, to balance the desires of the farmer, farming in a difficult area, to improve the potential of his farm against the desires of conservationists to maintain the countryside as it is today.

Another indicator of the degree to which an area is dependent on livestock is the area of permanent grass. In regions where the amount of permanent grass is substantial, dairying and livestock rearing are likely to be the predominant enterprises. Permanent pasture acreage is of significant importance in Wales where 45.2 per cent of the agricultural area is under permanent grass, the South West with 43.8 per cent, the West Midlands with 45.4 per cent and Yorkshire and Lancashire with 34.3 per cent*. In these areas a high dependence on livestock would be expected, whether dairying or livestock rearing is the most important it is impossible to say at this level of analysis.

The arable area is the final indicator in this simple appraisal of farming pattern. It includes both the area of tillage and the area of temporary grass so both crops and livestock are likely to be present, but the importance of livestock is likely to be secondary to crops. Arable is extremely important in the East, East Midlands and South East where over 50 per cent of the agricultural land of each region is used for arable. Again, as with the examination of permanent grass area, it is impossible to deduce what particular arable enterprises are carried out in these regions.

Using these three groups of land-use in agriculture, a broad picture of the pattern of farming does however emerge.

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* Calculated from MAFF "Agricultural Statistics for England and Wales" HMSO

It is likely that the North and West with their high proportions of rough grazing and permanent pasture will be mainly concerned with livestock production whereas the East and South East of the country with their large proportion of arable land are likely to be concerned with crops rather than livestock. This picture can be verified by examining the distribution of farm animal populations and crops. The reasons for this demarcation are primarily climatic and topographic, as on the whole the North and West are wetter and hillier than the East and consequently not so suitable for crop production.

The pattern of farming can be deduced in greater detail by examining the type of farming practised and noting the predominant enterprises. There are eight agricultural administrative regions in England and Wales. The following table (Table 1.6 gives a regional breakdown of all the holdings providing 275 Standard Man Days (SMD's), or more, of work (generally called significant holdings) according to the major enterprise practised. Nearly all farms will have a number of enterprises contributing to the overall output but for classification purposes the major enterprise identifies what type of farm it is. Mainly dairying for instance includes all farms which derive at least 50 per cent of their output from dairying.

TABLE 1.6

Percentage of all holdings according to main enterprise 1975

Source: Compiled from MAFF (1976) "Farm Classification in England & Wales 1975" HMSO

This table tends to confirm the previous analysis which used the areas of rough grazing, permanent grass and arable as indicators of the likely type of farming. The regions in the West and North do have a high dependence on livestock. Wales has 92.5 per cent of its significant holdings practising some form of livestock husbandry as the major enterprise, the South West has 81.3 per cent, the Northern region 77 per cent and the West Midlands 72 per cent. The Yorkshire and Lancashire region deviates slightly from the expected pattern as crops are of considerable importance here despite the large area of rough grazing and permanent pasture. The fact that the region stretches across the country, from the west coast to the east, partly explains this as large areas of East Yorkshire are very suitable for crop production. There is also a history of horticultural production and poultry keeping in Lancashire[6]. Despite this non-conformity to the expected pattern, exhibited by this region, the rest of the North and West does depend very heavily on livestock. In Wales, as expected, dairying is important, and sheep and beef production even more so. Crops hardly figure at all, as the major enterprise on a holding, accounting only for some 3 per cent of total full-time farms. In the South West dairying is very much the major enterprise while livestock rearing and fattening takes second place. Beef and sheep production, and dairying are of roughly equal importance in the Northern region, 35.2 per cent of holdings are classified under beef and sheep production and 37.1 per cent under dairying. Cropping enterprises are also reasonably important, presumably most of these are found along the Northumberland coast. The West Midlands show a fairly mixed pattern of farming, dairying is of great importance, especially in the north and west of the region. Livestock rearing and fattening, particularly beef and mixed beef and sheep are also important. Crops too are the major enterprise on 20.8 per cent of full-time holdings with a fairly large number of these devoted to horticulture.

The Eastern regions also conform, in general, to the expected pattern. They show far less dependence on livestock than the North and West. In the Eastern region, particularly, cropping forms the major enterprise on a very large proportion of the region's full-time holdings. The most significant livestock enterprises here are pigs and poultry. The East Midlands have a roughly even split between livestock and crops as the type of farm classification, 47.1 per cent of full-time holdings have some form of livestock as the main enterprise, while 46 per cent depend mainly on some form of cropping. In the South East, a very mixed pattern occurs, dairying and livestock rearing of all sorts are important and so are crops. However, whereas the Eastern and East Midlands regions showed a high proportion of holdings involved in cereal growing and general cropping, in the South East these are of less importance than general horticulture which becomes the main type of farm involved in crops.

This more detailed examination of the pattern of farming does in general substantiate the original examination but it also serves to identify regional enterprise mixes. The mixture of enterprises in a region, although primarily dictated by local physical conditions and constraints, will to some extent also be influenced by traditional regional patterns of farming, such as beef production in parts of the West Midlands and sheep on the Romney Marsh in Kent(7).

Another important structural consideration, which may well have a bearing on the alternative proposed in this thesis, is the size of holdings (in hectares) within a region. If farms are predominantly small (or large) in an area this may well influence the type of enterprise practiced. A wide variation in farm size does occur in every region but in one there might well be a larger proportion of a particular size of farm, than in another. Table 1.6 can again help with a crude estimate of whether a region is likely to have a large number of small or large farms. A rough average area can be calculated for each type of farm as classified in Table 1.6. Using this average and the proportion of that type of farm in a region, a very rough estimate of the preponderance of small, medium and large farms is possible. Table 1.7 gives the average area, in hectares, of farms in each type of classification.

TABLE 1.7

Average Size Of Holdings
In Different Type Of Farm Classifications

/Source: Maff (1977) "Farm Classification in England and Wales 1975" HMSO/

The larger farms (at least from the area covered point of view) are therefore likely to be mixed or arable, both general cropping and mostly cereals, and sheep and cattle rearing and fattening farms (especially where these are in the uplands). There are, therefore, likely to be a large number of big farms in the arable areas of the East and in the uplands of Wales and the North. Where dairy farming or horticulture are the main types of farming such as in parts of Wales, the West Country and the South East there are likely to be a lot of small to medium-sized farms. Type of farming maps, classified according to type of farming practiced and the area of holdings, tend to confirm this rough appraisal[8]. The size of farms (in terms of their area) can have an effect on the type of farming practised, amalgamation of farms to form bigger units often increases the potential farming enterprise possibilities and may even encourage a transition from one main enterprise to another. On a small farm there may be less flexibility of choice over enterprises which both suit the conditions on the farm and provide sufficient income for the farmer. It is possible, therefore, that the pattern of farming is maintained not only through the action of physical constraints on practice, and tradition but also through the size structure of farming which may well help to maintain a regional pattern of farming. Other factors will impinge on this as well such as the pattern of ownership within an area[4 & 9].

1.22 Output From British Agriculture

An examination of the output from British agriculture will help to determine the relative importance of the various sectors and how self-sufficient the country is in food. Self-sufficiency has already been discussed, but no mention was made of precisely what agricultural produce Britain is self-sufficient in. The following table gives an indication of the levels of self-sufficiency in home-produced food, commodity by commodity.

TABLE 1.8

Quantity Of Home-produced
As A Percentage Of New Supplies 1975/76

[Source: MAFF (1978) "UK Food and Farming in Figures]

Some comment has already been made about the amount of feedingstuffs that has to be imported to support the livestock in this country, 5,329 thousand tonnes of miscellaneous feedingstuffs at a cost of £381.1 million in 1975/76[10], which has to be offset against the relatively encouraging levels of self-sufficiency in some animal products shown above. The level of self-sufficiency in wheat is low because of large imports of hard wheat, thought to be necessary for making the British loaf. English wheats are largely soft wheats, suitable for biscuit making but not for making well risen white bread with good keeping qualities and the desired crumb. What wheat is produced in Britain therefore goes mainly for cake and biscuit manufacture and animal feed, and only small amounts go for bread making. Oilseed rape is a fairly new crop in Britain and it's introduction may well help to relieve some of Britain's dependence on imported vegetable oils, however, Britain is still only 49 per cent self-sufficient in oilseed rape, so its self-sufficiency in all other vegetable oils must be even lower. Sugar is another commodity in which Britain is not self-sufficient. The Government called for an increase in the acreage of sugar beet in "Food From Our Own Resurces"[11], and no doubt the acreage will increase. Expansion is limited by the availability of refining plant among other things. There is also a body of medical and nutritional opinion which believes that as a nation we eat too much sugar[12, 13 & 14]. If our sugar consumption were to fall to more medically acceptable levels the achievement of self-sufficiency in sugar would be easier. The self-sufficiency levels for apples, pears and tomatoes are also fairly low. Any large increase in the level of self-sufficiency for tomatoes in this country is unlikely as they are highly perishable fruits with a distinct season. A sustained supply of fresh tomatoes therefore relies on imports and any large increase in the home acreage might just glut the market. Apples and pears on the other hand are more easily stored and increasing the level of self-sufficiency in these does not seem to be an unreasonable goal, even though the output of orchards varies around the country and from one season to another. For most other temperate vegetables and fruit that can be grown in this country there are some imports and the self-sufficieniency figure, given for cauliflowers, of 86 per cent probably applies to most of them.

The self-sufficiency situation in animal food products varies as much as for the vegetable produce. For milk, eggs, poultry,meat and pork, Britain is self-sufficient. The skimmed milk powder shows a huge surplus for 1975/76, provisional figures for the following year show a drop to 129 per cent self-sufficiency and a rise in the proportion of supplies of butter and cheese that were home produced. Trade agreements have, to an extent, affected the home production of bacon, ham, lamb, butter and cheese which may be one reason for the relatively low levels of self-sufficiency shown for these commodities. A recent report on the Dairy Industry[15], suggests that much of the short fall in cheese and butter could be made up from home supplies if there was a change in the type of liquid milk marketed i.e. partially skimmed with a lower fat content, and a shift to dairy cows producing milk with a high fat content, such as the Channel Island breeds. Reaction to this report from both the Milk Marketing Board and the National Farmers Union has been less than enthusiastic[16], mostly because of the report's suggestion that marketing milk as a "natural" food would have to be abandoned and because of the possible problems that would arise in the dairy beef sector as a result of using a single purpose breed, as the main breed in the National Dairy herd, rather than the more dual purpose Friesian.

In many food commodity areas there are theoretical ways of achieving greater self-sufficiency, but the situation is complicated by the requirements of the market at any time and the existence of trading arrangements and the Common Market, or just a cheaper source of the commodity than British agriculture.

The gross output from British agriculture amounted to nearly £6,000 million in 1976 (17). The following table gives a condensed picture of the output-input situation for British agriculture.

TABLE 1.9

Output, Input and Net Income of British Agriculture
1976 (£ millions)

[Source: Cmnd 7058 "Annual Review of Agriculture 1978" HMSO]

The most important sector in terms of the output value is fat livestock, second is farm crops, with cereals accounting for roughly half the output from this sector. Milk and milk products are important, considering the number of holdings on which dairying is the main enterprise this could be predicted. Eggs alone are of relatively minor importance but the combination of eggs and poultry meat raises the output value from these two parts of the poultry industry to £686 million, a higher output than from horticulture. The table goes on to show the inputs and the calculated Net farming income. This reached a peak in 1973/74 but has fallen in real terms since then. This fall is a cause for concern if productivity is to rise, as falling farm incomes, for whatever reason, are likely to reduce the level of investment in the industry and slow down the rates of productivity increase(18). Nowadays farming is very much a business dependent on reasonable levels of investment if it is to continue to prosper and adopt new technologies in the attempt to raise the productivity levels of labour, and land. The size of farm businesses is an important consideration in farm structure and in the overall output from the industry. In 1977 50 per cent of all holdings provided full-time work for at least one man and accounted for 90 per cent of the total output(17). The remaining 10 per cent of output was derived from holdings providing insufficient work for one man over the year. In England and Wales there 86,356 holdings of this sort covering nearly 1,158,120 hectares which is about 10 per cent of the total agricultural area of England and Wales(25). If it is assumed that some direct proportionality exists between England and Wales and the whole of the United Kingdom (a rather sweeping assumption) the small holdings providing less than

275 SMD's of work would seem to be as productive if not, in some cases, more so than the full-time holdings. Small holdings may in fact be producing more output to the hectare in certain cases, rather as allotments do(19), because of the effort put into them. Even within full-time holdings there will be a wide range of output potentials because of interacting factors which affect the final outcome. There is, nevertheless, often reckoned to be a small farm problem which stems not so much from poor output levels but from the difficulties involved in making a living from the holding, this may well be true for some full-time holdings also(20 & 21). The whole question of small farms tends to be clouded by issues such as the productivity of capital and labour and the "desirable" income levels for farmers (however people will have different concepts of what is "desirable"). Small farms are therefore considered problems on the basis of their poor efficiency according to labour and capital use criteria and through concern over possible hardships suffered due to very low incomes. On the other hand the presence of small holdings providing part-time employment can have beneficial spin offs(22). Hobby farms may fulfill a useful recreational gap enabling some people to do something they enjoy and providing a substantial amount of output even if it is produced inefficiently in terms of labour and capital, the motives of a hobby farmer are likely to be somewhat different from a full-time farmer. On the agricultural side, part-time farms may offer the only possible way into farming for those who wish to enter the industry on an independent footing. If farm income can be supplemented by income from other employment sufficient capital may eventually be accumulated for the individual to expand the business or progress to a larger

holding. There is obviously a strong social case for alleviating hardship amongst small farmers but possibly not a good social case for squeezing them out of farming altogether.

The performance of full-time holdings, even those producing the same enterprise blend, varies considerably. The significant difference in performance between the top 25 per cent of farms and the average is often pointed out. The better arable producers, for instance, may obtain yields 25 - 30 per cent better than the average and this not necessarily with tonnes of extra inputs(23). The following table shows the recorded differences in performance in terms of output, variable costs and gross margins for certain cropping enterprises and a livestock enterprise in 1974(24).

TABLE 1.10

Comparison of performance between
top 25% of farms and the average farm:
£ per acre

		Output	Variable costs	Gross Margin
Winter wheat:	Top 25%	162	17	145
	Average	132	17	115
Potatoes:	Top 25%	451	98	353
	Average	369	97	272

£ per cow

		Output	Variable costs	Gross Margin
Dairy cows:	Top 25%	318	123	195
	Average	294	133	161

(Data from ICI recorded farms, crop year 1974)

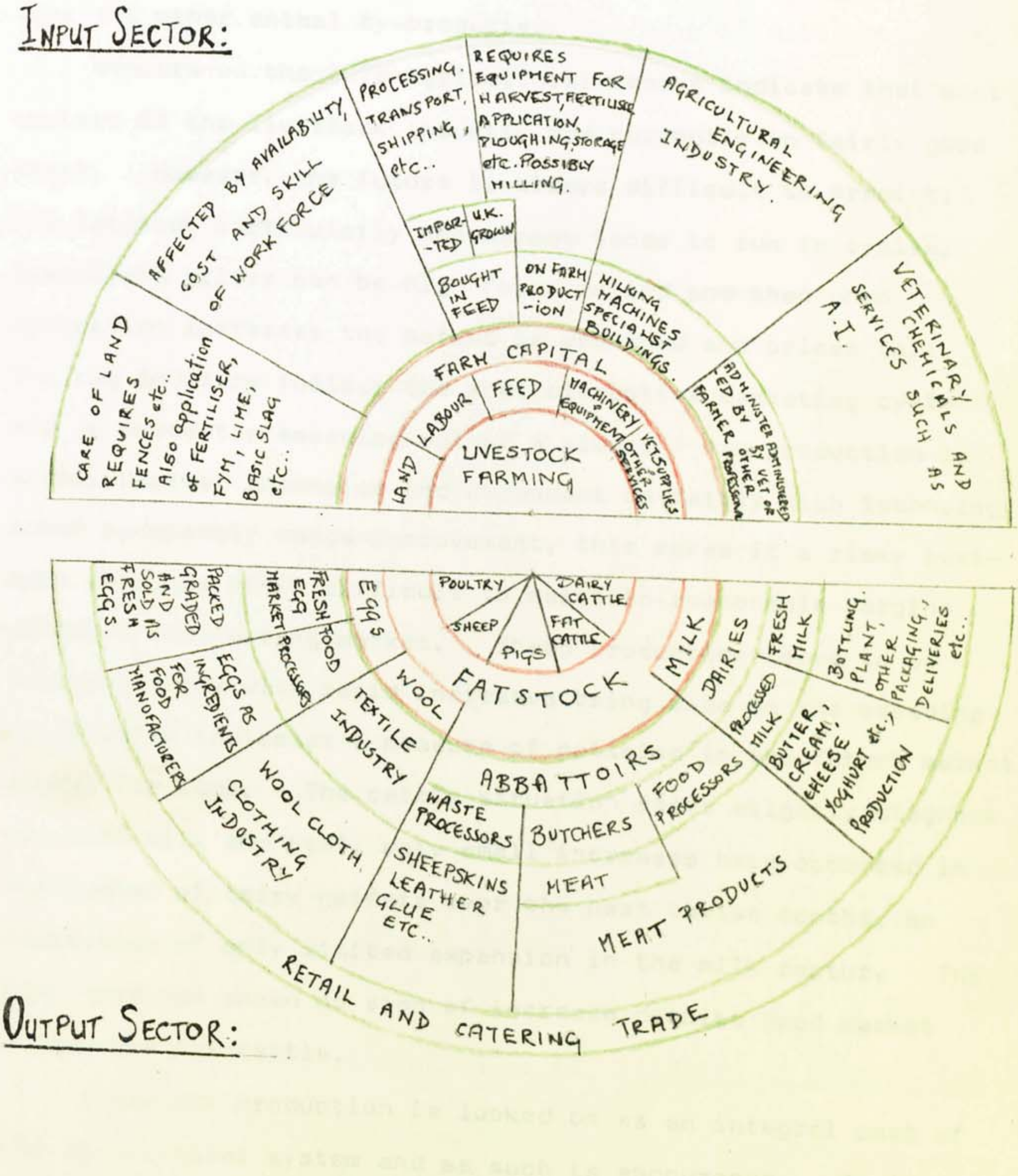
The conclusion reached in the ICI report was that output was of great importance and that careful control of costs so that output was not reduced was preferable to just cutting cost indiscriminately. The better performance in individual enterprises is reflected in better all round financial performance from the top 25 per cent of farms. If, as is suggested in the report, there was no significant difference in the enterprise mix and the fixed assets of comparable best and average farms, the variations in performance must be due to management skill and to an extent on the physical and biological condtions on the farms. Closing this gap between the top 25 per cent of producers and the average is often cited as one way of increasing overall output[18 & 23]. Blaxter[23] says that "... by a massive programme of education and advisory work in farming sector it is probable that yields can be boosted by a further 10 per cent without drawing heavily on physical resources in the industrial and energy sectors of the economy". The point that this increase could come without recourse to extra inputs is very important as is the fact that it is potentially possible to realise this increase without waiting for improved crop varieties and better breeds of animals or new developments in equipment, buildings etc.. This potential improvement should, in the current situation, be exploited as it not only allows farmers to realise a better income but need not put non-renewable resources under undue extra pressure. The "massive" education and advisory programme required to achieve a 10 per cent improvement is, however, unlikely to be cheap in terms of people or money.

1.3 A Review Of The Meat And Livestock Industry

The previous section showed just how important livestock is to British agriculture. A large proportion of the agricultural land in this country is unsuitable for anything but livestock husbandry and in other areas, although livestock and crops are potentially interchangeable, livestock offers a better enterprise base because of the potential income, size of farms, the unpredictability of the weather in the area, the nearness to markets, the limited range of possible crops etc.. In terms of the overall output from British farms, livestock and livestock products are the predominant components, accounting for nearly 64 per cent of Gross Output in money terms[15]. This situation continues despite a heavy reliance on imported food and feed.

The objective of this project is to determine the effects on British farming and the population's diet of a move away from livestock farming to a system devoted entirely to crops for human food. A fairly detailed study of the meat and livestock sector of agriculture and food production is essential in any attempt to estimate the impact of its removal. It is important to study not just the numbers and distribution of farm animals in this country but also the amount of meat produced and consumed. Examination of the support industries and the processing sector for meat and livestock production is also important as these would have to readjust or disappear in a meatless situation. Even allowing for a gradual transition there may be substantial problems generated by the removal of livestock farming, as many people and much money are involved at the farming, support industry and processing levels. Figure 1.1 gives a diagramatic representation of livestock farming input and output factors and the support and processing sectors likely to be affected in the event of a drastic shift away from livestock farming. The red area covers the main on-farm situation for both inputs and outputs, while the green area expands into possible areas of impact related to individual inputs or outputs.

Fig. 1.1: Livestock Farming Input and Output Factors.



This section will deal mainly with the red area rather than the green area, although selected items from this are inlcuded. The main concern is over meat production and consumption and so these will receive more attention than eggs, milk, wool and other animal by-products.

Reports on the 1978 agricultural census indicate that most sectors of the livestock industry are currently in fairly good heart. However, the future is always difficult to predict. For fatstock particularly the market tends to run in cycles, demand and prices can be high for a period and then when production increases the market is weakened and prices fall. The pig industry follows the most disruptive marketing cycle and is currently emerging out of a slump. Pig production is highly capital intensive and dependent on fairly high technology which constantly needs improvement, this makes it a risky business as it is often difficult to maintain reasonable margins within a fluctuating market. Sheep production seems to be fairly healthy with rapid increases being made in the breeding flock which indicates a measure of optimism in the future market market for lamb. The cattle situation seems slightly stagnant for both milk and beef, only small increases have occurred in the number of dairy heifers over the past twelve months, an indication of only limited expansion in the milk sector. The beef herd has shown no sign of increase despite good market prices for fat cattle.

Livestock production is looked on as an integral part of the agricultural system and as such is encouraged. As far as the future is concerned the problems connected with increasing input costs, particularly of feedingstuffs, and the fact that a large proportion of protein feed still has to be imported, are seen as surmountable, in some circles, without having to reduce the current size of the livestock sector[2]. Improved stock, new husbandry techniques, better farm structure, new types of feed, more home produced feed and better feed utilization and conversion efficiencies are all seen as ways of maintaining the livestock industry at its current level or even of expanding it. The livestock industry in Britain is encouraged because of its import saving role in a meat consuming society, and because livestock within the current system maybe the only enterprise possibility for some farmers it they wish to make an acceptable living in farming.

On the other hand there are a number of criticisms directed at the system, most particularly at its heavy dependence on livestock and the burden which this places upon the balance of payments through the use of large quantities of expensive imported feed and the inefficient way animals utilise the available agricultural resources[3 & 4]. This is of course one of the reasons for conducting this investigation into an alternative system without livestock. However, it it highly probable that the removal of meat and animal products from the diet would place many farmers in the situation where they could produce virtually nothing at all for human food, this need not in theory, at least, be an insoluble problem.

1.31 The Numbers And Distribution Of Livestock In England and Wales

The main concern in this whole chapter is meat production. However, first it is important to give an estimate of the total number of farm animals in England and Wales. Table 1.10 gives the approximate numbers for both England and Wales and the United Kingdom in 1973.

TABLE 1.11

Livestock on agricultural holdings 1973
(approximate figures)

Aston University

Illustration removed for copyright restrictions

/Source: agricultural statistics England and Wales 1973 and agricultural statistics UK 1973. HMSO/

These numbers are not static but vary from year to year depending on the state of the market and the level of support afforded for a particular livestock product. In "Food From Our Own Resources" the government advocated a steady increase in agricultural output at a rate of 2½ per cent a year between 1975 and 1980(5). Within the livestock sector expansion was indicated for dairying, beef from the dairy herd and sheep meat. Proposals for pig and poultry production suggest that these should merely keep pace with growing demand for poultry and pig products rather than increase the proportion of supplies derived from home production. Since 1975 when the white paper was published, the increases in livestock numbers have not been very great, the number of dairy cows has risen, pig and poultry numbers rose only to fall again and sheep and beef cow numbers have declined. In terms of increased production in livestock products, measured as the change in percentage self-sufficiency of these products rather than precise increases in volume of output, home produced beef and veal, and bacon and ham contributed less to total supplies in 1977 than in 1975 but sheep meat and dairy produce, produced in the United Kingdom, have made an increased contribution to supplies(14)*. The proposals seem not to have been matched by performance although in some areas significant increases have been achieved.

The distribution of livestock has already received some attention during the discussion on the pattern of farming. Increasing specialisation in all types of farming has tended to reveal a demarcation between livestock and arable areas(6). In some situations, livestock enterprises, such as dairying, lowland beef and lowland sheep, compete directly with arable farming for land. Pigs and poultry, on the other hand, are invariably raised under intensive or semi-intensive systems and do not as a result occupy large areas of land. Their location, therefore, is not dictated by type of agricultural land and can therefore be more flexible. Pig farms are found throughout the country but in terms of the density of the pig population, the most important pig areas are in East and West Yorkshire, Lancashire, Cornwall and in counties just to the west of London. In terms of the percentage of pigs out of all livestock in a region, they are important in the eastern half of the country. Few pigs are found in upland areas. A certain concentration of pig enterprises has occurred around large urban areas, in horticultural areas where there is considerable vegetable waste and to a lesser extent, in dairying areas; this must be partly due either to the nearness of markets, or the availability of cheap pig food.

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* The figures for self-sufficiency in 1975/76 are given in Table 1.8

Poultry production is also intensive and again the type of agricultural land has little bearing on its location. The important consideration for poultry production seem to be proximity to large markets and feedingstuff supplies. In terms of the density of the poultry population in an area, Lancashire is the main poultry county. However, poultry is an important livestock enterprise in East Anglia and West Yorkshire also. Broiler production is mainly concentrated in the South East half of the country. Poultry, like pigs, are of limited importance in upland areas.

The likely location of dairy farming was discussed in the previous chapter; of particular importance are Lancashire, Cheshire and the South West peninsula. Beef cows are somewhat different, the population distribution of these shows a concentration on the Welsh borders, the uplands of the South West, Lincolnshire and Northumberland. Beef production as an important livestock enterprise occurs in the North East and East down to the Wash as well as the East Midlands and, to a lesser extent, West Midlands.

Sheep farming is of most importance in the uplands but it is also of significant importance on the Romney Marsh in Kent. Lowland sheep production is of less importance than it was in the past but is still of some importance in parts of the Midlands.

1.32 The Production Of Meat

The production of meat includes not only the slaughtering numbers but also the import and export of meat and live animals, and the quantities of meat and meat products moving into consumption.

In 1975 the number of animals slaughtered in the

United Kingdom was:-

TABLE 1.12

Number of Animals Slaughtered: 1975

Aston University

Illustration removed for copyright restrictions

/Source: MLC Economic Information Service"Market Survey - Cattle, Sheep, Pigs" Autumn 1976.

Poultry figure from MAFF "Output and Utilization of Farm Produce in the UK 1969/70 to 1975/76" HMSO/

The number of animals slaughtered can vary considerably from one year to the next. The slaughter rate for cattle, for instance, in 1975 was high because large numbers of stock were sold for slaughter owing to the diffuculties involved in maintaining animals through a winter in which feed was costly and scarce. The number of fat animals going to slaughter will also usually increase if market prices are high. Slaughter rates are usually highest for cattle in the autumn and winter months, for fat lambs in the late summer and autumn but for pigs and poultry slaughterings usually stay steady throughout the year. The farm gate value of fatstock and poultry going for slaughter in 1975 was £1,883 million[15].

The production of meat from home-killed sources increased steadily in recent years up until 1974. In 1975 total production of all home-killed meat came to 3,069,500 tonnes[17], which was less than in 1974. However, production in 1975 accounted for a larger proportion of supplies moving into consumption than it had in previous years, this indicates a decline in demand for meat. The production of home-killed sources is listed below in Table 1.13.

TABLE 1.13

Home-Killed Meat Production 1975

Aston University

Illustration removed for copyright restrictions

⁄Source: MLC (1976) "Market Survey, Cattle, Sheep and Pigs" MAFF "Output and Utilization of Farm Produce in the UK 1969/70 to 1975/76"⁄

Production of meat tends to increase over the autumn and winter period, in line with the seasonal variations in slaughter rate for sheep and cattle.

The self-suffficiency levels for meat vary. Britain was traditionally an importer of meat particularly, beef, sheepmeat, and bacon. The importance of the British market for overseas suppliers of these meats was great. When Britain joined the EEC there was an immediate shift in the source of British food imports, most temperate type foods now being obtained from within the community. Beef and pork are now imported mostly from countries within the EEC, rather than from other countries which were formerly main suppliers, to make up the deficit in home production. In 1975, 61 per cent of imported meat supplies came from the EEC compared with 43 per cent on average between 1967 and 1969[16]. New Zealand has been able to maintain much of its share of the British sheepmeat market mainly because the EEC as a whole is only 65 per cent self-sufficient in sheepmeat[7]. Not only meat is imported but also live animals, most of these come from Eire as store cattle for "finishing" and slaughter. The following table gives a full breakdown of the quantity and value of imports of meat and livestock for 1975.

TABLE 1.14

Imports Of Livestock And Meat Into United Kingdom 1975

/Source: Overseas Trade Statistics of United Kingdom 1975 HMSO/

Quite substantial amounts of prepared meat as well as fresh meat are imported, for instance bacon, the main supplier of which is Denmark.

Britain also exports meat and livestock. Trade in this direction has increased since joining the EEC. The total value of exports of meat and livestock in 1975 was £254 million[14]. The main components of this trade are live animals and sheepmeat. The sheepmeat market in Europe is seen as a potentially remunerative market for British sheepmeat producers.

The volume and value of meat moving into home supplies and being imported into and exported from this country makes it an extremely important sector not only from the agricultural standpoint, but also for those involved in meat production and food manufacturing. In this country a large proportion of the meat moving into consumption is destined for the manufacturing market to be processed into such things as sausages and beefburgers. Out of the total beef available for consumption in the United Kingdom in 1969, 23 per cent went for manufacturing purposes and most of this was imported beef[8]. Large quantities of pork are also processed into bacon, ham and sausages. An estimated 300,000 tonnes of sausages and other manufactured pork products (other than bacon or ham) are produced every year in the United Kingdom[20]. There are well over a 1,000 industrial establishments concerned primarily with bacon curing and meat and fish product manufacture[9]. This sector of the food industry employs some 113,000 people in establishments that range in size from one or two employees to over 1,000 employees. Big food manufacturing companies may have substantial meat interests too, for instance those involved with frozen foods such as Unilever or Ross[10]. The largest company in which meat and meat products are the main interest is FMC, with a yearly turnover in the region of £239 million (1975 figure)[10].

At the start of the manufacturing and distribution chain for meat there are slaughterhouses of which Britain has 1,600(11). The number of these has been declining over recent years as hygiene regulations become more stringent and the older, small houses find it too costly to meet the required standards. Nevertheless, a substantial amount of plant and a not insignificant workforce are employed in slaughterhouses. At the retail end of the chain there are some 38,627 outlets for meat and meat products, in butchers' shops, supermarkets, co-operatives and mobile shops(9). The number of persons employed in these outlets came to 184,653 in 1971. In the same year there were 33,939 specialist butchers' shops. The alternatives available for these specialist shops, in the event of a radical change in food habits away from meat, is far less than for say, a supermarket.

From all this it is clear that a great deal of capital and manpower is tied up in the production of meat from the farm to the butchers' shop. For some sectors of the industry and some people involved in it the change would not necessarily be catastrophic as some enterprises are sufficiently diversified to adjust to change over a period without too much trouble. On the other hand there are those for whom the change might well be disastrous. The impact of change, and the necessary measures which would have to be taken to alleviate the problems of change for the meat and livestock industry, depend on the nature of the change envisaged; whether it is immediate and complete conversion to vegetarianism by the population or a gradual shift in dietary habits away from meat which might take years. It should also be remembered that the discussion on the manufacturing and retail industry for meat which is covered above does not cover other aspects of livestock output. The removal of livestock farming would also have important effects on the dairy industry, egg producers, food manufacturers using eggs or milk products as ingredients and the textile industry. Again a substantial amount of financial resources and labour are tied up in these areas as they are with the meat industry, all of which has to be balanced against any potential benefits derivable from the removal of meat from the diet.

1.33 The Supply And Consumption Of Meat

Supplies are taken to be the amount of meat that is available for consumption. Table 1.14 gives the supply situation in 1970 and 1975.

TABLE 1.15

Estimated Meat Supplies Per Head Of Population

[Source: MLC "Meat and Livestock Statistics 1973" and MLC 1977 "Tenth Annual Report" - Table 5 page 40]

The supplies of beef and offal fluctuated over this period, for sheepmeat there was a decline until 1974 then a very slight rise, the supplies of pork, imported canned meats and poultry peaked in 1972 and then began to decline again, for bacon and ham there has been a steady decline in supplies. The supply figure do to a large extent reflect the consumption and demand trends for meat. It is certainly true that owing to the economic problems encountered during this period and the rising price of meat, consumption had declined a little.

The consumption figures for meat for 1970 and 1975 are given in Table 1.15. As expected from the supply figures total consumption of fresh meat and meat products has declined over the period. The figure for beef is higher in 1975 than in 1970, this is probably a result of the high slaughter rate for the year which meant that prices were relatively low in 1975 compared with 1972 and 1973. From the figures it is impossible to say whether there is any real decline in meat consumption although for certain meats such as bacon and sheepmeat, decline in consumption seems to be apparent. The relative price changes for bacon and sheepmeat over the period were higher than for most other meats. The decline in bacon consumption is possibly a result of changes in breakfast eating habits. The decline in sheepmeat consumption is thought to be a result of a change in consumers' taste and its steadily rising price[12]. However, changes in consumption of certain types of meat or meat preparation maybe compensated for by increased consumption of other types of proteinaceous food. Poultry meat consumption, for instance, has risen stadily and so has cheese consumption (from 3.53 oz/head/week to 3.79 oz/head/week)[12]. Fresh carcase meat consumption accounts for a larger percentage of total meat consumption in 1975 than it did in 1970 (41 per cent compared with 40.3 per cent) although the amount of fresh carcase meat was greater in 1970 than in 1975(12).

TABLE 1.16

Meat Consumption In 1970 And 1975

(oz/person/week)

[Source: MAFF "Household Food Consumption And Expenditure: 1975" HMSO]

Consumption of any food is affected by the price of that food and the willingness of the consumer to pay that price. The meat portion of the household food budget has always been a major part of the expense. In real terms over the 1970-1975 period the price of carcase meat did not vary greatly although prices rose sharply in 1972 and 1973 they then fell back again to an intermediate level between the high of 1972/73 and the 1970 prices. In 1975 the average weekly expenditure on food per person came to an estimated £3.77, of this nearly £1.18 was spent on meat and meat products, 31 per cent of the total bill compared with about 30 per cent in 1970(12). The following table lists the weekly expenditure per person on individual meat items in 1975.

TABLE 1.17

Expenditure Per Person On Meat And Meat Products: 1975

(pence/person/week)

Aston University

Illustration removed for copyright restrictions

/Source: MAFF "Household Food Consumption and Expenditure 1975" HMSO/

Beef is the most popular fresh carcase meat and consumption has been maintained over the five years from 1970-1975, although during this period there were fluctuations both in the amount purchased and in the price paid(12). In terms of total volume pigmeat is the most important type of meat although it is mostly eaten not as pork but as sausages, bacon, pies etc.; 40 per cent of total meat consumption is reckoned to be pigmeat(13).

Demand for a food is very much affected by its price, the price of other possible alternative foods and the amount of income available for food purchases as well as peoples preferences for particular foods. Meat is sensitive to price. In 1975 the National Food Survey gave the direct price elasticities for carcase meat and poultry as follows:-

TABLE 1.18

Direct Price Elasticities for Meat:

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/Source: MAFF "Household Food Consumption And Expenditure: 1975" HMSO/

Direct price elasticity calculations tend to give different values every year but on the whole the demand for meat tends to be fairly elastic as the values fluctuate around -1(12). Interestingly in 1975 beef and sheepmeat were less sensitive to price changes than pork or poultry meat. All of the meats mentioned above have negative price elasticities of demand and consequently if there is a general upward movement in prices this is likely to cause a reduction in meat consumption.

The consumption of a type of meat is also sensitive to the price of alternative types of meat or other protein foods. This relationship between different types of meat is estimated by calculating the cross-price elasticities of demand. The most likely alternative for beef, for instance, if there is a price increase is pork, while an increase in the price of lamb is likely to result in greater poultry consumption[12]. Increases in the price of all carcase meat is likely to affect a small increase in the purchases of cheese and bread[12]. These observations based on the calculated cross-price elasticities are presumably a reflection of consumers budgeting adjustments and an indication of taste in so far as consumers will give some preference to one alternative over another in the event of the original choice being too expensive at that time.

The purchase of meat is also affected by changes in income. A real increase in income is likely to result in an increase in the expenditure on meat. Increases in income of the average British consumer result in only marginal increases in the expenditure on most types of meat and meat products except canned meat, canned meat products and beef sausages for which expenditure decreases[12]. There is remarkably little variation in the quantity of meat consumed per person per week between income groups in Britain. Households consisting of adults only are likely to consume more meat per person than those with children but the variations in consumption between households of similar composition but different incomes varies very little. For example, households in income Group A, consisting of adults only, have an average meat consumption of 46.64 oz/person/week. A similar household in Group C have an average meat consumption of 48.25 oz/person/week[12]. The effects of income change are less dramatic in more affluent societies where the diet is already varied and relatively plentiful, most rises in income are more likely to be absorbed into areas of expenditure other than food. As a result of increased income the extra spending power which is allotted to food purchases, is likely to be used for buying food of better quality as well as greater amounts of certain commodities such as coffee and fruit, and less is spent on items such as sugar and margarine(12).

1.34 Conclusion

Livestock farming and the production of meat and other animal products are extremely important from a farming and manufacturing point of view. An extremely complex infrastructure of industries and professions exists to provide support inputs for livestock farming, either as goods or services and to market, process and distribute the output from livestock farming. The elimination of meat from the diet is likely therefore to have a profound effect on many peoples' livelihoods and is going to render much equipment and machinery redundant, particularly if the period over which change occurs is relatively short, say 10 years or less. If transition were to occur at this sort of rate massive compensation and investment in alternative industries and retraining schemes would be essential. At a very rough guess the total number of people involved in all aspects of the meat and livestock industry is currently about 500,000. A fair proportion of these will be skilled labour or have substantial investment tied up in livestock or other aspects of meat production and consumption. If transition were to be a lengthy process, taking place over half century or so the adjustment would be easier, if those who were in a position to change either their jobs or particular enterprise were encouraged to do so.

There would be those for whom change was not so easy, but who, within a gradual change, could continue in whatever meat or livestock related business they were in until retirement or death. Steps would need to be taken, nevertheless, to ensure that the industry continued to shrink and that those who had to remain in it did not suffer economic hardship. Farms, for instance, which could only be economically viable as livestock enterprises, might have to be bought up on the retirement or death of the occupier, to prevent the continuation of livestock farming. Numerous institutions and specialist training courses would have to be phased out, or changed. Precisely how fast change would occur would depend on whether there were specific motives for it or whether it was just a gradual evolution. If the change were a planned one, based on a long or short term scenario there is no doubt that considerable costs would have to be incurred by government to cushion the effects of the shift, and to ensure that the country was fully prepared for a future based on plant-foods. For instance, substantial investment would be required for research into medical and technological aspects of a vegan future.

Apart from indication where the pitfalls to change lie, a review of the meat and livestock industry does show why change might be necessary from an economic point of view. If the flow of money through the whole industry and its subsidiaries is ignored and only the import and export situation is examined, it can be seen that Britain pays a high price for meat eating. Although there is a healthy but small export trade in livestock and meat, this is overshadowed by enormous quantities of imports of meat, livestock and feedingstuffs to support the home livestock population. Other inputs for meat and livestock production are also imported, not to mention animal by-products. However, ignoring these and examining only the balance between exports and imports is sufficient cause for some alarm and the suggestion that change might be necessary. The trade deficit in meat and live tock, ignoring inputs to production, amounts to £556 million. For feedingstuffs the deficit amounts to very roughly £322 million[17 & 19]. (This assumes, for exports of unmilled cereals, that barley exported is for malting and the remainder is feedingstuffs priced at the average price for wheat in 1975/76, £65 per tonne[18]). Summing these two figures does not give a realistic overall deficit for meat production because feedingstuffs are not exclusively fed to "meat" animals, and the livestock trade includes breeding stock, horses etc.., as well as meat animals. It is however clear that meat production, at its current level in this country, is maintained at very considerable cost, in import terms. It could be argued that a rationalisation of livestock farming, so that British farming only supported an animal population which it was capable of supporting from home-produced feed, and a reduction in meat consumption to a level which excluded the need for imported supplies, would be more sensible than eliminating livestock altogether as this would solve the trade deficit in this area but provide fewer problems in terms of adjustment to an altered system. Nevertheless, the purpose of this project is to examine the impact of the complete removal of meat from the diet and the justification for such an investigation does not rest entirely on the economic considerations of a trading deficit for meat and feedingstuffs.

1.4 The Present Dietary Pattern In England And Wales

1.41 Introduction

A shift from animal-based to plant-based food production is bound to result in a considerable change in the diet of most people in England and Wales. The project seeks to examine the potential for and limitations of this shift not simply from an agricultural, but also from a dietary and nutritional point of view. It is therefore useful to examine the dietary pattern which currently exists, the nutritional worth of this diet and the likely evolution of food habits.

Any discussion on the dietary pattern of a country is likely to be broad-based as it is impossible to take into account the odd variations in the eating habits of some individuals. However, broad dietary characteristics do exist and these are the result of a variety of interacting factors, including the traditional pattern of food consumption, new trends in cooking, eating and lifestyle, the range of foods available in the shops, personal taste and income,as well as the cost of food. There are still regional differences in eating habits which presumably arise as a result of regional variations in the above mentioned factors and others which mould dietary patterns. Essentially, though , most people in England and Wales are omnivorous, eating foods of both animal and plant origin. Some individuals do follow vegetarian types of diet and a few may even be virtually carnivorous, but this discussion is confined to the omnivorous diet of the "average" individual in the population.

Nowadays most people, but possibly not all, can afford to buy sufficient food to meet their nutritional needs. Some people may not satisfy their nutritional needs because of lack of knowledge of what they do in fact need, or because of poor diet resulting from the individual's lifestyle or other reasons not necessarily connected with insufficient income for purchasing a balanced combination of foods. There are risk groups such as old age pensioners and immigrants who may suffer from deficiencies in certain nutrients[1]. The main problem that seems to exist in England and Wales from the dietary point of view, is in any case, according to current medical opinion, rarely the problem of too little food but rather the problem of too much[2]. Certain, so called, "diseases of affluence", such as ischaemic heart disease, cancer and obesity, have been linked with the diet of western type cultures. One justification for examining a plant-based food system is that the resulting diet may in fact reduce the incidence of these diseases. [Discussion, in full, of the criticism of the present diet can be found in Chapter 5 and discussion of diets containing no animal products follows in Part 2].

This chapter will therefore review aspects of the current diet taking into account how far it goes to meeting recommended nutrient intakes, what proportions of nutrients are derived from plant or animal sources and examining ideas as to how dietary pattern is changing and what could be done to alter it in a beneficial manner.

1.42 Influences on dietary pattern in England and Wales

It is important to have some idea of the factors which affect the pattern of diet in a country, especially if the routes to a possible change are to be investigated. Food habits can be changed but it is presumably easier to affect change by taking into account the factors which dictate what people eat rather than by ignoring them. A change to total vegetarianism is such a complete change that full adoption would probably take a long time and would require intelligent decisions to be made to encourage the shift. In any event the practical aspects concerned with agriculture, the food industry, economics, the environment and the public health would have to be the main determinants of whether the concept of a shift to total vegetarianism is a realistic alternative to the current system. Only on the basis of information about the likely impacts in these areas can decisions be made on whether it might be desirable to encourage a shift towards the proposed alternative.

Each individual will have his or her own food habits but, despite these individual variations, national dietary patterns are evident. Within countries there are also likely to be marked regional patterns which differ from the national pattern; this is certainly true for England and Wales[3]. The variations may manifest themselves in regional preferences for different foods, variations in local cuisine and in the timing and nature of meals. The reasons for these differences are many and various. Although food habits are in a constant state of gradual change, national dietary patterns have tended to persist or have evolved in a characteristic way. Certain influences such as country-wide food processing and distribution companies and much more international contact and travel might be thought to be creating greater uniformity in diet within countries and across boundaries, but this does not seem to be entirely so. In fact the food industry has often had to adapt to regional variations in taste and must certainly take them into account when launching a new product[4]. Foreign foods, although now much more a part of the British diet than formerly, are often modified to be more acceptable to the British palate and are certainly selectively chosen.

People's tastes vary considerabl but also conform to some measure of national or regional preference. Precisely what determines tastes in food is poorly understood but it would seem to be a mixture of basic physiological palatability, what feels, smells and tastes good; traditional food preferences often based on almost forgotten taboos and prejudices; the experience of the individual within his or her family, amongst his or her peers and in terms of lifestyle, willingness to experiment with food and exposure to new food experiences(5, 6, 7 & 8). What we eat is more concerned with the cultural aspects of our life and the subjective experience of palatability than with nutrients. Any attempts to encourage the consumption of food for health must first attempt to promote the concept within the prevailing cultural situations, although the question of palatability and the individual's reaction to the novel gastronomic experience will eventually decide whether the attempt fails or succeeds.

Food choice is different from food preferences as it takes into account what people in fact purchase in the food line(5). Food preferences may not in fact be totally satisfied because of restrictions on availability or income etc. Food choice, therefore, tends to be a compromise between what an individual would most like to eat and what he or she can actually obtain and afford. Dietary patterns are therefore influenced by availability and income level(7).

The supplies of food available for purchase in England and Wales cover a wide range of foodstuffs. However, the situation is always changing. Oysters were once plentiful and cheap and therefore suitable fare for the less well off. Nowadays they are an expensive luxury and their role in the diet of most people has changed(9). On the other hand, chicken was in former times an expensive meat, reserved for special occasions; now as a result of modern farming practice it is one of the cheapest meats available and has become a far more important dietary item(10). International trade ensures a supply of "exotic" foods which might not otherwise have been part of most people's diets, such as tea, coffee and bananas. The existence of British colonies overseas and other large areas of previously unexploited land enabled Britain to obtain cheap imported supplies of meat, dairy produce and cereals from the last century and into the early part of the present. This situation eventually had a profound effect on diets, particularly when real incomes began to rise amongst the low income working classes in society. The effect of rising real incomes and more varied, plentiful and cheap supplies of food did not, however, have an immediate impact on the nutritional standards of the diet of some groups of people whose diet was monotonous and had a fairly low nutritional content(11). Whether this phenomenon was more widespread amongst low income groups towards the end of the last century is not known because only sketchy data is available. However, it does suggest that, when people are lifted off the subsistence level and start to have more spending power, a possible lag period occurs in dietary improvement. Whether this is because of an innately conservative approach to food or a shift in priorities for expenditure it would be difficult to say.

Availability of food has also been affected very considerably by the growth of the food industry. New techniques of preservation on an industrial scale has ensured year-round supplies of formerly seasonal products at a relatively stable price[31]. Processing of food has also led to additional and new dietary items, so the food industry influences dietary pattern and content. Margarine is an obvious example of a totally new food introduced into the diet by the food industry. Some sort of highly organised food processing and distribution system is essential in a heavily urbanised country like Britain, to ensure supplies of palatable and interesting food[31]. Apart from the food industry's role as a supplier of food, it also attempts to directly effect what people eat through advertising. Consumer advertising costs to the food industry in 1973 came to £88 million[32]. Most of the effort is directed at maintaining established markets by promoting familiar brand names, an essential process apparently in a highly competitive market, such as food. However, new products and sometimes even new foods are launched by the industry and advertising has an important role to play in encouraging people to at least try the new product. The success of advertising in changing people's eating habits is questioned by people inside and outside the food industry[12]. Certainly it creates an awareness of new products but the belief is that eating habits are more likely to be changed by social and economic considerations rather than advertising. Nevertheless, new products do get integrated into the diet. The role of some food products, particularly convenience and snack foods, seems to be growing in importance [13, 14], and from a nutritional and culinary point of view, this may not be a good thing. Both types of products save the meal preparer time, an advantage to those who wish to reduce the time spent in the kitchen. At least one writer suggests that convenience foods tend to stultify cooking skills[15]. However, to an extent the reverse might be true as the elimination of part of the drudgery of cooking meals may encourage the pursuit of cookery as a leisure activity. McKenzie[16], writing on the potential for change in food habits in this country noted various themes which seemed apparent in consumer attitudes towards food and meals, one of which was a growing distinction between formal and casual meals. The formal meal would require the exercising of cooking skills to produce a meal that was an occasion, while the casual meal would require minimum preparation and may in fact depend to some extent on convenience or ready prepared foods. Snack food use, from a nutritional point of view, may be detrimental if they are frequently, or always, eaten instead of proper meals as some are low in valuable nutrients, being mainly between meal, energy, stop gaps. Their popularity and apparently growing use may mean that their nutritional worth should be improved if only to protect vulnerable groups like children.

Income is the other major determinant of food choice. In this country the average consumer uses only 17 per cent of his or her disposable income for purchasing food[33]. This indicates a fairly high standard of living and the fairly low priority placed on food purchases. This has not always been the case, when people were in a real sense poor expenditure on food had high priority. In the mid 19th century, most people had to spend between 60 and 80 per cent of their income on food[33]. As real incomes rise the amount of money spent on food also rises but at a slower rate, so that the proportion of income spent on food declines over time. This relationship was first noted, in the 19th century and is called Engel's law, after the investigator who first noted it[33]. As the standard of living rises people wish to allot more of their income to items not fundamental to life. In fact some of these luxuries may become pre-requisites to maintaining or improving a certain standard of living. In terms of the household budget, food, therefore, declines in importance but consumer sensitivity to food price rises increases. It is now generally accepted that food price rises can be major contributors to inflation[17]. As incomes rise and the standard of living improves, consumers may also change their food habits, buying more of certain things, less of others and buying for quality. Starchy staple foods become less appealing and more is spent on proteinaceous foods such as eggs, cheese, milk, meat and "luxury" items[18], which certainly add interest to the diet. Baines[19] noted that when, at a point in time and over a period of time, the food goals of both more and less favoured groups in British society were compared, ..."the British consumer's collective inclination is towards a diet which is relatively high in fat but low in carbohydrates, and in which protein and fat both come from animal rather than vegetable sources". This then seems to be the diet to which people aspire.

In most groups of foodstuffs, say meat, there is a range of possible choices. The price of one sort of meat can affect the demand for another sort of meat or for itself. Consumers will also substitute another sort of food if the price of the original choice is more than he or she is prepared to pay, for instance, if the price of carcase meat rises by one per cent the demand for carcase meat falls by 0.9 per cent[20]. The elasticities of demand for a product and between products tend to illustrate again the roughly fixed amount of money consumers are prepared to spend on food.

The social influences on dietary pattern have largely been skipped over because of their complexity and the fact that they often stem from traditional habits and preferences. However, as society evolves new pressures on food habits continue to emerge. The quote from Baines above indicates a collective inclination to aspire to a particular sort of diet. The general trend in food habits tends to be that the poorer members of society aspire to the diet of the more wealthy and that food and eating habits move from town to country[18]. Dietary pattern can also be affected by changes not only in the foodstuffs that people eat but also in the timing and type of meals. In some areas of the country the old format of meals is still adopted but as McKenzie[16] noted there is a trend towards casual and formal meals, and a greater number of people now eat in the evenings rather than at midday. Breakfast, formerly an important cooked meal in this country, is now more likely to consist of cereal and toast. In 1956, 47 per cent of adults ate a cooked breakfast, nowadays less than 20 per cent do[16]. Changes in the physical nature of work, the role of women[7] and in the amount of leisure time[20] are all having effects on dietary habits and are likely to continue to do so.

1.43 The Current Dietary Situation

1.431 Range of foods eaten and observable trends in consumption

As was mentioned previously, the diet of the "average" person in England and Wales is omnivorous, which means that it is selected from a range of foods of both animal and vegetable origin. The raw foodstuff groups from which foods are selected for consumption include cereals (most especially wheat), meat, dairy produce, sugar, vegetables and fruit. The possible selections from each of these groups is constantly changing as new foods become more acceptable or available and as new processed products come onto the market. The diversity of possible items for inclusion in the diet is extremely large at the present time.

The raw food groups and the types of food within them are similar for the whole of northern and western Europe, because of similarities in the crop and livestock possibilities throughout the area. Marked differences in diet nevertheless occur as a result of variations in food preferences and the diversity of local cuisine, as well as to some extent local potential for growing, and predilection for other foods not common to the whole region[3 & 21].

Traditional cooking in England and Wales is based on stewing, boiling or roasting. Preservation techniques were traditionally confirned to smoking, pickling or salting. Baking was originally virtually confined to specialist shops and only became a widespread household occupation when practical and cheap household ovens were available[9 & 11]. Nowadays a whole host of culinary possibilities exist for preparing meals which must add much to the resulting diet, especially in terms of potential variety.

The relationship between rising incomes and changes in food consumption has already been mentioned in the previous section. During this century as real incomes rose there have been substantial changes in the importance of various foodstuffs in the average diet. Table 1.19 shows the trends in food supplies per head of the population for certain years from 1909 - 1913. Supplies can be taken as roughly mirroring consumption.

TABLE 1.19

Trends in UK Food Supplies 1909-1913 (lbs/head/year)

From Wardle, C.(1977)[7]

Total dairy product consumption, as indicated by total milk as solids, has increased, liquid milk and cheese seem to have accounted for a large proportion of this rise. The changes in meat consumption have not been to dramatic, in fact the figure for 1973 is less than that for the period 1909 - 1913 if poultry and game are not included. Poultry meat supplies and consumption have risen dramatically since the 1960's. Fish supplies have declined and consumption is not nearly so important as it was in the early part of the century. More eggs are available and consumption of these has increased over the period. Butter consumption has remained relatively steady on average but the supplies and therefore the consumption of other visible fats and margarine has risen considerably. Sugar consumption has also risen. Potato supplies increased dramatically during the war years but seem to be declining slightly. Fruit and vegetables have become more important but wheat flour and other cereals have become less so. The table therefore illustrates the idea, expressed in the previous section, that as people become better off they tend to move away from consuming starchy staple foods and prefer to eat a richer diet with more fat, dairy products, sugar, eggs, fruit and vegetables.

The table, although it gives an idea of long-term trends between broad food groups, does not indicate trends within groups. In recent years other trends in consumption are becoming apparent. The total consumption of bread and fish is declining but demand for wholewheat and wholemeal bread is showing an upward trend. A downward drift (rather than a definite trend) has been noted in total sugar usage since 1961[19]. For butter and margarine, the demand trend is away from butter, and towards margarine in the long-term although marked year by year fluctuations are observable in the consumption of these two products because of changes in the price of each, relative to one another. The main reason for a shift in consumption seems to be the development of soft margarine with its spreadibility properties and improved taste reather than the fat and heart disease issue[19 & 23]. In the meat group there is an apparent decline in consumption of sheepmeat and bacon. The decline in sheepmeat consumption is thought to be due to a genuine change in consumer tastes[23], while that of bacon is probably the result of the decline in the British cooked breakfast. In the vegetable group demand is growing for processed vegetables, especially frozen vegetables. The 1975 Annual Report of the National Food Survey Committee[22] goes so far as to suggest that processed vegetables may in fact to an extent be replacing fresh vegetables even when they are in season and probably cheaper than the processed alternative. Liquid milk consumption is following a slight downward trend but consumption of other dairy products especially cheese and yoghurt seems to be growing. There has in recent years, been a decline in egg consumption which seems to be related to the decline in cooked breakfasts rather like that of bacon consumption.

Table 1.20 gives a breakdown of regional consumption of foods, as well as the average consumption for all households, per person per week for a six year period from 1970 - 1975. The table does indicate that variations in taste exist between regions for one reason or another. Butter consumption in Wales, for instance, is markedly higher than it is in any other region. Sugar consumption is much higher in the west Midlands and processed vegetable consumption is higher in the North. The

TABLE 1.20

Household food consumption, for the main food groups, according to regions. Six-year average consumption figures 1970 - 1975

Food Groups	All Households	REGION: Wales	North	Yorkshire and Humberside	North West	East Midlands	West Midlands	South West	South East and East Anglia
Liquid milk (pints)	4.45	4.30	3.89	4.16	4.43	4.66	4.57	4.70	4.66
Cheese	3.65	3.41	2.84	3.14	3.46	4.0	4.06	3.98	3.99
Beef and Veal	7.41	7.10	7.65	7.79	7.58	6.31	6.63	7.30	7.18
Sheepmeat	4.71	5.08	3.66	3.82	5.69	3.89	5.35	4.38	5.60
Pork	2.97	3.14	2.59	3.26	2.09	3.02	3.89	3.52	3.48
other meat and meat products	22.34	24.22	25.23	22.85	22.96	21.59	22.73	21.57	21.68
TOTAL MEAT	37.43	39.53	39.12	37.73	38.31	34.79	38.59	36.76	37.94
FISH	4.82	4.48	5.81	6.16	4.65	4.62	4.46	4.13	4.73
EGGS (number)	4.32	4.22	4.94	4.45	4.17	4.24	4.07	4.34	4.33
Butter	5.44	7.15	5.26	5.03	5.22	5.19	5.51	5.94	5.73
Margarine	2.95	2.37	3.59	3.76	3.79	3.26	3.19	2.54	2.32
TOTAL FATS	11.28	12.85	11.89	12.34	11.76	11.96	11.68	11.39	10.93
Sugar	14.21	15.66	13.81	15.02	14.80	15.62	16.13	14.08	13.46
TOTAL: Sugar & Preserves	16.74	17.85	16.64	17.93	17.42	18.08	18.30	16.32	15.93
Potatoes (fresh)	46.94	50.05	53.11	49.27	51.21	47.93	49.62	47.90	41.24
Fresh green vegetables	12.69	13.47	9.97	12.61	9.39	14.99	14.18	15.60	15.40
Other frsh vegetables	13.87	14.45	14.22	14.14	14.10	12.72	13.35	13.85	14.95
Processed vegetables	13.73	14.71	16.31	15.46	13.57	14.75	13.94	13.04	13.39
TOTAL Vegetables	86.76	92.68	93.61	91.48	88.27	90.39	91.09	90.39	84.97
Fresh fruit	18.22	17.67	14.97	16.20	16.58	17.58	17.58	18.87	21.73
TOTAL Vegetables	24.71	23.98	20.57	22.01	22.51	23.63	23.90	26.06	29.37
Bread	34.62	38.05	37.12	34.11	36.66	35.65	38.41	32.27	30.50
Total cereals	58.88	61.41	65.36	61.63	60.36	60.61	61.21	58.32	54.01
Tea	2.29	2.41	2.46	2.41	2.38	2.35	2.37	2.29	2.22
Coffee	0.61	0.45	0.56	0.61	0.63	0.63	0.63	0.70	0.69
Salt	0.92	1.03	0.8	0.76	0.78	0.93	0.94	1.18	1.00

Source: MAFF (1977) "Household food consumption and expenditure Report of the National Food Survey Committee 1975" HMSO differences over a period of a week only amount to an ounce or two but this difference becomes quite large when viewed over the whole year. Average consumption figures, like these, which cover whole households also tend to obscure the likely existence of greater differences in consumption, along particular regional trends, for an individual within the household; as children, for instance, are counted as equal to their parents. Tables showing the percentage variation in regional food consumption, above and below the national average for various foods can be found in the appendices. These show that in Wales an individual's butter consumption can on average be 31 per cent above the national average consumption per person, and that other significant proportional differences are also evident between regions for many types of food. The percentages do not, however, give any idea of the magnitude of the differences in terms of actual quantities of food. Table 1.20 is a condensed table and therefore does not show regional taste bias for items within some food groups, such as "other" meats and meat products, vegetables or bread. Brown, whole-wheat and wholemeal bread, for instance, is a proportionally more important type of bread in the north of the country (North, North West, Yorkshire and Humberside) and in the South East and East Anglia than it is elsewhere. More uncooked bacon and ham is consumed in the West Midlands, the North, Wales and the North West. Pork sausages seem most popular in the West Midlands, East Midlands, the South East and East Anglia. Other differences in regional taste can also be identified.

Table 1.20 also gives a clearer idea than table 1.19 of the quantities of food eaten, on average, during a week. The bulk of the diet is made up of cereals, meat and vegetables (particularly potatoes), although the quantity contribution of visible fats, sugar and preserves, fruit and milk is also high. The relative importance of the different sorts of fresh meat also emerges, beef being more important than either sheepmeat, pork or poultry meat (although the figure for poultry meat isn't shown). The addition of bacon, ham, pork sausages etc., to the figure for fresh pork meat probably makes it more important than beef in terms of total meat consumption. Butter consumption still has a large margin over margarine consumption on average and tea is still a far more important beverage than coffee.

1.432 The Nutritional Value Of The Diet And Important Changes That Have Occurred During The Century

The previous section showed that the "average" diet in England and Wales is drawn from a wide variety of foods, but gave no indication of the nutritional worth of this diet. Table 1.21 gives a breakdown of the nutritional content of the average diet, but unfortunately, does not include the value of food taken outside the home, or of sweets, soft drinks and alcohol. The figures are therefore likely to be an under estimation of the total nutritional content of the daily diet.

TABLE 1.21

Nutritional Value Of Household Food: Average For 1975

		(consumption per person per day)
Energy	(k cal)	2,290
Total protein	(g)	71.9
Animal protein	(g)	45.8
Fat	(g)	107
Carbohydrate (as monosaccharide)	(g)	275
Calcium	(mg)	1,010
Iron	(mg)	11.6
Thiamin	(mg)	1.15
Riboflavin	(mg)	1.77
Nicotinic acid equivalent	(mg)	28.9
Vitamin C	(mg)	51
Vitamin A (total retinol equivalent)	(mg)	1,370
Vitamin D	(mg)	2.63

Adopted from Table 29. Annual Report of the National Food Survey Committee 1975 HMSO 1977.

The Estimations for 1975 are based on revised calculations as to the butrient content of foods and are, therefore, not directly comparable with years prior to 1974. However, examination of earlier data does expose certain trends. A comparison of the 1975 figures with data from 1950's[34] shows that there has been a decline in the energy content of food eaten within the home (2474 K cal being the estimated dietary energy content for 1950). Protein content did not vary very much but the proportion of the diet's protein which was derived from animal sources rose from 38g[34] to nearly 46g, a rise of 14 per cent from 49 to 63 per cent. The amount of fat in the diet has increased from 101g[34] to 107g which is less than might have been expected and deserves further comment.

It has already been noted that as incomes rise, consumers tend to adopt a richer diet with more fat, protein and luxury items and less of the starchy carbohydrate staples. Table 1.19 clearly showed an increase in the supplies of visible fats over the period covered from 1969 to 1973, so it would seem that there was a decline in fat from other sources. In the same period there was a decline in wheat supplies and a fairly steady situation with regard to meat supplies especially if poultry and fish are included in the reckoning. The decline in the consumption of carbohydrate staples will have caused a slight decline in fat consumption from that source. Meat consumption is often accused of being the main cause of a high fat content in the diet, however, over the century the fat content of meat may well have been heavily reduced. Trenchard[24] maintains that many theories connecting fat consumption with the increased incidence of heart disease are based on the false premise that total fat consumption has increased dramatically over the century. He bases his argument, that this is not so, on observations and data which suggests that the fat cover on carcases is decreasing; that there has been a proportional increase in the consumption of lean poultry meat within a fairly steady level of total meat consumption; that there has been a marked decrease in the consumption of rendered meat fats, especially dripping; and that there is increasing and intentional wastage of meat fat in the home. The reduction in total meat fat may, therefore, over the century be quite large and virtually balance out the increase in fat consumption from dairy products, an area in which consumption has increased. These arguments may in part explain the fairly small increase recorded for fat consumption over the period 1950 to 1975. However, although the amount of fat consumed may not have altered as much as is often suggested the form of that fat certainly has. There has been a real increase in the consumption of visible fats of both animal and vegetable origin. There has been a real decrease in cereal product consumption with an accompanying decrease in fats from this source. There may well have been a real reduction in meat fat consumption and there has certainly been an increase in the consumption of fat from dairy sources and a decline in fish consumption indicating a decline in fat from this source. The profile of fat consumption now is, therefore, markedly different from that discernible at the beginning of the century. Theories connecting heart disease with dramatic increases in fat consumption may be on shaky ground but any based on changes in the source of fats, eaten may prove to have a more concrete foundation. The arguments that meat is becoming leaner is sometimes countered by comparing the dimestic meat animal with wild meat animals[25]. Rapidly reared domestic livestock tend to lay down more intramuscular fat than their wild counterparts. It is difficult to say whether this is a fair comparison, or a relevant one, since it is a long time since anyone in this country derived most of their meat from wild sources. Nevertheless, animal husbandry practice has changed over the century. Most meat animals are selected for rapid growth rates under farming conditions and are slaughtered younger than was common practice in earlier times, which may or may not have an effect on the type of fat likely to be present. When animals matured slower there was, though, an important requirement for good fat cover on the eventual carcase and therefore most animals were finished on high energy diets which may well have encouraged the laying down of intramuscular fat even then[24]. All in all, therefore, this aspect of fat in the diet is confounded by a plethora of unknowns. On the other hand, certain discernible trends are apparent when fat is examined in the context of total dietary energy.

Before examining this, however, it may be helpful to establish how far the "average" diet goes towards meeting an individual's nutritional needs and what proportion of the protein and energy intake is derived from plant and animal sources. Table 1.22 shows to what extent the diet meets recommended intakes for energy and some of the main nutrients. The figures in this table are weighted to include values for meals taken outside the home, unlike those in table 1.21. The average diet would seem to meet the nutritional needs of the individual adequately. Recommended intakes tend to include a fairly wide safety margin above estimates of minimum requirements for health so on the face of it there is little cause for concern over problems of nutritional insufficiency. However, the fact that

TABLE 1.22

Nutritional Value Of The Average Diet In 1975 As A Percentage Of Recommended Intakes

Source:
Table 29, Annual Report of National Food Survey Committee 1975. HMSO (1977).

deficiency problems still emerge, even in England and Wales, gives no grounds for complacency and highlights the fact that a multitude of problems can remain hidden in an average. On the whole though it is probably time to say that the diet of most people usually meets or exceeds their nutitional needs. A cryptic comment from Payne(26) concerning national estimates of recommended nutrient intakes is worth repeating, even though he suggests that it is not an entirely fair description of the attitudes and activities of public health nutritionists. Recommended intake levels have to be based on the observed intakes of healthy people within the community. Perhaps though it is an indication that an element of complacency is evident in nutritional thinking at a political level which is worry at a time when there is increasing evidence that diet can be a major factor in the aetiology of diseases common in this country. He says, "Visually, the recommended intakes turn out to be remarkably close to the actual composition of the national avérage diet as assessed from food balance sheets, or from averages of household intake surveys. This concurrence is often regarded by ministries as reassuring evidence of the overall correctness of national policies related to food supplies, education, control of the food industry, income distribution etc.." Despite these remarks the whole issue of recommended intakes is constantly under review as new nutritional knowledge emerges, new health problems manifest themselves and society itself changes[27 & 28]. Perhaps the most pressing problem in England and Wales, as with most western nations, is how to discourage overeating and the ingestion of energy to levels which exceed requirements. The 1975 figure for the percentage of energy requirements met by the average diet is interesting in that it falls below 100 per cent, but at a time when many people lead comparitively inactive lives and live and work in warm premises, this is probably not a cause for concern. The figure in any case dies not include such high energy dietary additions as alcohol and sweets. Table 1.22 gives the situation for an "average" diet from a selected sample of households, within the sample certain individual groupings for 1975 indicates that all groups receive adequate diets on the basis of recommended intake levels, although the values for individual nutrients varies. Energy intake is, on the whole, higher for the lower income groups than it is for high income groups (gross weekly income £82 and over). The energy value of an individual's siet if part of a large Household is likely to be smaller than that of someone from a smaller household (2 or 3 persons). Protein consumption is also higher in the low income groups but the contribution made by animal protein to total dietary protein is lower than for those in the high income groups. The size of households also affects protein consumption, individuals living in small households are likely to consume more than those in large households. The average contribution of animal protein to total dietary protein intake was estimated to be 63.7 per cent in 1975. Animal fats contribute at least 75 per cent calculated from National Food Survey of total fat intake. In terms of the total energy content of diet, however, plant products are slightly more important than animal products, accounting for very nearly 60 per cent of food energy[29].

One of the main effects of rising affluence has been a marked change in the energy sources contributing to total dietary energy. The change is perhaps most dramatic for the top income group A1[10]. Figure 1.2 gives the changing situation from 1954 to 1975 for this group. Fat, for this group, is now the most important energy source in the diet, although for most other groups carbohydrate is still more important but only by a small margin of a few per cent. In all groups over the same period the same trend is apparent, with fat increasing its share of dietary energy intake. Protein has remained a fairly steady contributor to dietary energy throughout. The food energy supplied by carbohydrate has been falling over this century but within this overall decline there has been an increase in the proportion of the energy, derived from carbohydrate, attributable to sugar. The current contribution made by sugar to total dietary energy is about 15.2 per cent[29]. Many of these changes relating to the contributions made by various food types to overall dietary energy have given rise to theories relating diet to disease. Further discussions on the adverse health aspects of modern day western diets will appear in Chapter 5.

Fig. 1.2

Percentage Of Energy Derived From Carbohydrate, Fat And Protein. Income Group A1 1954-1975

[Table from Hollingsworth. D (1974) "Changing Patterns Of Food Consumption In Britain". BNF Bulletin No. 12 p. 31[10], plus the additional 1975 figures from Table 33. Annual Report Of The National Food Survey Committee (1977) HMSO]

1.433 Household Expenditure On Food And New Trends In Eating Habits

This section will briefly cover household expenditure on food to determine what, in money terms, are the most expensive items in the diet and whether an individual receives value for money in terms of nutrients. It will also examine new trends in eating habits which may be important for introducing new food ideas to people, such as an increase in the number of meals taken outside the home.

An individual's level of income was identified as a factor determining food choice in the first section of this chapter. It was also noted that in England and Wales only some 17 per cnet of an individual's personal disposable income was spent on food purchases. Over recent years there has been a levelling off in the proportion of income people are prepared to spend on food. Growth in demand for food grew rapidly in the 1950's and 1960's. The sixties were particularly characterized by a rapid growth in the demand for convenience type foods, most especially for frozen foods(19). This growth corresponds with a rise in the home ownership of refrigerators, 33 per cent of households owned one in 1962 by 1975 this had risen to 88 per cent(22). In the 1970's though there has been little growth in demand for food and no part of the rise that has occurred in purchasing power since 1970 has been used for increasing household food purchases(19). However, there have been alterations in the pattern of food purchases even within this steady level of expenditure. The trends observable in actual consumption levels confirm this. Rapidly rising food prices are perhaps the main reasons for shifting patterns over this period. Consumers, not wishing to devote more of their income to food, have tended instead to opt for cheaper foods and have made efforts to avoid waste in the home[19].

In 1975, the average weekly expenditure on food per person amounted to £3.77[23]. The largest item on this bill was meat, which absorbed 31.3 per cent of the weekly household food budget, a higher proportion than in 1970[23]. Demand for meat is supposed to be sensitive to price rises and the price rises for most types of meat were high over the period 1970 to 1975 when compared with some other food items, but this does not seem to have deterred people from buying it and devoting a greater proportion of the weekly food bill to it. The proportion of weekly food expenditure devoted to a food item when compared over a number of years does have to include consideration of the changes in the price over that time, especially the relative change when compared with other food items and also changes in taste. Other items which have absorbed a larger share of the average food bill, when comparing 1970 with 1975, are cheese, sugar, vegetables, and fruit (the price of all these had risen by quite a large percentage over the six years). Those which absorbed less included milk, eggs, fats and beverages (these had less dramatic price increases). Rather than examine the price changes and consumption changes more fully, it is sufficient to say that consumers seem to adjust their purchases within the limit of their budgets, but will also to some extent increase the proportion of total food expenditure devoted to a particular food item if they think it is justifiable.

Expenditure on food varies between households in different regions, with different weekly incomes and according to the number of persons making up the household. The differences in total household food expenditure between regions and income groups are on the whole quite small, but the size of the household can make a big difference to the average weekly expenditure on food per person. In large households consisting of two adults and two or more children, or three or more adults and children, significantly less is spent on food for each individual than in small households. This is not very surprising as it will be more expensive in total to feed a large number of people than a small number if the diets are roughly similar and most people aim to minimise their outlay on food.

In 1975 the food providing the best value for money in terms of nutrients bought per penny was probably bread. Bread provides significant amounts of energy, protein, calcium, iron (although this is questioned by some), thiamin and nicotinic acid for a penny.

Other cheap energy sources include the fats and sugar. The cheapest sources of protein, in terms of the amount of protein to be bought for a penny, were bread, milk, cheese and eggs. Other nutrients are more variable but milk for instance is about the cheapest source of calcium. Meat and meat products are the most expensive items in terms of the proportion of total household food expenditure they absorb, but they do supply 16 per cent of total dietary energy, nearly 30 per cent of the dietary protein, 27 per cent of dietary fat and 23 per cent of dietary iron so in simplistic terms their contribution of nutrients to the diet is also high.

A number of other trends, which are coming to the fore at the present time and which may have an effect both on food expenditure and the pattern of eating, are worthy of mention.

These include eating out, deep freeze ownership, growing demand for snack foods and confectionary and growing interest in "health" foods. The number of meals taken outside the home is increasing, this includes both midday meals taken at school or work as well as eating out for leisure. In 1975 the average person had just over three meals a week outside the home, nearly two of these were midday meals, so on average one meal a week was for leisure purposes or was a take away meal giving a break from home preperation. Certain groups of people, such as old age pensioners, were less likely than the average person to have meals outside the home. Eating out as a leisure pursuit has encouraged the consumption of foreign food whether from a take-away (where chinese food is the most likely alternative to traditional fish and chips[30]), or from a restaurant. The number of foreign restaurants has proliferated in recent years, especially outside London, which indicates growing demand for eating out and more unusual foods.

Deep freeze ownership is another growth area. The National Food Survey for 1975 reports home freezer ownership in 26 per cent of households in the survey, by 1977 this figure had risen to an estimated 35 per cent[30]. Freezer ownership tends to encourage bulk buying and also greater consumption of frozen foods than in non-freezer owning households. Consumption will, therefore, to some extent vary to include more of what can be bought in bulk for freezing and what can be bought frozen. The items most likely to be affected in this way are carcase meats and vegetables. Freezers are a useful addition for households with gardens or allotments and growth in ownership may mirror to some extent growing interest in gardening, particularly were this done to produce food to reduce the household food bill.

The growing demand for snack foods and confectionary ("fun" foods) has already been noted with reference to trends towards casual and formal meals. Ice cream for consumption at meal times, for example, has increased in the years between 1970 and 1975 by over half an ounce per person per week. Between 1972 and 1977 United Kingdom production of ice cream increased by 88 million litres[30]. Ice cream at meal times may well have replaced more traditonal desserts. The effects of growing demand and consumption of "fun" foods does not seem to be known but they are often high energy foods with few other nutrients so the level to which they replace balanced meals or are additions to meals or eaten between meals may give rise to concern. The National Food Survey gives no information as to the quantity of extra energy that may be consumed by people between meals and outside the home. As a growth area they are nevertheless important and can be useful for introducing novel food ideas.

McKenzie[16] noted not only the trends towards "fun" foods and casual and formal meals but also growing interest in nutrition, medicine and foods for health. The number of "health" food stores in the country has grown in recent years, and there is significant interest in returning to more traditional forms of some foods, most especially beer and bread. The rising consumption of wholemeal and wholewheat breads is one indication of some movement away from the "processed" foods, to what people believe to more natural and healthy. In some cases the consumption of alternative diets consisting of more "healthy" foods may only be a passing fad but if concrete or seemingly concrete nutritional merits are suggested for certain foods the movement may not just be a passing phase, provided people continue to be concerned about health and personal appearance. The fact that so many people are over-weight in this country (one estimate suggests that 50 per cent of the United Kingdom population is over-weight[35]) may indicate that concern over health and personal appearance is not that widespread but even within the over-weight group there must be those who are attempting to lose weight. From the point of view of the project the growth in interest in food and the increasing number of shops selling foods that differ from the traditional foods, or are whole foods etc., is important in that invariably these alternatives tends to be plant-based. Any movement which encourages the consumption of plant-based foods or just makes people aware that alternatives exist, would seem to make the possibilities for encouraging people to accept a diet, which did not include animal based foods somewhat more feasible.

1.5 Criticisms Of British Agriculture And Diet

1.51 Introduction

It is important when considering the criticisms currently being levelled at agriculture to identify what role agriculture is expected to play in society. One of the primary goals of man has always been to secure an adequate supply of food. This objective does not necessarily involve agriculture, but there is little doubt that the advent of agriculture gave mankind greater control of its food supply. It also created the need for greater social organisation. This was because agriculture, by its very nature, required people to be organized in fixed (or nearly fixed) communities in order that farming operations could be carried out and food supplies be forthcoming. The existence of social organisation eventually generated additional roles for agriculture, some of which are still considered important. These included, according to Jansen(2), "the role of maintaining a labour reserve; of conserving the societal fabric or "good" traditions; of being a biological antidote to the "unhealthy" process of urbanisation; or even of conserving the purity of race or the fighting power of the nation state".

During the latter part of the industrial revolution in Britain, agriculture's main role was seen as the provider of a labour reserve. Consequently, the possibly more fundamental role of producing food was given less weight. The securing of food supplies could of course be achieved without relying on home agriculture. The release of labour from rural areas was seen as a major factor in economic growth. The prevailing economic situation at the time did, however, lead to a dilemma in attitudes towards agriculture. Houston(3) explains it as follows, "Agriculture, in an obvious and practical sense, is uniquely fundamental to human existence, yet its relative decline has been an essential feature of economic progress. To neglect it would bring disaster, to protect it from (relative) contraction would ensure stagnation". The economic development of Britain from the mid-eighteenth century onwards tended to encourage economic growth outside of agriculture, and to rely on trading interdependence between nations to provide food in exchange for manufactured goods. This situation was slightly altered by the Second World War because of the realisation that for security reasons Britain could not afford undue dependence on imported supplies. There was also a desire to encourage home agriculture in an attempt to raise the standards of living of farmers and agricultural workers to that of the non-agricultural sector. Agriculture's role as food supplier was once more recognised as important. Despite this the principles of international dependence were not abandoned, trade, with food as the major import, was still considered an important factor in economic progress. As long as imported food supplies were available to Britain at a cheaper price than home produced food this was seen as being beneficial to the nation's welfare.

Nowadays, agriculture's role in the fabric of society has been greatly reduced because of the decline in the rural and farming communities as a result of economic progress. It is now looked on as a sector of primary production rather than as a sector occupying a more fundamental place in the nature of society. Farming has also become far more industrialized. The conditions of the mixed market economy within which it exists have encouraged the acceptance of productivity of labour and

and capital as major criteria of efficiency.
Agriculture's role could be said to be that of an "efficient" food producer. This has encouraged moves to enlarge the scale of agricultural production and to restructure traditional farming patterns. Although on the whole the proportion of small farms, below 20 hectares in size, is relatively small in Britain, these small, more traditional farms still exist. Conventional economic thinking still advocates moves to rationalise the structure of farming to increase productivity in terms of land, labour and capital. However, since the World Food Crisis of the early 1970's and the oil crisis of 1973/74, there has been an increasing body of concern building up to question these premises and the role of agriculture in today's society. Other factors have impinged on this reaction. Agricultural policies in recent years have cost a great deal of public money, "society" asks that this money be well spent and farmers accept it as a "right" due to them if their economic well being is to be on a par with society in general and if they are to function as a productive section of society. Government intervention in agriculture can therefore be, according to Jansen(2), "a highly explosive political issue involving the manipulation of food prices charged to increasingly numerous urban consumers and the provision of financial support for the contracting and often inefficient farming sector". This situation tends to create a strain between the farming and urban communities. Added to this are roles increasingly imposed on agriculture by a largely urbanized society which according to Jansen(2) "having achieved a high material welfare through the 'benefits of economic growth' have become conscious of their relative deprivation in 'well being' and lay claims on their 'rural

environment' for more space, beauty, silence, recreation etc". This awareness and concern for the rural environment has also added to the conflict between farming and society. Modern farming with its drive for greater efficiency has, no doubt, resulted in detrimental effects on the countryside in terms of pollution and alteration of the traditional landscape. The major responsibility for these alterations can be attributed to society in general because of its "adoption" of the "economic technological growth model," to quote Jansen(2) yet again. Future development of agriculture for the common good, he goes on to say, is dependent on the resolution of the conflicting roles presented for agriculture by society and between society and the farmer. His remarks are based on consideration of the situation in the whole of Western Europe but can be applied to Britain.

The essential dilemma at the present time, of how much food to produce and in what way, and how to provide desirable social and environmental conditions, has generated many criticisms of the current situation and alternative possibilities. The main criticisms of British agriculture fall into five groups: economic, environmental, nutritional, social and moral. Most specific criticisms tend to embrace more than one area, although some concentrate on individual areas. The main types of criticism are broadly along the following lines:-

- Britain is over reliant on imported supplies of food and feed.
- Modern British agriculture is profligate in its use of resources.
- Modern agricultural practices damage the environment.
- Agriculture is using techniques that are morally reprehensible.

- Agriculture in its industrialised form has divorced mankind from its "ecosystem".
- The modern British diet is giving rise to serious health problems.

All these points illustrate a great deal of concern over the way we farm the land and to what purpose.

1.52 Britain's Over-Reliance On Imported Food And Feedingstuffs

The first area, which is concerned with over-reliance on imported food and feed, revolves around considerations of our responsibilities to the poor of the world, Britain's economic position in the world and the desirability of self-sufficiency. The early 1970's scare over world food supplies has now died down as stocks are beginning to build up again and no one seems to anticipate great shortages in the near future. The fact still remains, though, that despite ample food to go round, many people in the world are under fed. In 1974, nearly 29 per cent of the World's population were reckoned to be seriously underfed or on the brink of malnutrition[4 & 5]. It seems unlikely that this figure has improved as it is now generally recognised that the problem stems not so much from the lack of capacity of the world to produce food but the more intractable problems of weather, population, distribution of resources and food, and poverty[6]. Many of these problems are internal to those countries suffering from a high level of poverty and accompanying malnutrition but it is also evident that considerable interference from rich nations, industrial firms and international agencies has in some cases exacerbated the situation[7 & 8]. As well as direct interference, rich nations by their very lifestyle help to maintain this imbalance between the rich and the poor. Developed countries, which account for a quarter of the World's population, eat annually half the World's food and feed grain production of 1,250 million tonnes(7 & 9). Out of this 625 million tonnes goes into livestock feeding; if it were used as direct human food it has been calculated that it could feed the whole population of India and China at their current rate of consumption. The practice of keeping large numbers of livestock and raising them on feed grains has enabled farmers in developed countries to add value to primary plant products, thereby increasing their income. It has also supplied most of the developed world with an extravagant, and some would say unhealthy diet, in which a large proportion of total nutrient intake is derived from animal products. The diet of many people in the developing world on the other hand is derived nearly entirely from plant foodstuffs. The release of even a portion of this grain, currently used as animal feed, for human food would surely be desirable. Many would counter this by saying that even if it were released no one but the richer countries could afford to buy it. This may or may not be true but the question still remains as to whether the rich have a duty to improve the plight of the World's poor. If not through food aid which can be potentially harmful to agriculture in the Third World(8), then through measures designed to strengthen agriculture there which may still involve diversion of resources. According to at least one writer(4), one reason for attemption to redress the balance could be security. The poorer countries of the world are not totally impotent. They could make life for richer countries uncomfortable through terrorist activity or the formation of cartels to control their vital primary outputs which are going for export, similar to the formation of OPEC. This is possibly, as the writer himself suggests, a rather spurious argument as making life uncomfortable does not necessarily make it impossible. The main arguments for attemption to solve the problems of food worldwide are concerned mainly with the morality of the situation. Colin Tudge(4) puts it thus "... to live in a world where some seek ways of jettisoning wealth while others starve is intolerable, even if we are on the winning side. The decision to exert ourselves is fundamentally one of ethics and all other arguments are subsidiary." However much the ethical issues involved in solving the inequitable division of food supplies worldwide are debated, it may soon be necessary to make adjustments to our agricultural system inspite of the situation in the Third World. This is because of Britain's weakened position in the world economic order and the vagaries of world trade in food.

Houston(3) considered that two crucial factors had come to the fore in recent years. The first is that the balance of power has shifted considerably from the food importing countries to the food exporting countries (particularly if the exports are food and feed grains). The following table, Table 1.23, shows the trade situation for grain in the World.

TABLE 1.23

The World Grain Trade

[Source: Ulbricht TLV (1977)]

The second factor is concerned with the fact that food deficits in the Third World are increasing, consequently their need for imports is rising. In a world in which food is in short supply, those who have it to export are in a strong position. Those who do not have enough must compete for the surplus. The ethical issues raised above are, of course, related here, but the situation is also serious for the rich countries which have a food deficit. Western Europe has thoughout this century been importing grain, even though yields and output have risen dramatically in this region since the Second World War. The deficit is primarily due to the increased feeding of grains to livestock. Out of the whole of Western Europe, Britain uses more grain for livestock feeding than any country except Holland, in proportion to its livestock population(6). A considerable amount of this is imported at ever increasing cost. In the past, grain feedingstuffs were cheaper for Britain than for the rest of Europe but this is no longer the case. It is unlikely that the real price of cereals and other feedingstuffs on the World market will decline when demand around the world is so high. The cheap food era through which Britain's agricultural and consumer sectors profited seems to be over. The possibilities for even buying on the world market are severely reduced. Only a small proportion of world food production is traded internationally and in years of shortage, supplies may, therefore, be difficult to come by(10). There are two options; either Britain continues to buy in its animal feedingstuffs at whatever price and whatever the consequences, or it attempts to become more self-reliant.

By joining the Common Market, Britain acquired greater protection from World markets than it had ever had. However, the principles of efficient resource allocation could still apply. If relatively cheap food is the goal, a country must weigh the benefits of diverting resources into home agriculture at the expense of other sectors, if this provides the cheaper product, or buying cheap supplies form outside, thereby releasing resources that were or could be used in agriculture into other sectors. This economic argument seems most applicable to a healthy strong economy, Britain certainly cannot admit to that. According to Houston[3], "the greatest economic danger for any individual country is likely to come from a serious lack of balance in its international position rather than from its conformity to a general deficiency of performance". Britain is certainly in this state of imbalance as long as it relies so greatly on expensive imported food. The current figure is around 45 per cent of food supplies, making up a quarter of our total import bill. This is a high cost to pay for a weak economy with a balance of payments problem. There have been many calls for a greater measure of self-sufficiency in food supplies. There appear to be three political arguments for a greater degree of self-sufficiency in agricultural produce.

1. To anticipate the possibility of a long-term adverse movement in the World's terms of trade for food products.
2. To increase the "security" of the nation's food supply.
3. To contribute to the balance of payments[11].

The British government currently seems to adhere to all three arguments on economic grounds rather than consideration of the possible effects, beneficial or otherwise, on the rest of the world. In its 1975 White Paper[12] "Food from our own resources," it justifies its proposals for increasing home output as follows: "... a continuing expansion of food production in Britain will be in the national interest. It is mainly the cost in sterling terms of alternative supplies from abroad which determines whether expansion of home production is economically worthwhile and, if so, to what extent; and the expectation now is that the cost of food and feed will be higher, relative to other prices, than over most of the past two decades." The thesis that we should be more self-sufficient still seems to be held but the target rate of increase in production has not been realised for a variety of reasons.

Britain's original entry into the European Economic Community (EEC) and adoption of the Common Agricultural Policy (CAP) was expected to give a fillip to domestic agricultural production, as food import prices would rise sharply because of the protective market mechanisms, and home output would therefore be stimulated[13]. However, immediately after entry, world food and feed prices shot up as a result of the oil crisis and other factors, and it proved cheaper to buy from the community rather than world markets anyway. The result of this could have been to force up food prices more rapidly than was anticipated in the transition phase, because Britain was not yet fully integrated into the EEC, nor had full CAP prices been adopted. The monetary compensation amounts (MCA's) were introduced to protect the consumer but they prevented the hoped for increase in domestic food output, by levelling out any possible advantage the British producer might have had over farmers in other parts of the community.

The hoped for increase in domestic food output has not yet materialized because of the weakness of the Pound compared with some of the other European currencies, and is one of the reasons why the target increases set out in "Food from our own resources" have not been attained. This only serves to show the difficulties of achieving greater self-sufficiency such that all parties, both producer and consumer, are not penalised by decisions made, and events which occur within our economic system. Despite this many writers still feel that there is a case for continuing the drive for expansion of agricultural production to secure more of our own food supplies from home sources. Marsh(13) suggests increased home output will enhance the scope for the United Kingdom to influence CAP price levels, by giving us a stronger bargaining position, and that it will help to reduce the currently high cost of food security, provided that we pay attention to the efficient use of home agricultural resources. Houston(3) feels that once farm prices in the United Kingdom and the EEC are on a par certain sectors of the home agricultural industry will be able to expand and still hold their costs below those of EEC producers. He sees a case for expansion to a level of 90 - 95 per cent self-sufficiency in temperate food supplies. One obvious result of greatly increasing the level of self-sufficiency in this country would seem to be an increase in the overall surplus generated in the EEC, which is currently virtually self-sufficient in many temperate foods. Although as long as it is economically good sense for Britain to produce more of its own food it should do so, there is no doubt that the generation of even greater surpluses in the future will cause problems within the EEC.

These last few paragraphs covering Britain's attempts to achieve greater self-sufficiency in food can hardly be looked on as criticisms of the current system. Rather, they indicate the prevailing economic conditions which have justified proposing that we extend the current system to produce more food. Although the efficient use of agricultural resources is advocated this seems to be envisaged with the same mix of livestock and crops. The increasing efficiency in production deriving from further rationalisation of farm structure, more prolific crops, less energy use in tilling, and more productive animals, for instance, rather than any fundamental change in approach[10 & 12]. From the introduction to this section it is evident that society demands more from agriculture than reasonably priced food, and criticisms have therefore been directed at this scheme for intense efforts in agriculture along the same old, already criticized lines. However, before going on to look at criticisms of the techniques of modern farming it is worth investigating further the arguments surrounding self-sufficiency, and some of the self-sufficient alternatives for Britain that have been drawn up.

Self-sufficiency is one of those phrases that has to be surrounded with qualifying statements. The self-sufficiency discussed above is concerned with producing more food from British farms to meet current demand, thereby reducing food imports. It does not imply total self-sufficiency in food, which would require all food supplies to be home produced, but just an increase in the level of self-sufficiency. Some people have advocated the idea of total self-sufficiency, even going so far as to insist on the use of only indigenous resources for the production of food. Others see self-sufficiency as an individual or small community ideal, enabling groups of people to become independent in the provision of food, clothing, shelter, etc., and helping them to re-establish the "spiritual link" between man and his "ecosystem". Perhaps because of the overworked and confused nature of the phrase "self-sufficiency" Colin Tudge[4] uses the phrase "self-reliance". This he takes to mean the production of all the food a country needs to meet basic nutritional requirements, but with the additional benefit of trade between nations to add variety to the diet, as well as for cultural, educational, and political reasons. Self-reliance is rather similar to increasing the level of self-sufficiency to provide a reasonable diet for all people from home produce, but never reaching total self-sufficiency. However, Tudge goes further in that he feels more attention should be devoted to encouraging the careful use of agricultural resources. This could require substantial alterations to today's pattern of agriculture. His reason for advocating what he calls "rational" agriculture stem from his belief that only through the adoption of self-reliant food production systems in all countries of the world, as a first step, can the world food problem be overcome. Rational agriculture depends on judicious use of land, careful attention to crop rotations, fewer livestock (and then only reared extensively), careful use of non-renewable resources and a larger labour involvement on the land. The main components of the resulting diet would be cereals and potatoes as staples, with plenty of vegetables and a little meat and other animal products. Some low level of sugar production is suggested, even though he feels we should eat far less, as it is gastronomically desirable. The point is that certain items in the diet, though not intrinsically essential from the nutritional point of view, are desirable if the diet is not to become dull and uninteresting.

The reasons behind this alternative, as expressed by Tudge, rest firstly on the need to do something about the world food problem and those who are severely undernourished. Self-reliance, he says, although difficult to achieve, is a possible and equitable solution. Secondly, though well aware that "such an agriculture, in today's commercial conditions, would be an economic disaster," he feels that there is a case for changing the economic framework of agriculture. This is because he believes that food production does not fit into the capitalist framework if it is to provide a sufficient healthy diet. The motive of profit can only encourage lack of balance in production by shifting farming towards increased specialisation. It also encourages the increased use of expensive non-renewable resource inputs to boost yields and therefore hopefully to gain a better profit margin. This can act to the detriment of the land and possible to the dietary supplies of the population. Tudge does not believe that farmers are solely geared to the making of profits but is aware that if they wish to survive in the commercial world they have little alternative but to adopt this as a prime aim. This fairly lengthy discussion of Colin Tudge's ideas on world food production and its possible reorganisation is included to illustrate a growing body of concern that originates from the belief that the capitalist approach to farming is having a disastrous effect on the land, peoples' diets, the farmer and society in general.

If we ignore radical solutions and seek to increase self-sufficiency beyond its current level within the present economic system, the necessary increases in efficiency will doubtless involve an increase in the use of fertilisers, feeds and energy, as well as a move to greater specialisation and larger farms, even if hoped for improvements in livestock, crops, machinery and farming techniques occur. This approach to increased self-sufficiency will most probably serve to generate surpluses in certain food products on a fairly regular basis, increasing market instability and encouraging greater need for governmental involvement to prop up the see-sawing system. This may or may not be the desirable way to carry out, or even to sustain, food production in Britain. The choice, if it exists at all, rests with society and its aspirations in terms of food and in the value it places on agriculture and the countryside. The alternative could entail a radical reorganisation of the economic system and a substantial change in dietary components. Barely any information exists as to the possible outcome of perpetuating the current system along its present direction; those who criticize it seem to feel it will break down as resources run out and those who advocate it have not discussed the likely impact on anything save increased technical efficiency and output.

Other studies are worthy of mention when discussing the issue of self-sufficiency. Mellanby[14 & 15] in his book "Can Britain Feed Itself?", attempts to show how much food Britain could produce to feed its own population without relying on imports. The motivation for a study like this is based on the premise that cheap and plentiful supplies from overseas are unlikely to be available in sufficiently large quantities in the future. Consequently it is advantageous to establish how much could be produced and what sort of diet would result. One of the basic facts that he gives is that Britain is producing some 15 million tonnes of cereals which, if nothing else were produced, would give us 90 grams of proteing and 3,000 K cal of energy each per day. This would, of course, be a very dull diet. However, he uses this fact to illustrate that we could, on only 9 million acres, a fraction of our agricultural land, produce sufficient food to prevent us from starving. The way to self-sufficiency lies through reducing livestock numbers. Animals are in direct competition with man for available plant foods and are inefficient converters of this food into edible products. The possible exceptions to this are milk and egg production. Mellanby suggests that the dairy herd could be maintained at around its current level, or even increased, providing milk, butter and some meat (about one pound per person per week). The sheep flock too could be maintained in upland areas but pigs, poultry and the purely beef herd would be drastically reduced. Crops would be produced along the same lines but wheat would have to be used as a direct human food and the amount of sugar would fall to around half a pound per person per week.

Blaxter(16), in his examination of the self-sufficiency possibilities, calculated how much land is needed to feed us in the manner we are now accusromed to. The figure was 46.2 million acres, far more land than is available for agriculture in this country. Given this fact he goes on to say, "It is impossible for Britain to attain self-sufficiency in temperate foods given that the national pattern of food consumption and the technical efficiency of farming remain unchanged." He then goes on to discuss the available agricultural land per head of the population taking into account land losses to other usues and projected increases in the population. If Britain is to be self-sufficient each acre has to provide food for nearly two people (1.75 to be exact). He believes that it is unlikely that self-sufficiency could be achieved as a result of massive increases in productivity, similar to those seen since the end of World War Two. The solution therefore if self-sufficiency is to be the goal, is to change our diet and our crop and livestock policies. His proposals call for reduction in the beef herd to a third its present size and on increase in the dairy herd for milk production, of 30 per cent. Most dairy bred beef calves should be killed at or shortly after birth for low quality veal. The cereal and legume acreages should be increased and there should be widespread introduction of oilseed rape. Sugar beet and potato acreages would be increased by 70 per cent. The resulting diet would include substantially less meat, fat, sugar and fruit, and quite a bit more dairy produce, potatoes, vegetables and cereals. The most limiting item in the diet is fat, which would be in short supply if none were imported. Although only small quantities are necessary for health, a low fat diet, especially when the cereal content is high, can be rather unpalatable and of limited acceptability. Many improvements in the varieties and methods of growing oilseed rape would have to be made to supply sufficient fat, even allowing for some butter production from the dairy herd. To achieve these proposals, Blaxter suggests that certain changes would be necessary. Two million acres of permanent pasture would have to be ploughed up and the area of temporary grass reduced to maximize the area for tillage. Changes would have to occur in the technology of bread making in order that home produced wheat could be utilized. A margarine industry based on oil from rape would have to be developed and considerable capital investment would be needed for sugar beet factories, creameries and possibly potato processing plant, as well as on farms. He also sees a need for more farm labour.

Watkin Williams(17) investigated a number of alternatives available in the event of food supplies becoming highly restricted world-wide. Concentrating first on the reduction of inefficient meat production, he suggests that the short fall in protein, brought about by drastically cutting the beef herd, lowland sheep flock, pig herd and the poultry meat sector, could be compensated for by increasing milk and egg production. Milk production could be increased by 60 per cent and egg production could be doubled. To ensure that sufficient land was available for cropping, some milk production would have to move into the uplands. He sets aside an area for the production of concentrates for feeding cows and poultry but no imports would be needed. This, he feels, would not significantly impair our capacity to produce sufficient food. Another two alternatives to compensate for the reduced protein supplies are mentioned. The first would involve increasing the supplies of protein rich grain crops, such as peas, beans and home grown oilseed residues, and the gradual running down of dairying and egg production. The second is to combine increases in milk and egg production with increases in vegetable protein supplies. The second alternative, in his opinion, might be the most sensible to pursue.

All of these studies show possible alternatives for food production in Britain which would reduce our dependence on imported supplies. The particular worries expressed are primarily concerned with the dependence of our livestock on imported feedingstuffs and the direct competition between animals and man for the food already produced in Britain. The possibility of Britain adopting, or even being forced to adopt, total self-sufficiency seems remote. The merit of these studies lies in their illustration that self-sufficiency in food is not impossible for Britain if dietary and farming changes occur. The impact of these alternatives on anything save livestock numbers, individual crop acreages and the population's diet is not dwelt on, although all of them mention some other impacts. The feeling of all these writers is probably expressed by Blaxter(16) when he says, "without accepting the need for compete self-sufficiency, however, it would be prudent to increase the extent of our dependence on home agriculture through the planning of a support policy".

1.53 The Use Of Resources In British Agriculture

The whole question of self-sufficiency is intimately connected, not only with the criticisms levelled at Britain's over reliance on imported food and feed, but also with the question of resource use. The use of resources in a sector is largely dependent on how efficiently they can be used in that sector compared with another. The arguments for increasing self-sufficiency on purely economic grounds rest on the relative cost of producing food at home compared with buying it in from abroad, and this is connected with the cost and efficient utilization of the resources involved. Home agriculture also has to compete with other home industry for the available resources. This is a simplification as other constraints on the use of resources also exist. However, in a growing industrial economy priority was usually given to those sectors which utilized available resources in a way most advantageous to the economy as a whole. This, for instance, resulted in a movement of some of agriculture's labour resource into manufacturing industries. Nowadays, other considerations are taken into account but the drive for efficient use of resources in economic terms still guides many policy decisions relating to agriculture. The criticisms which arise concerning resource use in the present system are firstly, can Britain justify support of the agricultural industry at its present size, and secondly, from a broader outlook, are the resources being used in the most efficient and sustainable way?

The major inputs to agriculture are:-

Land

Labour

Capital

Non-renewable energy

Other non-renewable resources such as phosphate, potash, metals etc.

The wasteful use of any of these resources should be discouraged. However, current criticisms is directed most specifically at the use of non-renewable resources.

1.531 Land

It could be said that the finite resource, land, is well used. Productivity per hectare on much of the agricultural land of Britain is fairly high. The exception to this is the large upland area which has low productivity in agricultural use. To achieve high productivity, however, modern farming invariably introduces large quantities of other resources, to provide mechanisation, fertilisers and agricultural chemicals. Added to this is the fact that land for agriculture in Britain cannot be viewed as a resource of static dimensions. Large areas of land, about 32,000 hectares per annum, are lost from agriculture to other uses[18]. This fundamental resource for farming is therefore under considerable strain. Untimely, if the situation continues, our potential for producing food, not to mention fibre and timber, will be affected. The feeling of many people is that insufficient attention is paid to the loss of agricultural land in the planning processes[19]. If more food is to be produced at home, some solution to the problem of fixing priorities for the various possible uses of land, will have to be found. On a world scale it has been calculated that there is sufficient available land for agriculture to produce sufficient food for a population of up to 50 billion, if unused land is bought into agricultural production. Considerable resources would be needed to make this land productive[19, 7 & 12]. Whether, considering the problems of the world's poor and the vagaries of world trade, this is much comfort, it is difficult to say. The current feeling is, in any case, that Britain should aim to produce more of its own food. If, as Blaxter[16] says, there is only one acre of "effective" agricultural land available for every 1.75 people in this country, the efficient use of land deserves high priority. The potential of this acre of land to produce food, or anything else, is governed by its own inherent properties and by the input of other resources to improve it, or encourage it to produce the eventual output. There is an optimum level of use for virtually all resources above which the law of diminishing returns comes into effect. To achieve maximum productivity from an area of land, the most productive enterprise mix and the optimal use of resources must be employed, but the realisation of this is often restricted by the availability and cost of a certain resource, not to mention the call for resources in other sectors. The examination of other resources helps to illustrate the conflicting views about which should be given priority for the sustainable production of food and for the good of society in general.

1.532 Labour

The productivity record of labour in agriculture since the Second World War has been good. Between 1960 and 1975 output per man increased by 140 per cent. The regression growth rate per annum being 6.7 per cent as compared with 3.4 per cent in manufacturing industry[20]. This is largely due to the substitution of capital for labour. It has already been pointed out that agriculture is highly capital intensive. Labour movement from agriculture was a necessary component of economic growth and it also enabled agricultural incomes to rise, a desirable social goal. The fact that agricultural wages are still, on average, lower than those in the non-agricultural sector could be taken to indicate that the size of the workforce is still too large or that the price of agricultural produce is too low, or even that workers in agriculture are being exploited. Continuation of the current agricultural system will probably encourage the continued reduction of the agricultural workforce as mechanisation increases and farm structure changes. It is generally held, however, that the rate of loss will be much slower than previously. The loss of agricultural labour and the depletion of the working population in rural areas has lead to some decline in services in these areas and this is becoming a subject of increasing concern and criticism. On the other hand, there have been labour problems in agriculture concerned with levels of skill[20]. To some extent the rapid changes in technology have created a need for different types of skill than were previously required and the industry has found it difficult to attract labour with the necessary skills. This is not considered to be a long term problem if wages can be kept relatively competitive and if labour needs continue to decline.

If, however, Britain is to increase its self-sufficiency in food by any substantial amount and there are no dramatic technological breakthroughs in agriculture, Blaxter[16] suggests more labour would be required on the land. Tudge[4] in his description of "Rational" agriculture calls for the much closer involvement of society in food production and a larger labour force on farms. Selly[21] reflecting on the loss of labour from the land and the value of labour productivity as a measure of economic efficiency suggests, "where the output per man on the land is still low and the holdings pathetically small it is customary to talk about the concealed unemployment in agriculture... But once the rural workforce has shrunk to the level it has in this country perhaps the concealed unemployment is no longer on the land? Perhaps it is in the factories?" He goes on to suggest that this might be a cause of our inflation and our unhappy industrial relations. This is debatable but it does serve to introduce a point. The actual levels of unemployment in this country are currently high. An opinion often expressed is that man is out of touch with his environment and the production of his food. Greater involvement in this area might be highly beneficial to society. Back to the land movements have over recent years become relatively common. Although it is probably misplaced romanticism to consider mass movements back to the land, it is interesting to note the feelings that exist and also to consider the fact that alternatives to the current system of agriculture may well require greater numbers of people to be directly involved in food production.

1.533 Capital

Agriculture is a capital intensive industry. The value of assets per man in the industry, whether land is included or not, is higher than that in many manufacturing industries[22]. In recent years the pattern of deployment of invested capital has changed. In the sixties and early seventies a far larger proportion of total capital investment was spent on equipment, buildings and farm improvement. Now, because of the rising cost of physical inputs, the amount of investment that has to be directed towards work in progress on the farm has increased substantially. The requirement for working capital reduces the potential for investment in fixed assets and farm improvement. Despite this change in the nature of investment the Agriculture Economic Development Council (EDC)[22] have stated that there should be no shortage of funds to facilitate the proposed increases in output envisaged in "Food From Our Own Resources"[12]. However, there is some debate as to the effectiveness of capital in the industry. The return on investment in agriculture is usually low, or even negetive, on all but the largest farms. An estimate of 10 per cent as the maximum level of return is sometimes quoted(23). The return on investment is linked with productivity. Output has grown at around 1½ per cent per annum since the last war, the productivity of labour has increased rapidly, but the increase in the productivity of land has not been so dramatic, partly because of the early on set of diminishing returns in the use of certain inputs such as fertilisers. The various factors that have to be included in calculating the productivity of capital complicate the issue and have produced conficting results. Stabler(23) suggests that because both the return on, and the productivity of capital are lower in the agricultural sector than in other sectors of the economy, the agricultural sector might be larger than it would be if it were not for government support and to some extent the inelastic demand for its output. However there are conditions under which a sector can be larger than it should eventually be even within a market economy. These include the fact that moving resources between sectors is a slow process and that economies of scale could be experienced in the future if resources are held in a sector until such time as it becomes economically viable. Despite these reasons for maintaining a larger agricultural sector, critics still argue that agriculture absorbs too much capital considering its contribution to the economy as a whole, some 2.5 per cent of Gross Domestic Product. Agricultural policies proposed by the government tend to emphasize the need for increased capital intensiveness on the grounds that this will help farming incomes and encourage expansion in production. These arguments do, however, rest heavily on what many writers seem to regard as poor estimates of efficiency and the opportunity costs of resources in agriculture(22). Also the replacement of labour with capital has encouraged the use of other resources, such as oil and rock phosphate, which have a finite availability and are becoming increasingly scarce. The rapidly rising costs of these physical inputs to farming has already been noted. The quantities of non-renewable resources being used on farms is also a source of worry.

1.534 Non-renewable Resources

The growth in energy utilization on farms in the form of mechanisation, petrochemicals, fertilisers etc., accompanied the decline in the size of the farming workforce. In the period of greatest expansion, resulting from this shift in resource use, between 1950 and 1970, the cost of energy was relatively low. This helped to facilitate the change and encouraged increased food production at reasonable cost, thereby keeping food prices at an acceptable level. The situation has now changed because of a growing realisation that the energy resources consumed are not inexhaustible, and because their price has risen dramatically since the oil crisis of 1973/74. There have been calls for economies in the use of energy in all sectors but the likelihood of these having any substantial effect on usage is dependent on the relative cost of using alternatives in any given situation. The inflationary conditions in Britain have not helped to reduce energy consumption on the farm much, for despite the fact that energy costs have risen, the cost of most of the alternatives, such as labour, have risen too. Nevertheless, farm consumption of primary fuel did fall by about 14 per cent between 1974-75 and 1976-77[24]. Over the same period there was a reduction in output which may or may not have been caused, in part, by this reduction in energy consumption. The use of energy on farms, if this is so, can be critical when considering the potential to produce food under the current system. Concern over the level of energy use on farms has led to the development of some techniques which can save energy. Intelligent management can also prevent unnecessary wastage of energy.

Agriculture in Britain consumes one per cent of the primary fuel supply of the country directly[24]. This does not seem a very large proportion but it does not take into account the use of indirect support energy needed for the production of fertiliser, machinery etc. If the consumption percentage is readjusted to include this, British agriculture consumes about 4 per cent of primary fuel supply. Even this is an under-estimation for the complete food production system from farm to consumer. Leach[25] calculated the energy required for the whole process to the point of sale in shops and obtained a figure of 15.7 per cent of United Kingdom primary energy supply. It is obvious from this that the processing, packaging, transportation and selling of food account for a greater proportion of the total energy consumption than farming, but this does not justify complacency within agriculture. The actual physical quantity of energy required for food production was calculated to be 0.8 tonnes of oil equivalent for every individual in the United Kingdom each year[25].

A breakdown of the energy consumed in United Kingdom agriculture can be seen in Table 1.24[26].

TABLE 1.24

Energy Consumed In Agriculture In The UK 1973

Aston University

Illustration removed for copyright restrictions

/Source: "Energy Use and British Agriculture" (1976)
Ed: D. M. Bather and M. J. Day. Reading University Agric.
Club p. 5/

The main contributors to energy consumption on the farm are therefore machinery (including its manufacture, maintenance and running), fertilisers and feed. The economies called for and suggested are usually in these three areas. The development of new machinery and methods of using machinery to provide greater economies in the use of energy are underway(26), for instance, the development of minimum clutivation techniques and more efficient sprayers. There still remains a fear though that many farms maintain a power capacity, in the form of machinery, in excess of their actual requirements. However, this issue is confused by the need to organize machinery for jobs on the farm. It maybe more economical in terms of time to have two tractors on a farm rather than one, even it this is not wholly efficient in energy terms. This is one result of a reduced labour force.

Fertilisers consume much of the support energy in agriculture, this is mostly for their manufactufacture or extraction Energy consumption on farms might be significantly reduced if economies were made in fertiliser usage or if alternative sources of plant nutrients were used. The enormous increases in the use of inorganic fertilisers have not been accompanied by anything like the same sort of increases in eventual crop output, partly because fertiliser usage follows the law of diminishing returns. This is a fact often used as an argument for diverting more inorganic fertiliser to the developing world, where its use can provide spectacular gains in output. One of the major problems with fertiliser use in British agriculture is not so much its over-use but its less than optimal use in some areas. It is claimed that sugar beet gets more nitrogenous fertiliser than it requires and that grassland does not get enough(27). There is therefore potential for using the fertiliser available in a more efficient way. Only 50 per cent of inorganic nitrogenous fertiliser applied to crops is taken up by the plants(28). There is therefore significant wastage which has led to environmental problems of water pollution in some areas. Careful use of organic manures, nitrogen-fixing legumes and sensible crop rotations can also reduce the need for inorganic fertilisers. If the finite availability of some inorganic fertilisers is recognized or the cost of fertilisers becomes too high for optimal use the alternatives will receive more attention than they currently do. Many farmers already make good use of farm yard manure (FYM), legumes and rotations. However, the possibilities open to some farmers to use FYM as an alternative fertiliser for arable systems are reduced in areas primarily devoted to cropping. The shortage of animals in these areas means there is a corresponding shortage of manure. In livestock areas especially where stocking densities have increased or intensive stock husbandry is practised the reverse can be true, with considerable problems arising from having too much manure. The transport of this extremely bulky substance makes its movement, from areas of plenty to areas of scarcity, rather costly. Therefore, although potential exists for decreasing dependence on inorganic fertiliser to some extent through the greater use of animal wastes, the pattern of farming and the costs of transport tend to work against this possibliity. Increased specialisation has created waste problems both in terms of animal excreta and crop residues which could be seen as a major imbalance in the system. Traditional mixed farming systems are largely able to re-cycle wastes internally.

The final major absorber of support energy is feedingstuffs. This tied in with the arguments concerned with the numbers of livestock in Britain and with the often intensive way in which they are kept. The support energy involved in feedingstuffs includes that required for processing and transport of both home-produced and imported feedingstuffs.

One of the fundamental questions surrounding the use of support energy on farms is how efficiently it is used in terms of the ratio of support energy to eventual food output, measured in either protein or energy terms. Blaxter(29) calculated the ratio of edible food output (in energy terms) to total fossil fuel used as 0.34:1, which compares with Leach's(25) ratio of

0.35:1. Therefore, for every joule of energy put into farming only one third of a joule, in the form of edible energy, is recovered. The energy ratios for cereal and potato production in the United Kingdom are usually greater than one. Although when they have been processed into a simple food, such as bread, the ratio drops below one[25]. The main reason for the overall ratio being so unfavourable seems to be the over-emphasis on animal production. Some 70 per cent of the primary output from British farms is fed through animals before it becomes food for human use in the form of meat, milk or eggs[27]. Animals are inefficient converters of feed into edible food products. The efficiency of an individual animal, in terms of protein or energy conversion, is influenced by a number of factors, some of which can be selected for with careful breeding. These include such factors, as, how efficiently the animal makes use of the energy available to it for the production of milk, eggs or meat; how quickly the animal reaches maturity (the more quickly this is achieved the lower are the costs of maintaining an animal until it becomes productive). How prolific and reliable the animal is in breeding, and how much feed the animal can take in above its requirements for maintenance (this is largely dependent on the digestibility of the feed it is given)[30]. Ruminants, although fairly inefficient in their conversion of the energy in their food (80 per cent of the digestible energy is metabolised), need not compete directly with humans for their food, as their diet can consist predominantly of food with a high cellulose content like grass. The energy they do extract from this diet, can be used reasonably efficiently, especially if they are milk producers. Energy conversion of metabolisable energy for the dairy cow ranges from 28 to 40 per cent, depending on the amount of milk produced by the individual[30]. For beef animals the rate of increase in liveweight gain is important, the higher it is, the more efficiently the animal is using the metabolisable energy in its diet. The situation is complicated for milk and egg production by the fact that high energy conversion efficiency is only maintained over the most productive period of the animal's life. Once it is past its peak the efficiency with which it converts energy into milk for instance, is reduced and metabolised energy above that needed for maintenance will preferentially be used for producing muscle and more likely body fat. Monogastric animals which have a dietary requirement similar to humans, are often seen as direct competitors for potential human food. They do however utilize 90 per cent of the digestible energy in their diet, and are considerably more efficient meat producers than ruminants. Their primary drawback, as was discussed in the section on self-sufficiency, is their dependence on compound cereal and protein feeds. The modern pig and broiler chicken are no longer scavengers on waste and crop residues.

The efficiency with which farm animals produce edible protein also varies. The most efficient are the dairy cow and the egg laying chicken. Meat production, for protein, in relation to the amount of metabolisable energy required is far less efficient[30]. The productivity of animals still has room for improvement through careful breeding but it is impossible for animal systems ever to be as efficient food producers as crop systems in energy terms. Man can choose to adopt a diet containing animal products, which puts him on a higher trophic level than the herbivore (or vegan) but which also increases the element of inefficiency in his food production system[31]. This choice reduces the potential for feeding a large population on a fixed area of land. At some critical point in the size of the population or its level of demand for animal-based food, , the agricultural system would have to import feedingstuffs and other inputs to preserve the chosen diet. Any country whose food production system is dependent on produce from "borrowed" land to feed its human and livestock population, in a world where the total agricultural area is, to all intents and purposes, fixed, seems likely to encounter severe problems in the future if it seeks to maintain a diet for the population containing a high proportion of animal-based foods.

Output per hectare from animal systems is also lower than for cropping sytems[30]. Wheat can produce 57 GJ* of edible energy per hectare per year. The support energy needed works out at one unit of input to every three units of output. Dairying on the other hand produces 13 GJ of edible energy per hectare per year. The energy ratio, of output to support energy input, in this case is 0.39, far less than for wheat. For broilers the situation is even worse, 6 GJ of edible energy are produced per hectare per year but the support energy needs are extremely high and the energy ratio is only 0.1[30]. Finally sheep, these are the least energy intensive in terms of support energy requirements but because of the poor quality of land on which sheep farming is practised in the United Kingdom, edible output per hectare per year is small, at only one GJ. The energy ratio for sheep systems in Britain is about 0.25[30]. As an example of the support energy input to animal systems, Table 1.25 gives a breakdown of the energy inputs for milk

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* One GJ = 10^9 joules

production from one Friesian cow over a year.

TABLE 1.25

Inputs To Milk Production
(average figures for a cow in UK 1970-71)

[Source: Leach, G (1975) "Energy and Food Production" International Institute for Environment and Development p. 122.]

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1. The energy 'cost' of raising cow is offset against output, this table assumes a 4 year milking period.

2. Concentrate input assumes 70 per cent of concentrates purchased and 30 per cent produced on farm.

3. Electricity figures vary according to milking parlour equipment and type of, on farm milk storage.

From all this it is clear that the current system of agriculture is very inefficient in energy and land-use terms. The shift to greater production of meat and other animal products has resulted in drastically reducing the efficiency with which the available energy, both in solar and non-renewable support energy terms, is utilised. The possibilities for maintaining our current level of production with a reduced energy input are minimal unless accompanying changes in the use of other resources are introduced. An increase in the area farmed in the United Kingdom is not a feasible solution to the problem. The labour resource is more flexible. Blaxter calculates that if production at the current level is to be maintained but support energy reduced by half, the labour requirement would need to be increased by fifteen-fold[24]. This represents a possible alternative in the short term but a fairly difficult one to put into practise, should the support energy situation become highly critical. In the longer term it would be wise to consider the development of ways of increasing food production which were not dependent on non-renewable resources or altering the balance of agriculture so that less priority was given to animal production, because not only will energy resources become increasingly scarce but also increasingly expensive.

The final area of inputs mentioned was non-renewable resources other than energy. These include phosphates, potash, metals, etc. The same arguments in general apply to these as to the energy resources. The cost of supplies is likely to rise as the resources become scarce, although this might be further off in the future than for energy sources. However, the energy costs of extracting and processing other resources of the type mentioned above will become increasingly high. Consequently, the careful use of any of these resources is very important for the future.

1.54 Modern Agriculture And The Environment

The issue of the impact of agriculture on the environment currently hinges on two main themes; first agriculture's effect on rural landscape and second on actual environment damage caused by farming techniques. The more immediate of the two is probably the effect on the rural landscape, although both are, in some measure, linked. As more and more people have the time, money and inclination to travel in the country, more concern is being shown over the contryside's amenity value, and landscape is a very important consideration when assessing this. Specialist leisure pursuits, such as bird-watching, and the rise in the study of environmental science have highlighted the more insidious damage that can be caused by agriculture, through the use of agricultural chemicals or simply the destruction of habitats.

There seems little doubt that both kinds occur, the real problem is how to find a balance. On the one hand, the production of food from home resources is encouraged to ensure greater food security and to help the balance of payments. The Government's White Paper, "Food from our own resources"[12], mentioned earlier, expresses a need for expansion in home production in selected areas along established lines, which implies greater intensification in farming. This gives environmentalists cause for concern. The Nature Conservancy Council[32] suggests that a dilemma exists when it says, "In other words the considerable pressures which are already exerted on wildlife by modern farming are likely to be increased, at a time when appreciation of the value of wildlife is also increasing, not least among the farming community..."[32]. There need not be total antipathy between conservationists and farmers for in part their objectives are similar. However, overlying the desire for a healthy productive environment there are differences in opinion or circumstance which overshadow the areas of agreement to some extent. The Nature Conservancy Council stresses the interdependence of the two sides in a recent report, when it says, "Agriculture depends on the conservation of beneficial bacteria, soil invertebrates, pollinators, predators and parasites, while conservation of most other species depends on what agriculture does or does not do to rural land"[32]. The antagonism arises from a farmer's need to make his farm financially viable which may encourage him to make structural changes in farm layout, or introduce new drainage, or adopt intensive methods for the production of crops or livestock, all of which may have environmental repercussions. The conservationists have every right to question these moves but must also be aware of the farmer's position.

Farm improvement in this situation must not necessarily mean environmental damage as well. It is becoming more and more apparent that agriculture takes place in a highly complex system and that some measure of balance is necessary if the costs of preserving that system are not to become outrageous. To a very marked extent imbalance already exists as agriculture depends on the control of the natural environment[31]. As more demands are made of agriculture to produce food and the traditional resource base changes, new aids are required to steady the imbalance. New agricultural chemicals and crop strains are in constant demand as diseases and pests modify to suit the new environment produced by man, thus agriculture finds itself in what is often called a "technological fix". From the environmental point of view this chain should be broken or should evolve in a more ecologically sound direction. If increased concern for the environment is also being shown by the farming community, as is suggested above, breaking the chain would also please farmers, but overriding the feeling that an ecological approach might be best are fears as to what effects it might have on yields and therefore on returns.

Landscape, and changes in it as a result of farming practice, are possibly the easier of the two problems to resolve as they effect the senses of both the farmer and the visitor to the country. There will of course be differences in what people find aesthetically pleasing and there are obviously those in town and country who do not care much anyway, as witnessed by the dropping of litter, untidy farms etc. For most people the main form of recreation taken outside the home is pleasure driving which often takes people into rural areas(33). The most obvious amenity this exposes them to is the landscape. England and Wales are fortunate to have a wide diversity of landscapes. Some landscapes are relatively untouched by human interference but most have been moulded by the people who have lived and worked in them over the centuries. Despite this idea of continuous evolution in landscape most people do have ideas as to what they want to see in a rural landscape, therefore, change is not always a good thing. Some areas of the country are relatively free from landscape changes as they are in some measure protected from intrusion and radical alteration. These include the National Parks and the areas of Outstanding Natural Beauty, although even the landscape here is not entirely sacrosanct. The main area in which landscape change is most dramatic currently is the farmed countryside of lowland England and Wales. Here modern farming has encouraged the removal of field boundaries, the felling of trees in awkward places and the construction of new farm buildings. Farming is not the only agent of landscape change in these areas, road building and other public works, for instance, also have substantial impact. Change is not always for the worse either, but any change which encourages a move to uniformity in rural landscapes throughout the lowland areas should be discouraged for what is probably valued most of all is the rich diversity which exists. The sort of changes that worry people like the Countryside Commission are the loss of trees, woods, hedgerows and special habitats - all of which lend distinctive character to rural landscapes[34]. The loss of trees is perhaps greatest in the arable counties of Eastern England where up to 80 per cent of the trees have been lost in the past 25 years[34]. Many trees, throughout the country, are also very old and insufficient new trees are planted to replace the dead and dying. Natural disaster can also strike such as Dutch Elm disease, which had killed off 9 million Elms by mid 1976 in southern and central England[34]. Woods and copses are also disappearing, although the rate of loss is not known. In former times these had a productive function either as a source of timber or as cover for game. Production of timber from small woods is no longer thought to be viable so many woods are removed or lie derelict. Hedgerow removal has been dramatic, most especially in the eastern counties where an estimated 50 per cent of hedges were removed between 1947 and 1972. In the mid 1960's about 10,000 miles of hedgerow were being removed yearly[34] throughout the country. This rate has since declined. Care of hedgerows that still exist has also changed, most are now mechanically trimmed, which means that individual trees growing above the level of the hedge are difficult to protect. In some areas the disappearance and non-replacement of hedgerow trees is going to have a marked effect on the traditional landscape, as it is depriving the English countryside of one of its most characteristic features.

Other changes in the rural landscape and its amenity value are brought about by the reclamation of wild areas of heath, cliff top etc. and the destruction or decay of features of archaelogical or historic interest. There is reason, therefore, to be concerned over changes in the quality of the landscape, and a need to look at ways in which farmers can be encouraged to replace, or leave undisturbed, features that add interest and individuality to a particular area.

Changes brought about by reclaiming wild areas have an effect not only on landscape but also on the specialized flora and fauna living in these areas. Certain species of mammals, insects, birds, plants etc., have evolved in a highly specific habitat and many of these are threatened by modern farming methods which are able to improve, in an agricultural sense, land that was previously marsh, moor or heath etc. Not only "wild" areas are at risk. Many species live on farmland too but with the reduction in hedge cover, moves away from untreated permanent pasture and the use of pesticides, these are finding it difficult to exist[32]. A wide variety of factors can work against the survival of a species in a particular site; plants can be affected by changes in soil pH or drainage and animals by reduction in their food supply. The grey partridge, for instance, has been in decline over recent years[35]. This bird lives in open arable type areas and the yong chicks feed on small insects at ground level. The spraying of fields to kill off cereal pests has also killed off the often innocuous insects which are the chicks' food supply, thereby reducing the possibilities for chick survival.

Certain particular chemicals used in agriculture have caused more alarm to people than others. The organo-chlorine compounds, such as DDT, are just such an example and their use is now more controlled[36]. The problem with some early and effective pesticides was their stability, they did not break down in biological systems and therefore tended to gravitate up food chains where they could cause problems. Dieldrin, for instance, at certain dose levels causes the shell of birds' eggs to be soft and fragile. Highly toxic chemicals are still in use, but most now break down rapidly after application, which reduces their toxicity. However, as the example of the grey partridge chicks shows, there can be secondary effects. It is desirable therefore to monitor the effects of sprays and to point out problems that can occur, such as spray drift which may have detrimental effects on both the environment and the farmer if the job is done inefficiently.

Modern agricultural practices can also have an impact on water quality. Certain pollution problems can arise as a result of agricultural waste run off into water. Many agricultural wastes have a high biological oxygen demand, for instance, silage and slurry effluents and the quantities of these likely to reach waterways is increased with intensive farming methods. Another cause for concern is nitrate and phosphate run off from agricultural land resulting from inorganic fertiliser application. Nitrate and phosphate can seep into slow moving or stationary water supplies and cause algal blooms which sometimes lead to eutrophication, a result of severe reduction in the dissolved oxygen content of the water. Stagnant water supports less life than well oxygenated water and has reduced amenity value. High nitrate concentrations in water can also be a health risk, particularly for bottle-fed babies[27]. The World Health Organisation recommendation is that nitrate concentration in public water supplies should not exceed 22.6 p.p.m. Pesticides and their residues may also find their way into water supplies with deleterious results on some aquatic life and often unknown potential effects on other forms of life, including humans. There are therefore considerable risks involved in the use of some aids to modern farming which must be balanced against the possible benefits.

1.55 Moral Aspects Of Modern Agricultural Techniques

There are a number of aspects of farming and food production in England and Wales that many people find morally unacceptable[38 & 39]. In the widest context the moral issues maybe concerned with the disparity between the developing and the developed nations in terms of food supply and how this is exacerbated by the eating habits of developed nations, or on another level with the moral dilemma of consuming meat, which required an animal to be slaughtered, an action which can be seen as an infringement of the sanctity of life. These wider aspects will not be covered as it is modern farming techniques that are specifically under examination. In recent times, because of growing demand for cheap and "efficiently" produced food, particularly from animal sources, many intensive systems of animal production have been developed. The substitution of labour with capital and the abundance of relatively cheap feedingstuffs and energy have all contributed to the realization of these intensive methods, as has the development of hybrid varieties of livestock, particularly pigs and poultry, which mature rapidly under controlled conditions. The objections arise as emotional or moral reaction to the perceived inhumanity of these methods.

Most intensive methods depend on increasing the ratio of stock to stockman and rely heavily on high output and/or rapid turnover for profitability. Intensive methods of dairying, for instance, usually involve zero-grazing which means that the cows are kept in at all times and feed is brought in to them. Larger numbers can be kept on a farm under this system than if they were allowed to graze outside. Less grazing is wasted if the grass or other forage crop is brought in and fed to the cows. The stockman also wastes less time collecting the cows for milking as the milking parlour and the area where the cows are kept are usually part of an integrated system. The number of cows per man is also increased by the introduction of technological aids such as computers, automatic feeders and milking equipment. The theory is that the less time spent on the humdrum aspects of the job the more time the cowman can spend keeping an eye on the well-being of his cows; watching for ill health, heat, persistent low milk yields etc. In large measure the economic efficiency of this type of system depends on the level of stockmanship and managerial skill.

For poultry and pigs too, intensive methods of production have been devised. These usually involve high stocking densities and controlled environments but are also dependent on types of stock which mature quickly and simultaneously, or in the case of egg-laying chickens, are prolific producers. Animal breeders to a large extent have tailored their animals for the intensive "factory" system. Rapid turnover and high output from pigs and poultry (broilers or egg layers) is essential to offset the costs and to keep the price of the product down.

Another intensive method of meat production which has created public concern is the rearing of young calves for white veal. Not much veal is eaten in this country so much of what is produced here is for export. For white veal meat production calves are often kept in small cubicles and fed on a diet with a highly limited iron content to ensure that the flesh retains the required pale colour. The animals are therefore intentionally kept anaemic and it is perhaps as well they only have short lives.

The public objections to these methods usually rest in the main, on the apparent "cruelty" of these techniques. The feeling is that the conditions to which the animals are subjected are not natural, or not, in any case, like they were under "traditional" farming practice. It is thought that keeping animals in crowded, indoor conditions, or in small wire cages must therefore involve suffering and that the farmer has sacrificed animal welfare for economic gain. It is, however, obviously not in the farmers' best interests to let animals suffer unduly as this will reduce the potential economic gain by adversely affecting performance. Many farmers argue that if the animals are warm, dry and well fed they must be "happy", and production figures are given to substantiate this argument. More traditional methods often exposed animals to far worse conditions of dampness, cold or restricted living conditions, which were ppssibly equally or even more "cruel" in some respects(39). That is not to say that cruelty should be condoned now, nor that it does not in fact occur.

Intensive animal husbandry does have real problems associated with it from an agricultural point of view. For one thing if animals are kept at high population densities the risks from disease and stress are higher than in some other methods. The level of stockmanship required to minimise these effects is therefore high. The Brambell Committee which reported on the welfare of animals under intensive systems in 1965 suggested that the main cause of real cruelty to animals was likely to be bad stockmanship rather than anything else(39). Nevertheless, the fact that the public do, in some measure, object to intensive or more particularly factory farming techniques should be taken into account, even if this opinion consists mainly of emotional over-reaction or a high level of anthropomorphism(40). Farming has an important place in many peoples' imaginations and maybe the farmer should not be encouraged to sacrifice humane criteria for economic expediency. Perhaps from a wider viewpoint society should review how far it is prepared to go in exploiting and manipulating livestock to provide cheap food. The modern animal under intensive production systems has been specially bred to meet the demands of the system, as a result of that it may be less susceptible to the rigours imposed, but this does involve exploitation of animals, an activity that deserves careful moral exploration. The issue now becomes philosophical in that it questions how far mankind should develop its power over animals rather than work towards a more symbiotic relationship with them. This same questioning applies to conditions of dampness, cold or restricted living conditions, which were ppssibly equally or even more "cruel" in some respects(39). That is not to say that cruelty should be condoned now, nor that it does not in fact occur.

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1.56 Society's Feelings Of Alienation From Modern Agriculture

Agriculture in its very beginnings separated mankind from the natural ecosystem simply because it sought to control the natural system. In order to feed growing numbers of people order had to be created by selecting specific plants and animals, and nurturing only them, to produce food. The naturally high entropy of the system had to be lowered and this required inputs of energy to maintain the new system . In modern times because of the need to produce an abundance of food on a limited area the energy input is extremely large. This input creates a highly managed and "unnatural" environment[31]. Perhaps, however, the criticism that modern agriculture has separated mankind from its "ecosystem" is not directed at this fundamental controlling function of agriculture but at the increasing technological and impersonal basis of agriculture. A number of people are concerned that they are isolated from the process of producing food and have lost contact with their "roots" in an agrarian past. Very few people nowadays in this country are connected in any major and direct way with food production at a farming level, although more and more are becoming involved with gardening and home food production. Others even aim for personal self-sufficiency in food.

Movements of this kind must indicate some sort of requirement, spiritual of simply economic, for the opportunity to get to grips with food production at an individual level. It is difficult to assess how widespread the feeling is or what the consequences would be of large numbers of people "returning to the soil". It seems that a return to personal self-sufficiency in food for so large a population is unlikely to be a viable scenario[25]. The level of nutrition would probably be low, and labour would be very wastefully used. There is also the problem of productive land scarcity in the United Kingdom, with only about 0.6 acres of effective agricultural land per person available. As society demands more than just food, agriculture was rationalised and intensified and labour was lost from the land in order that sufficient food could be produced and some level of industrial production maintained. The question is how far should agriculture continue to move in this direction. The self-sufficiency scenarios mentioned in Section 5.2 suggest that more people would be required on the land under these schemes which to some would be a highly desirable consequence.

1.57 The Modern British Diet As A Causal Factor In Disease

Affluent western nations, including Britain, although they have largely overcome the problems of under-nutrition, do suffer from a high incidence of degenerative diseases within their populations. These diseases are sometimes called the "diseases of affluence", and include obesity, heart disease and cancer. Diet is overtly connected with obesity but that is not to say that other factors, such as stress, do not play an important part in the development of the condition. The western diet is also thought to be a mâjor factor in the aetiology of some of the other "diseases of affluence". Heart disease has been linked with fat consumption (particularly saturated fats), dietary cholesterol, animal protein, sugar and refined carbohydrates. Various types of cancer are also thought to be due in part to some dietary factor. The incidence of cancer of the colon, for instance, is possibly positively linked to the amount of refined foods eaten.

The unravelling of the precise causes of the diseases is complicated by the fact that more than one factor is usually involved. Many different compounds in varying quantities are ingested daily by the individual and many other factors impinge on him or her throughout life. Consequently, isolating the specific factor or factors involved is likely to be difficult if not impossible. Much of the early investigative work into these types of diseases is epidemiological, this involves statistical studies of the incidence of the disease and changes in this over time and between regions, countries and population groups in order to isolate major differences and possible causative factors. The fact that many of these diseases do not occur in the poorer countries of the world, where the diet is more likely to be based on starchy staples and to have a far lower fat and animal product content, and where little of the food is refined, led many to investigate the possible association between diet in western societies and the "diseases of affluence". Western diets, in contrast to diets in other parts of the world, are likely to contain plenty of animal products, sugar and refined foods and a decreasing amount of the starchy staples.

McLaren[41] defines obesity as "adiposity in excess of that consistent with health". Adiposity is the quantity of the fat stored by the body in adipose tissue. Fat is stored in the body when energy intake exceeds requirements. Obesity is considered to be a serious health risk when an individual's weight is 20 per cent or more than that considered normal for their sex, age, height etc[41]. Although obesity by itself is rarely noted as a cause of death, secondary effects of the condition can give rise to serious problems. Obesity can predispose an individual to ischaemic heart disease, diabetes, hypertension, gall stones, bone, muscle and joint diseases and, when very severe, respiratory problems[41]. Some of the secondary conditions are likely to be the result of metabolic changes caused by fatness, while others are simply the result of the excess load carried and the stress this places on the body. The condition therefore has a major effect on both morbidity and mortality. Life insurance companies estimate that obese persons weighing 20 per cent or more than the normal are likely to have a greater mortality rate (estimates range from a 31 per cent[42] to a 50 per cent[41] increase). The risks of being overweight are indeed high.

In most western societies it is now recognized that obesity is a serious problem. A joint report by the Agricultural and Medical research councils[43] (ARC and MRC) suggested it was the most serious nutritional problem faced by western nations. It is certainly a problem which concerns a large proportion of the population. One estimate, quoted by Breckon[42], was that 50 per cent of the United Kingdom population are overweight and half of these are actually obese. To quite a large extent this high proportion must be due to the ready availability of food and the increasingly more sedentary and inactive lives that are led now when compared with former times. However, not everyone becomes obese even though there is sometimes little obvious difference in the quantity of food eaten or the amount of excercise taken. The aetiology of obesity is fairly complex and aspects of it are poorly understood.

One concept of the condition divides obesity into two categories, "regulatory" and "metabolic"[41], the former category is thought to be due to an impairment in the central mechanism regulating food intake, whereas "metabolic" obesity results from metabolic errors in organs other than the brain e.g., the endocrine glands. The categories are not wholly distinct as many obese individuals may have problems in both areas. A list of factors are implicated in the aetiology of obesity including genetics, psychological approach to food, social and cultural forces, degree of physical activity, hormones, adipose cell numbers and size, and control of energy balance. For some of these factors evidence is inconclusive and others may be after effects of the condition rather than causes of it. Treatment of obesity is difficult in practice as noticeable results can be hard to achieve except in the long-term. Considerable perseverance is therefore required by the individual wishing to lose weight and reasonable levels of abstemiousness are needed when the desired weight has been reached. Pressures are exerted by society against the overweight as fitness and slimness are considered desirable. This presumably acts as an incentive for some to lose weight but must also induce stress in others. Despite this growing social pressure many are still overweight and greater health and nutrition education is necessary. Particular attention should be given to education at times when obesity or weight gain is likely to occur, for instance during pregnancy, at the menopause and when, for one reason or another, physical activity is reduced. The care of infants and especially the problems of overfeeding in early infancy, which may result in life-long obesity, require special attention[41].

Coronary heart disease (CHD) and strokes are the single most important causes of death in men in western societies between the ages of 45 and 65 years. In England and Wales the death rate from CHD for individuals between the ages of 45 and 54 years is 300 out of every 100,000 of the population, in the age range 55 to 64 years this rises to 800[44]. This means that coronary heart disease is a very serious problem with profound social costs, not only in terms of medical costs incurred by the community but also because it tends to strike persons in the prime of life. What is more, it is a problem virtually peculiar to western type societies. Coronary heart disease can manifest itself in a number of ways, either by causing sudden unexpected death or myocardial infarction or angina pectoris[41]. The aetiology of the condition is complex and believed to be multifactorial. Heart disease is often preceeded by the long-term development of atherosclerosis. This is characterised by an accummulation of soft lipid material on the inner wall of blood vessels and in time leads to a narrowing of the vessel and restiction of the blood flow. When this condition occurs in the coronary arteries, restriction can cause infarction which usually manifests itself as some form of heart disease. Atherosclerosis can also be responsible for strokes and vascular disease in other parts of the body. Precisely why atherosclerosis starts is not known but diet is believed by many to have an effect on the progress of the condition, thus diet is linked to CHD[51]. There are other clinically observed symptoms which appear necessary for heart disease, these include raised blood cholesterol and triglyceride levels and increases in insulin and cortisol levels[41 & 45].

It was noted above that the aetiology of the condition is complex. Many factors have been implicated as risk factors in the development of CHD. Heredity, sex, stress, low physical activity, high blood pressure, diabetes, hypocholesterolaemia, smoking, soft drinking water, salt and a number of dietary factors are believed to be risk-factors(41). A number of thesc are secondary effects of obesity, so those who are obese, if they develop conditions such as hypertension, are at risk from CHD.

Most of the evidence linking diet with CHD is epidemiological. Increases in the mortality rate from, and incidence of, CHD over time in western societies have shown correlation with a number of changes in diet. The dietary factors which have received special attention include fats, sugar, dietary cholesterol and animal protein. Chapter 4 showed the changes that have occurred in the consumption of fat, sugar and animal protein during this century and the changing contributions they make to total dietary energy. Most are eaten in greater quantities now (although total fat intake does not appear to have increased by much) and all make a more important contribution to dietary energy than formerly. Although very little is known about why atherosclerosis or hypercholersterolaemia develop the possibility that certain dietary constituents seem to exacerbate the condition gives some grounds for dietary reform, at least amongst susceptible individuals. There is a problem however in identifying those persons which are at risk. Not only that, there is also a great deal of controversy over which factor of factors in the diet have a detrimental effect.

Dietary fat has probably received the most attention with regard to CHD(41, 43, 44 & 46). In England and Wales fat contributes some 40 per cent of dietary energy intake(44).

Countries with fat consumption at this level tend to have a high incidence of CHD, whereas countries in which fat contributes 20 per cent or less of calories have low death rates from CHD[41]. Analysis of the type of fat death rates correlate with most specifically has pointed the finger at saturated fats. These are believed by some to have a hypercholesterolaemic effect and high blood cholesterol levels are a necessary condition for CHD[46]. Polyunsaturated fats, on the other hand, appear to possess a hypocholesterolaemic effect, i.e., they lower the levels of cholesterol in the blood[51]. This property of polyunsaturated fats has encouraged the production of margarine with a high polyunsaturated fatty acid (PUFA) content and has prompted investigations into ways of inducing a high PUFA content in animal fats, the major source of saturated fats in the diet. Some investigators believe that the important factor concerning fats in the diet is the ratio of saturated to unsaturated fats. No conclusive evidence is available as to the role of fats in CHD, for instance some observers point out that no difference is discernible in any study between the amount and type of fat eaten by CHD sufferers and those who are not affected[45]. A reduction in total fat and in some cases an increase in the proportion of PUFA's within the overall reduction are nevertheless usually advocated in medical recommendations concerning ways of reducing the risk of contracting CHD. Recommendations governing the contribution of fat to dietary energy usually range from 25 to 35 per cent.

Sugar is the second dietary factor most usually implicated in CHD. The consumption of sugar has increased dramatically over this century, very roughly in line with the increasing incidence of CHD, whereas total fat intake has not[42]. Sugar, which is composed entirely of sucrose, a disaccharide formed from the monosaccharides glucose and fructose, apparently causes increases in the blood levels of cholesterol and triglycerides. This is one reason for its apparent link with CHD causation. Reduction of the sugar content of the diet is a fairly sensible precaution even if no conclusive direct link is found between it and CHD. Its nutritional value lies only in the provision of calories, and as a population we have plenty of them, a large number of people have more than enough. Sugar is also a major cause of tooth decay which is a very costly public health problem(45).

Dietary cholesterol is another factor implicated in CHD. Certainly blood cholesterol levels are elevated in CHD sufferers which indicates either an error in the metabolism of the compound or that the body is overloaded. For most high risk sufferers with hypercholesterolaemia a reduction in dietary cholesterol is advised. In the United Kingdom the average daily intake is between 500 and 600 mg, most of which comes from animal sources(44). The consumption of animal products has increased over this century so the amount of cholesterol in the diet is likely to have risen accordingly. The quantity of cholesterol in the diet appears to affect blood cholesterol levels, therefore most recommendations for the postponement of CHD do suggest a reduction in dietary cholesterol to about 300 mg per day(44). Apparently the easiest way to do this if on a fairly normal British diet is to reduce egg consumption to four a week(44). A number of countries have made recommendation about ways of reducing the incidence of CHD(44, 46 & 47), even if the evidence concerning the risk factors is often flimsy. These usually include the avoidance of obesity by cutting down on calories, particularly those derived from sugar, alcohol and fat; reduction of the cholesterol content of the diet and in the framework of an overall reduction in fat, an increase in the proportion of PUFA's. Non-dietary recommendations include taking more physical exercise, cutting out smoking and a general plea for more research into the whole question of CHD. The recommendations tend to put the onus for reform on the individual, in this country, at least, no statutory intervention has occurred, presumably because of inconclusive evidence and the relative strengths of different interest groups likely to be affected by dietary and other reform. There is a feeling, evident from writings on the subject of diet and disease, that statutory intervention should be considered to implement some of the recommendations as there is no doubt that considerable social costs are incurred as a result of these diseases. Others, however, feel that more work is needed to identify the proportion of the population at risk, as only then can any sensible policy be formulated and action taken such that the benefits are not outweighted by the costs of implementation[45]. Blanket intervention might prove too costly if only a small proportion of the population is at risk and likely to benefit from the change. Despite the on-going discussion and the controversy that rages over which are the most important factors in CHD development, there does seem to be a need for an expression of policy on nutrition by the Government, if only in recognition of the important relationship between diet and public health.

Dietary fibre is another subject which has recently gained public and medical notice[42, 48, 49 & 50]. The carbohydrate content of the diet has fallen over this century and much of what is now eaten is highly refined. The refining of cereals for flour to produce white bread removes much of the fibre present in the whole grain. There are manufacturing and consumer demand reasons for this process but some medical investigators have correlated the decline in dietary fibre (from cereals and other plant sources) with a range of clinical conditions common in societies eating little dietary fibre. Dietary fibre, once referred to as roughage, is that portion of food which is not absorbed from the gut. It adds bulk to the diet, retains water in the gut and speeds up transit time through the alimentary canal. Fig 1.3 is reproduced from the final chapter of Burkitt and Trowell's[49] book, "Refined Carbohydrate Foods And Disease", in which they link lack of fibre in the diet with a range of diseases. It should be pointed out that some of the links are very tentative.

Fig. 1.3

Postulated Relationships Between Lack of Dietary Fibre And Certain Clinical Conditions

[Source: Burkitt, D. P. and Trowell, H. C. (1975) "Refined Carbohydrate Foods and Disease" Aca Press]

The diseases linked with lack of dietary fibre can be divided into those directly linked with lack of fibre in the diet; strain syndromes and metabolic disorders[49]. Fibre's role in keeping a relatively fast flow of digested food through the gut in a soft, high water content form is thought to reduce the possibility of strain and reduce the build-up of toxic substances, like bile salts, which have carcinogenic properties. Fibre also bulks out food and because of its effect on transit time it may well reduce the absorption of certain nutrients. Conditions such as diabetes, obesity and ischaemic heart disease may well arise from the body's inability to cope with overload from a variety of substances, thus fibre may act as a protector against these conditions by limiting absorption. At the moment little is known about the protective action of fibre in the diet. Nevertheless, if recommendations to reduce fat and sugar intake in the diet are heeded the most likely alternative in the diet would be carbohydrate. If this is less refined than that which currently makes up so much of the western diet, there could be substantial health benefits, certainly there would be less constipation.

In the future, other conditions peculiar to western society may be found to have dietary factors involved in their aetiology and further insight will hopefully be gained about the diseases which currently worry us. There is no getting away from the fact that diet is important to health and that both under and over nutrition should be avoided, even if the causal links between specific foods and specific diseases are not conclusively proven.

PART 2

A PLANT-BASED SCHEME FOR FOOD PRODUCTION IN ENGLAND AND WALES

2.1 Identification Of The Likely Areas Of Impact

2.11 Introduction

The first part of this thesis dealt with aspects of current British agriculture and diet, and pointed out some criticisms directed at both these areas which may well justify some measure of change in the system. This part will deal with the construction of a plan or scenario for an extreme alternative for agriculture in which human food is derived entirely from plants. The consequences of this sort of move will be assessed for agriculture and the diet but it is obvious that the repercussions would not be confined to these two areas. It is beyond the scope of this study to examine the effects of this sort of shift on all but a few areas in any great detail, but there is nevertheless a case for identifying likely areas of impact above and beyond agriculture and the diet. In this way, the project does not lose sight of the wider implications of change and the aspects which are studied can be placed within a more realistic framework. The general approach adopted for the whole study is that of technology assessment, which incorporates a number of research methods.

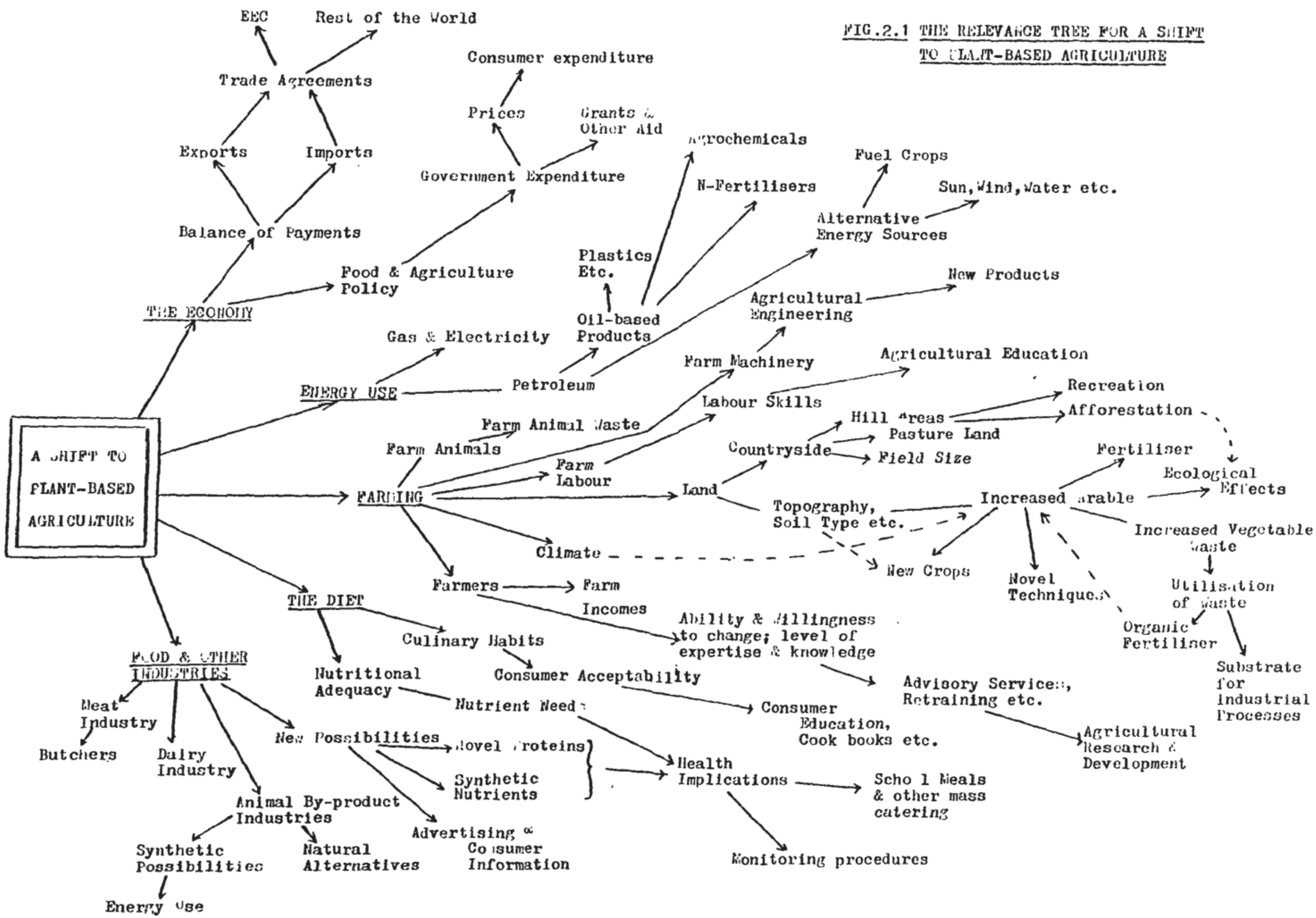
As a starting point to the study therefore it was important to identify the areas of likely impact. In order to facilitate this a relevance tree was constructed. Relevance trees can be used for a number of different tasks although their main value is probably in promoting an orderly flow of ideas. The change, or goal, is first set out and then the main areas of likely impact. From these it is possible to branch out along various lines and pinpoint where change would have to occur in a fairly logical progression. It is unlikely that the areas identified constitute an exhaustive list but they serve as a reasonably broad frame of reference for further investigation. The following diagram, fig. 2.1, is the relevance tree constructed for a move to plant-based agriculture. Not all the items require change, some may in fact be factors limiting the potential for change, for instance climate and soil type. Others maybe novel spin offs resulting from change which would reqûire new research or administrative approaches. The relevance tree therefore identifies more than just the areas of impact, it includes many, if not all, of the factors pertinent to the idea of a shift to plant-based agriculture. It is, in fact, a way of listing what is relevant to the study.

2.12 Areas To Be Covered In The Study

Five areas of primary impact were identified, the Economy; Energy-use; Farming; the Diet and the Food Industry (plus animal by-product industries such as leather, textiles etc.,). From these main branches other considerations relating to the shift were traced out. A study of the "tree" will show that there is a good deal of overlap between the five major divisions especially towards the ends of the branches. It is difficult, however, to link these up without confusing the scheme of the diagram. The fact that the branches do overlap and that none of them really constitutes a water-tight area for study is, nevertheless, worth remembering.

This study was set up to examine the potential for and limitations of a shift to totally plant-based food production and to assess the consequences of this move. It is obvious from

FIG.2.1 THE RELEVANCE TREE FOR A SHIFT TO PLANT-BASED AGRICULTURE



the relevance tree that many very different areas would be affected by this sort of change and, as was mentioned previously, it is beyond the scope of this study to do justice to more than a few of the items identified. Initially therefore the two branches "Farming" and "the Diet" were chosen as areas of study. Even within these, some aspects have only been touched upon. Many of the items in these two branches acted as constraints upon the cropping scheme formulated and on the eventual theoretical output and, consequently, were major considerations for the study. Some of the peripheral items such as the possible need for changes in agricultural research goals, are dependent in the first place on the workability of the scheme from a biological and physical point of view. They are therefore necessary considerations when formulating implementation policies for such a scheme but not essential for estimating the fundamental practicability of the idea. The project therefore concentrated on the physical and biological determinants of the potential for a shift of this sort in agriculture and the nutritional goals that would need to be achieved.

2.2 Agricultural Goals and Constraints

The introduction to this part of the study gave an indication of the areas likely to be covered. The main part of the research work involved has been devoted to the construction of a novel cropping plan for agriculture in England and Wales, which would provide a totally plant-based diet for the population. This is obviously a major departure from current practice. The problem therefore needs to be carefully defined with full consideration given to goals and constraints, both agricultural and nutritional, which may affect the realisation of the theoretical scheme. The nutritional considerations will be dealt with in chapter 2.3.

There are a number of agricultural goals or objectives currently adhered to by government and these are not dismissed in the study. However, it may be impossible to do much to determine, other than by guesswork, whether some of these could be fulfilled by the novel scheme. Others are easier to assess. New goals have also been formulated which overcome certain of the criticisms levelled at current British agriculture. The novel plan will be assessed to determine whether it achieves these goals or moves some way towards them.

The constraints are covered in greater detail, particularly the biological and physical constraints to cropping in England and Wales. Much of the available information is highly specific to small areas and is, therefore, difficult to apply to the whole country, because of this a number of working assumptions or generalisations had to be adopted in order to construct the cropping scheme.

2.21 Agricultural Goals

There has been little change in agricultural goals in this country, as indicated by Government policy on agriculture, since 1947, even considering the country's recent membership of the EEC. The goals or objectives expressed in the Agriculture Act 1947 were roughly as follows*,

1) That agriculture in this country should produce food and other agricultural products but only to levels that did not prejudice international relations and trading arrangements, and did not cost too much, in terms of food prices to the consumer or costs incurred by the Exchequer.

2) That agriculture should provide those who live by it, i.e., farmers and farm workers, with a living standard commensurate with that enjoyed by workers in other walks of life.

and 3) That agriculture should be a viable industry in economic terms, i.e., that there should be reasonable return on invested capital.

Ten years later, the Treaty of Rome set out the objectives of the EEC's Common Agricultural Policy**, the principles of which we acceded to completely, in 1978. In many ways, the goals are similar to the three above, but the methods of achieveing them are different. The objectives of the CAP are to secure regular supplies of food at reasonable cost to the consumer; to stabilize agricultural markets, to increase productivity and to ensure that farmers have a reasonable standard of living. The most recent Government policy document on agriculture in this country was "Food From Our Own Resources"***, which reaffirmed previous objectives but stressed the need to secure more of our

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* See section 1

** See section 1.1

*** See section 1.15

own food supplies from home sources. This is really only a re-emphasis of goal(1) in the light of changing circumstances.

In general then, agricultural goals fall into four main areas:-

- Ensuring security of food supplies
- Achieving a stable and efficient industry
- Ensuring that the cost of food to consumers is reasonable
- Maintaining fair standards of living for farmers and farm workers

Methods of achieving these goals can vary considerably and interpretation of the precise meaning of each goal is flexible. Measures which are taken in the effort to achieve one goal may well act, either positively or negatively, on another. Nevertheless, the basic objectives expressed above seem socially desirable and the study will seek to assess whether they could be achieved under the theoretical system.

Certain goals need to be fairly well defined in order that they may serve as a framework for the study. The criticism of British agriculture mentioned in chapter 1.5 also give grounds for some other goals to be included for agriculture, covering such things as environmental protection and resource use. This will enable the two alternatives, present and theoretical, to be compared on the basis of how far they go towards achieving other objectives pertinent to agriculture. In fact, goals concerned with physical variables are the most straightforward to assess. Those concerned with less tangible parameters such as the economic goals are virtually impossible to assess for the theoretical system. It is therefore necessary to assume that the economics of the novel system, in terms of the cost of food to consumers and farmers' incomes, will be adjusted to meet the objectives for these factors.

The major goal for the cropping plan is to ensure security of food supplies, from home sources, sufficient to meet the nutritional needs of the population; nutritional self-sufficiency. This forms the basic framework for all the work on the novel system. Coupled with this are the goals to be used for comparing the alternatives. The first of these is that a prime objective should be the preservation of fertile productive soil and that the adverse effects of agriculture on the environment should be minimised. The second is that the use of resources in agriculture should be efficient and sustainable. Finally the basic objectives for agriculture noted above will be adhered to, as they are considered socially desirable. In the final parts of the thesis policy options for achieving the theoretical system are examined, there it will be important to attempt to seek ways of maximising the social objectives.

2.22 Agricultural Constraints

First there are those constraints imposed on agriculture by the study brief. The scheme proposed for agriculture does not include farm animals. The absence of farm animals removes the need for fodder crops. The study brief also specifies that only crops currently grown commercially in this country will be included. The range of possible crops is thus limited as crops currently grown exclusively for fodder cannot be included. Any novel crops which are not currently exploited (except at an experimental level), but which could prove beneficial in a plant based system, such as sunflowers, lupins and soya beans, are being examined in a separate study and will not appear in the cropping plan.

Second there are constraints, both physical and biological, imposed on cropping in this country which must be taken into account. These constraints, which include climate, soils and topography, can act as a guide for determining what can be grown where and with how much success. They can also provide a sensible estimate of the potential for a shift to plant-based agriculture throughout the country. Estimates of agricultural land potential will also be included in the discussion on constraints as these attempt to include all the different physical and biological constraints and thereby derive an overall indication of cropping potential.

Climate

The climate of England and Wales is classified as temperate, which essentially means that severe climatic conditions of cold or heat are rare. Nevertheless, the production of crops, suitable for this type of climate, can still be constrained by climatic factors. The basic limitation to crop production, according to Cooper[2], is the yearly input of solar energy. The use of this energy by the crop can, however, be impaired by other factors such as temperature, water stress and the availability of soil nutrients. The solar energy input in Britain varies on average from 20 MJ m^{-2} day^{-1} in summer to 2 MJ m^{-2} day^{-1} in winter[2]. Given the climatic limitations to the use of this energy only 70 to 80 per cent of the total solar energy input falls during a time when it can be used by the plant i.e. the growing season[2]. The average growing season in England and Wales runs from April to September[2], but in the

North and in upland areas it maybe shorter, whereas in mild areas, such as Cornwall, it may run for 8 to 9 months. Most temperate crops will start to grow when soil temperatures reach 5^oC and there is sufficient light[2 & 3].

Rainfall is another factor which limits crop production. Certain areas of England and Wales suffer from summer drought five years in every ten. This prevents maximal plant growth and irrigation is advisable to improve production. The areas most likely to suffer in this way are parts of the Midlands and South and East England. High rainfall need not necessarily be a problem for crop production if it falls at a convenient time and if drainage is good. Areas with high rainfall, particularly if this occurs in the early spring and autumn, may have problems with cultivation. If field capacity* is reached too early in the autumn, or if fields do not dry out sufficiently early in the spring, cultivation cannot occur because of the risk of damage to the soil by machinery[4]. Optimal use of the growing season for crop production is also impaired. A waterlogged soil in early spring will take longer to warm up than a drier soil, so germination and growth maybe retarded. April and October rainfall is likely to be higher, on average, in the North-West, Wales and parts of the South-West than elsewhere[5]. The preferred crops in these areas are therefore perennial to avoid the problems of cultivation, and this usually means grass. The most advisable areas for growing annual crops, on the basis of climatic considerations, are the East, South-East and parts of the Midlands.

Frost, too, can be a problem in crop production. Areas

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* Field capacity is essentially saturation point for a field

prone to late spring frosts may not be suitable for top fruit production, as they can damage blossom(1). Early autumn frosts can be a problem for some late harvested crops such as maize, celery and sugar beet(1).

Individual crops, even if they are generally classed as suitable for temperate climates, will vary in their response to climatic conditions. In cold areas, for instance, it is unwise to plant winter sown beans as they are susceptible to extreme cold(6). Peas can be grown widely throughout England and Wales but if they are grown for harvesting dry the potential area is reduced to the East of England, where rainfall is less than 30 inches a year on average(6). Top fruit is not only vulnerable to frosts, it is also liable to suffer from wind damage(1), so a sheltered site with good late summer sunshine levels, in order for fruit to ripen, is required. Any crop, in fact, which has to ripen for harvest requires dry, sunny weather around about harvest time. This is also important from the point of view of the harvesting process.

In most areas of England and Wales some sort of crop is grown but some areas are more favoured, climatically, than others for growing crops suitable for human consumption as these often are annuals. Even within regions, where rainfall is high and the growing season short, there will be areas with a micro-climate suitable for growing a fairly wide range of crops. Climatically speaking, therefore, no region is completely devoid of potential for contributing to an all plant diet, although the restrictions may be more severe in some than in others.

Soils

Soils are another limiting factor in crop production, especially if considered in conjunction with other constraints such as the topography of the land, climate, drainage etc. The main types of soil recognized are clays, sands, gravels, loam, chalk, peat, fen and mountain rock[1]. In many areas of Britain the types of soil to be found can vary considerably, even within small areas such as a field. The potential for growing crops exhibited by the different soil types varies not simply because of the particular individual physical make-up of a soil but also as a result of the environment in which the soil is found[1]. Soils which support the growth of only a few crops can under certain circumstances be improved, by the addition of organic matter, or lime or some other substance, or by drainage, to support a different crop or a wider range of crops[1].

Fens are soils with high organic matter content[1]. They are usually low lying and so require drainage. If they are well drained they are naturally fertile and ideal for root crops. Nevertheless, all fen soils are not equally useful for cropping. The best fen has clay beneath it which helps to prevent water shortage in times of drought. If the fen has sand or gravel beneath it, it is likely to dry out quickly in dry weather and erosion can become a problem[1]. The use and farming of fen soils therefore varies, depending on the underlying geology of the soil as well as the efficiency of drainage and the local climate. Most other soils have similar variability. Chalks, sands and gravels drain very efficiently and the maintenance of soil fertility requires regular addition of some sort of fertiliser[1]. Peat soils are often sour and have low pH, which reduces the number of possible crops. Improvement is possible with drainage and liming but this sort of soil is most likely to remain under grass[1]. Most soil types with the exception of mountain rock can under the right conditions be used for crop production. Each soil type will present its own individual cultivation problems and potential to the farmer.

The maintenance of soil structure and fertility is important in farming. In 1970 the Ministry of Agriculture published the Strutt Report[4] which was a country-wide assessment of the effects of modern farming on the soil. The assessment only covered the effects of current practice on the various soil types in each region but it did highlight areas of concern which are relevant to the idea of moving to a totally plant-based system. The conclusions on fertility indicated that there was no great problem with this, even where livestock farming, ley-farming systems and the use of farm-yard manure (FYM) have been replaced by all arable systems and chemical fertilisers. There was some concern expressed about the declining use of lime and the lack of knowledge shown about the distribution of trace elements under intensive systems, both arable and livestock. Soil structure, on the other hand, did give rise to considerable concern. Many soils were observed with deteriorating structure. Some soils are inherently unstable and are highly susceptible to structural damage under stress conditions. Farming can improve soil structure by influencing the organic matter content, subsoiling and through effective drainage. The report stresses the importance of the use of organic matter on unstable soils to preserve structure. In areas such as parts of the East Midlands, which have recently become more dependent on intensive arable farming than formerly, the declining levels of organic matter in soils, coupled with other factors, were beginning to cause structural problems. The answer suggested was the reintroduction of ley breaks into all arable rotations on difficult soils. In the absence of livestock or because of the difficulty of re-introducing livestock this is a rather commercially unproductive solution. Nevertheless, the resting of land under ley or other breaks may have to be integrated into the cropping plan if the structure of soils is to be maintained. Another observation in the report noted that a range of different soils were suffering from structural problems associated with the passage of heavy machinery in unsuitable conditions. This problem was often evident on farms, on difficult land in medium to high rainfall areas, practising a tight cropping sequence. Careful soil management and particularly timeliness of cultivation and other operations can enable farmers to succeed with an all arable rotation even on inherently difficult soils. The problems of the arable farmer with respect to soil structure would seem to be greater if rainfall levels are high and the growing season short.

Soils are an important limiting factor in crop production but they do not lend themselves to the production of an overall indicator of regional potential for cropping. This is because of their great variability under different conditions and the relatively dispersed occurrence of the different types even within a region. As far as the project cropping plan is concerned the most important fact to remember about soils is that under intensive arable systems problems can very easily arise with soil structure. In a situation where all agriculture was plant-based the state of soils would require careful monitoring to guard against dangerous deterioration in fertility or structure (that is not to say that systems which include livestock are free of such problems). It would also be advisable to ensure that farmers were aware of the possible effects of various techniques on soils. To maximise the potential area of useful arable land and to minimise certain soil associated problems, drainage and irrigation would merit greater investment. These points do, of course, apply to the current system too, but the more restrictive alternative under investigation would probably create a situation where these requirements were of even greater importance.

The Classification of Agricultural Land

A few attempts have been made to comprehensively classify agricultural land in this country. Classifications of this kind can be useful for planning such things as potential use and output. Consequently they provide the best framework on which to base the cropping plan. There are however problems with the available classifications. What follows is a discussion on the two most well known classifications of agricultural land in this country and an assessment of which is most useful for the project.

Agricultural land in England and Wales varies in quality and what it is capable of producing in terms of crops. Many factors can affect the quality of agricultural land, from the type of soil, to the standard of management. Quality can be measured according to a number of criteria; the range of crops the land can support, how suitable that land is for a given enterprise and its potential output. Each measure will be useful for certain problems connected with land-use.

The first attempt to provide some insight into the nature of our agricultural land resource was compiled by Dudley Stamp[7]. His system was published in the form of three maps covering land potential, type of farm and land utilisation. These maps could be used singly or in conjunction with each other. Agricultural land was divided into ten grades on the basis of ranging its potential, from first class to poorest. The amount of good land in England and Wales was estimated to cover 47.9 per cent of the agricultural area, medium land accounted for 32 per cent and poor for 17 per cent[7]. The remainder was land that was built over. These three divisions, good, medium and poor, were sub-divided into the ten grades and thus a fairly comprehensive coverage of the agricultural potential of land was achieved. However, it was also important to ascertain just how productive the land was in an agricultural situation. In order to incorporate some measure of the effect of farming on the land, Dudley Stamp devised the Potential Production Unit (PPU)[7]. The PPU was used to relate the various grades of land to each other by scaling from the base line of a calculated PPU for good average farm land under good management. First-class land had a PPU of 2 while poor light land had a PPU of 0.1. The system was never fully developed even though plans were made to extend the PPU system by equating a PPU with a certain quantity of energy. Boddington[7] suggests that the Dudley Stamp system would have been extremely useful for planners, if it had been fully developed, as it enabled actual comparisons to be made, even if only crudely, between different plots of land on the basis of their output potential. It is very difficult to determine, in some cases, the worth of two or more pieces of land for planning purposes because of the distorted nature of land values and the varying productivity under different systems of farming. A clearly defined index of the output potential of a piece of land which can be very roughly related to its economic worth could therefore be of considerable value.

In 1974 the Ministry of Agriculture published its Agricultural Land Classification[8] which was attempted because Dudley Stamp's work, published in 1940, was becoming rather out of date. The classification was intended to be of use to planners needing some indication of agricultural land quality for planning decisions. Certain problems were foreseen, such as the difficulty of ranking land, classified according to its physical conditions, in any meaningful order. A need for a supplementary survey based on economic considerations, such as productivity, was also foreseen. Producing a classification, even if it were only based on physical factors, is fraught with problems as there is a lack of precise data on soils, regional climates and on the relationship between physical factors and productivity[8]. The MAFF system divided agricultural land into five grades, according to the long-term limits on use. The physical factors considered were soils, climate and relief. Grade 1 land was land that was considered to have very minor or no physical limitations on agricultural use. Soils were therefore deep, well drained, lying on level sites and could be easily cultivated. Reserves of available water present in the soil and no climatic restrictions against crop production, were also essential for committing land to Grade 1. The grades then work down to the poorest, Grade 5, each grade having increasing problems for crop production associated with it. Grade 5 land is said to be land of little or no agricultural value because of extremely adverse soil, relief or climate. The regional breakdown of agricultural land in England and Wales into the five grades is shown in Table 2.1.

TABLE 2.1

Regional Breakdown Of Agricultural Land Into MAFF Land Classification Grades

(H E C T A R E S)

Source: MAFF "Agricultural land classification" 1976.

ADAS Technical Report 11/1 HMSO J.

A number of criticisms have been voiced about the MAFF classification, most especially by planners[7]. Boddington[7] identifies five reasons why he considers the classification an unsatisfactory system:-

1) It is based on the flexibility of land in agricultural use, not upon productivity, however defined.

2) The classification does not even reflect the productivity of land in agricultural use.

3) The grading system is of limited value as there is no stated quantitative relationship between the grades.

4) The system is not easily understood by planners, so is of little use for land-use decisions (one of the stated reasons for having a system of classification).

5) The existing classification does not, but should, form part of an integrated package, including current land

use, yield and financial data on land, which might provide a basis for land planning decisions.

These points are likely to be related to problems actually encountered while formulating some basis for decision on a particular planning issue. Boddington[7] seems to find the absence of quantitative data relating to land the most limiting factor. From the point of view of land-use planning decisions, the question is really whether they should be taken on the basis of available data pertaining to a piece of land, today and in the short term future, which can be fairly quantitatively assessed, or on the basis of how flexibly that same land could be used (at least for crops) in the long term future, a qualitative judgement on the basis of current knowledge.

The arguments surrounding the worth of the MAFF classification are of only minor relevance to the project. At a simple level, the construction of a radical cropping plan requires to know how flexibly a certain area of agricultural land can be farmed rather than what output or financial return is possible. The MAFF classification is perfectly adequate for this, and easily used on a country-wide assessment. The one big problem is the grade 3 land division which covers a large area and a range of possible land-uses. Some grade 3 is of high quality and could support nearly as many crops as grade 2. At the other end of the division, the land is of below average quality and suitable for little other than grass. This problem with grade 3 land is recognised by the MAFF and steps are being taken to split the grade into sub-divisions[9].

Other studies have been done to classify agricultural land. Some are only small scale and localised, so are not of any great use for a countrywide exercise[7]. The soil survey of

Great Britain has devised a Land Use Capability Classification[10] which groups certain soil types, identified in the survey, into seven grades. The grades are then sub-divided into sections which describe the constraints on use. A suffixed initial denotes the constraint, thus "w" denotes wetness. This system has not been completed for the whole country and though more thorough than the MAFF classification still lacks additional useful data on expected output, from different classes, in physical or financial terms.

2.3 Dietary Goals And Constraints

This study attempts to determine whether the population of England and Wales could be fed adequately on a plant-based diet derived from domestic production. The previous chapter discussed both the goals set for agriculture and the physical and biological constraints on farming which are likely to affect the construction of an alternative. There are also dietary goals which it would be desirable to achieve and factors which may well act as constraints on the adoption of the sort of diet likely to be produced under the novel scheme. The first section of this chapter will discuss the dietary goals and the remaining sections will cover nutritional issues which may act as constraints on the diet. It is also possible that the diet could yield nutritional and health benefits and this possibility should not be overlooked.

2.31 Dietary Goals

It was noted in the previous chapter that the main goal of the alternative system under examination was to attain nutritional self-sufficiency. This was taken to mean the provision of the population's nutrient needs from home-grown plant-based foodstuffs. In this way a nutritional goal is acting as a constraint on agriculture and the two areas become more integrated. The goal of nutritional self-sufficiency, if it is achieved, does not imply that the supply of foodstuffs will meet actual consumer demand. The radically different type of diet, resulting from an agricultural system devoted entirely to crops, makes any prediction of what actual demand might be virtually impossible. A further dietary goal, which affects the construction of the cropping plan, is that as great a variety of different types of edible crops as possible should be aimed for. This will help to ensure that the diet is as varied as possible, which should make it more interesting. A varied diet, even if only based on plant foodstuffs, is also likely to provide nutritional balance more easily.

The criticisms levelled at the British diet and other western-type diets suggest that goals to reduce the content of certain types of food in the diet, which appear to increase the risk of contracting certain diseases, such as CHD and dental caries, should be included. However, it is also important to be sure that the diet resulting from the novel scheme is neither deficient in any particular nutrient nor likely to produce other disorders which could become as serious in public health terms as those with possible dietary links that currently cause so much concern. The provision of a diet which will maintain health and result in no serious nutritional problems is a desirable objective of the study. The adequacy of the diet resulting from the cropping scheme can only be determined by an assessment of the medical and nutritional consequences of totally vegetarian diets, but even this information may not be directly applicable. Full coverage is given to the available information on recommended intakes of nutrients and on vegetarian diets in the following sections of this chapter, in an attempt to determine the adequacy of the diet proposed.

In the section on agricultural goals note was taken of current objectives for agriculture in this country. It is difficult to do the same for dietary goals as no comprehensive food policy exists in this country. Agricultural policy covers the provision of adequate supplies of reasonably priced food to consumers. The monitoring of consumption habits and of the nutritional adequacy of the average diet is also dealt with by the Ministry of Agriculture, Fisheries and Food. Health policy does dictate action in some nutritional areas, particularly the proper feeding of vulnerable groups. Efforts are made through legislation and as a result of stated policy to ensure that these groups, which include the old, babies, school children and pregnant women, are fed adequately and in ways deemed most beneficial to health. The Department of Health and Social Security has recently published a booklet(1) aimed at promoting healthier food habits in all sections of society, but no legislation to encourage the reduction of consumption of certain foods, such as refined sugar, is likely and the onus remains on the individual to eat foods which provide a balanced healthy diet. It is important, when constructing an alternative, to be aware of the need for careful monitoring of the average diet and the specific needs of vulnerable groups. Only when, and if, the diet resulting from the cropping plan is assessed as being theoretically adequate can suggestions be made as to whether special steps would be necessary to protect certain sections of the population.

2.32 Recommended Nutrient Intakes

Recommendations as to the desirable levels of dietary intake for essential nutrients are made in several countries and by some international organisations. The number of nutrients included in lists of recommendations varies, and the desirable levels differ between countries, particularly for trace elements. Standard tables of recommended intakes are published for use in a variety of ways. The sorts of use usually cited include the following[2 & 3]:-

* Use as a yardstick for comparing the diets of different sections of the community, thereby enabling officials to detect any increasing nutritional risk, most particularly risks of deficiency, in any sub-group.

* Use as a guide for dietitians and caterers compiling diets for individuals or groups of people.

* Use as targets for planning food supplies and policies at national or international level.

* Use in the nutrition labelling of food, the nutrient content of a tin or packet or an average serving of a foodstuff is sometimes presented as a proportion of the recommended dietary allowances for certain nutrients.

Recommended intakes are not usually comparable with an individual's precise needs for the essential nutrients, because each individual will have his or her own peculiar needs. Some individuals can also apparently adapt to diets with low intakes of certain nutrients, this has been noted for Calcium and Vitamin B_{12}[3 & 4]. A recommended intake must take into account the variablility of need exhibited between individuals. They are, therefore, usually the sum of the minimum requirement deemed necessary to prevent or cure deficiency (or some other criterion) plus a safety margin to take account of the variability of need within populations[3]. The variation in recommended intake levels, apparent between the various sets of standards, arises because of differences of opinion as to what the minimum requirement is and what the safety margin should be. Truswell[3] notes that the criterion for a lower limit on Vitamin C intake, for instance, has varied in the past. The US Food and Nutrition Board suggested that the lower limit should be the amount of Vitamin C needed to prevent tissue starvation of the vitamin, while the British opted for the amount needed to prevent or cure scurvy (the deficiency disease caused by insufficient intake of Vitamin C). Similarly, the criterion for determining the safety margin above the basal need for this vitamin can vary[3]. The British recommendation adds on 20 mg to the 10 mg deemed necessary to prevent scurvy, in order to allow for wound healing. The FAO/WHO, with an identical recommendation, suggests that the safety margin is to allow for variation within populations. Despite differences in opinions about what to take into account when making recommendations for intakes of nutrients, the variation between the standard tables, although it exists, is not very great[3]. This does not mean that the present tables are correct or that the recommendations are in a form appropriate for all the tasks for which they are used. There is still a great deal of work to be done to establish the physiological need for a number of nutrients. Masek[5] suggests that because of this lack of knowledge and because of changes that are occurring, and might yet occur, in society which could affect food needs, recommendations should be under constant review.

In chapter 1.4 a remark by Payne[6] was noted to the effect that recommendations in most developed countries closely matched the actual intake from the average diet. He felt this might well cause some measure of official complacency over the state of the nation's diet. Considering the current concern shown about the "diseases of affluence" and their possible link with western type diets this complacency is not, in Payne's opinion, justified. Truswell[3] also feels there is a need for a change of approach to recommended intakes. The present tables are used for a number of different tasks and may not be appropriate for all of these. He suggests a two tier system; "'Diagnostic' figures would be the physiological minimum requirement plus some allowance for inter-individual variation. They would be useful for diagnosing low intakes. 'Prescriptive figures', a higher tier, would be intended for dietitians, caterers, housewives, nutrition education and agricultural and economic planning[11].

The prescriptive fugures could be expressed in terms of food groups rather than nutrients (although they could be converted into the latter). In this way it would be easier to relate them to a nation's eating habits. If food source is taken into account, this might help to counter the problem of deriving too great a proportion of the intake of a nutrient or energy from a single source. Currently, a lot of concern is shown about the contribution of various food items to energy intake, particularly the proportion contributed by fat and sugar. Truswell[3] therefore suggests that recommendations should also include advice about desirable levels of consumption for certain types of food and other dietary constituents. One attempt to offer just this sort of advice is the fairly recent list of Dietary Goals for the United States[3 & 7]. These are:-

1. Increase carbohydrate (as complex carbohydrate) to 55 - 60 per cent of the energy intake.

2. Reduce overall fat consumption from the current level of approximately 40 per cent to 30 per cent of dietary energy.

3. Reduce saturated fats to 10 per cent of dietary energy and balance the remaining contribution of fat to dietary energy with 10 per cent monounsaturated and 10 per cent polyunsaturated fats.

4. Reduce dietary cholesterol to 300 mg a day.

5. Reduce refined sugar consumption to 15 per cent of dietary energy.

6. Reduce salt consumption to approximately 3 g a day.

These are goals intended to guide food related policies in the

United States but similar ones could be suggested for individuals. Examination of the goals shows that they are not in a form suitable for use, as a whole, by the individual as the sum of the contributions to dietary energy comes to 100 per cent or more without taking into account the contribution from protein (which usually amounts to about 10 per cent of energy intake[8]). Nevertheless for large scale planning the goals could be useful. If similar goals were compiled in this country they might well differ slightly from the United States goals because of differences of opinion about the importance of these particular suggestions in scientific and medical terms, but other goals might be included such as the fluoridation of water to reduce dental caries.

From the point of view of the project, it is important to determine how useful recommended nutrient intake tables will be. Two uses were initially proposed. Firstly the tables could be used for setting production targets for nutritional self-sufficiency. The gross requirements for protein and energy for the whole population are easily calculated from standard tables and are appropriate targets for the novel cropping scheme. Secondly the recommended intake tables are one way of establishing the adequacy of the resulting daily diet, especially for the trace elements and vitamins not covered in the gross requirements and production targets. The calculation of gross requirements for the whole population poses few problems and the addition of a safety margin to the production targets rules out any problems which might result from inaccuracies in the recommendations. The main problem arises not so much in setting the target but in determining whether or not it could be met, given the variability in crop yield and nutrient yield from crops, the wastage and loss of crops, and the effect of processing some crops to produce an edible product, on nutrient yield. The criticisms levelled at the recommended intake tables in the paragraphs above tend to suggest that they should be used with caution when assessing the adequacy of the resulting diet. When some idea of the likely food content of the diet is obtained assessment of the adequacy of the diet cannot be achieved merely by seeing if it meets the nutrient intakes as recommended, consideration of other factors is also important. For instance, although few tables contain a recommendation for a specific quantity of fat in the diet, some is definitely needed not only to meet essential fatty acid requirements and to supply fat soluble vitamins but also to render the diet palatable(9). An individual is only likely to be able to consume a certain weight and volume of food in a day so some consideration must be given the quantity of food in the resulting diet. The calculated nutrient yield of the calculated daily supply of food per person may suggest that the diet is adequate nutritionally but the bulk of the "daily" diet supplied may make it an impossible alternative. Truswell(3) urges caution when recommended intake tables are used for prescribing diets as recommendation rarely take account of losses in food preparation. Any country's standard recommendations for nutrient intakes will also be based on the foods most commonly consumed in that country and the recommendations are usually accompanied by the suggestion that needs are met from as wide a selection of food as is practicable to cover the need for minor vitamins and trace elements for which no numerical requirements are established(2 & 10). There is also the problem of interaction between nutrients or nutrients and other food constituents. This is poorly understood for current diets and might therefore prove to be an even greater problem for a totally new diet.

Bearing all this in mind, it is unlikly that the diet derived from the cropping plan can be assessed purely on the basis of standard recommended nutrient intake tables. This chapter therefore also examines the evidence available on vegetarian-type diets and on the availability of certain trace elements in plant foods. On the basis of this evidence and food intake recommendations some estimation of the adequacy of the diet can be made, although questions of palatability and social acceptability still remain.

2.33 Vegetarian Diets

The alternative examined in this study does not just propose a change in agricultural practice, it also advocates dietary change. The dietary change that would occur is great and would require people to change from an omnivorous diet to one in which all food was from plant sources, in other words a vegan diet. This is a very strict diet as it excludes all animal products. It is important to assess the efficacy of this alternative diet medically and to determine whether there might be any benefits incurred by adopting it, from the public health point of view. It is also important to determine what pitfalls there may be in putting veganism forward as a viable alternative for the whole population. This section will concern itself with the examination of available information on vegetarian diets. Most of this is medical but some sociological studies have been done on vegetarians in western countries. Many people in the world live on a vegetarian diet out of necessity but in the west any moves to follow this sort of diet are likely to be mainly voluntary. Thus most western vegetarians and vegans are highly motivated people, consequently it is difficult to extend information on this group in an attempt to determine the likely effects on the whole population. Studies of totally vegetarian populations are an unrealistic alternative as these are usually in the poor areas of the world where undernourishment and the problems associated with it are rife. This highlights the problems connected with making a realistic judgement on the suitability of plant-based diets for the population of England and Wales. Nevertheless, there may well be very desirable features of the diet which could suggest that moves towards this type of diet are worth advocating for the whole population.

Vegetarianism is hardly a new phenomenon. People have been practising it throughout history, but the reasons for it vary. Barkus[11] notes seven explanations for a vegetarian diet in her book "The Vegetable Passion". These are:

1. ethical objections to killing animals for food
2. nutritional disapproval of flesh foods
3. economic limitations
4. religions or philosophical conformity
5. aesthetic repulsion at the taste of flesh or sight of blood
6. ascetic means to self-discipline
7. mystical belief in the power of animal foods

It is probably fair to add another, namely, moral concern over the squandering of resources in the western world and the poverty and hunger in the Third World[12]. Disillusionment with western society and values has led to an increasing number of people seeking alternative life-styles. This is particularly prevalent in the United States and has resulted in an increase in the number of vegetarians and health food enthusiasts, who for one reason or another see diet as an area where individuals have some personal control which directly affects their health and well being. This growth in vegetarianism has attracted more attention in the States than here. So much so, in fact, that eminent medical bodies have issued warnings about the possible detrimental effects of some diets that are being pursued[13 & 14]. The condemnation is not total, in fact, it is largely confined to highly restrictive diets such as those practised by the followers of Zen macrobiotics. This philosophy stresses the need for man to achieve harmony through the balancing of the Yin and Yang elements of life. Food is an extremely important aspect of this and the dietary practices of Zen macrobiotics are deemed essential for the attainment of harmony. The dietary regime consists of a series of diets, each one more restrictive than the one before[15 & 18]. The higher levels of diet, consist largely of cereals. The maintenance of nutritional balance is therefore difficult and in some cases problems of malnutrition occur. The problem appears to be most severe among infants raised by Zen macrobiotic parents[16 & 17]. This example is obviously an extreme but does point out the need for caution when adopting a new diet. Most vegetarians are perfectly healthy.

It was noted above that vegetarianism can take a number of forms. There are those who object to the slaughtering of animals for food or the taste of meat, but are prepared to eat eggs and dairy produce. These are the lacto-ovo vegetarians. There are also those who eat no animal products at all, the vegans or "pure" vegetarians, and those who only eat fruits (this includes cereals, pulses and nuts but not vegetables), the

Fruitarians. Within these broad groups there are still possibilities for differing diets. The Zen macrobiotic example for instance consists of a range of diets from selective omnivore to highly selective fruitarian. Most of the vegetarian diets practised have a variety of taboos or dietary rules and goals assiciated with them, but then so do most omnivorous diets. The reasons an individual has for becoming vegetarian will to a large extent dictate the sort of diet he or she adopts and the beliefs he or she will have about food. If the reasons relate to health or spiritual well-being it is likely that the type of source of the food will be important. However, the selection of food may not always be governed by considerations of nutritional merit in the accepted sense as these may be overridden by special beliefs about individual foods[19]. There is likely to be a good deal of food faddism and other peculiar beliefs expressed by vegetarians, but this is true, to an extent, with people on mixed diets as well.

In the West people adopting vegetarian diets are likely to be articulate, intelligent, well-educated individuals from the higher socio-economic groups[6]. They are, therefore, not "average" people. The diet may not be cheaper than the mixed diet of the majority, especially if vitamins and other supplements are included[16]. Although, in recent years better organisation and distribution of foods likely to be eaten by vegetarians has emerged, which will probably have reduced the cost of maintaining a balanced and sufficient vegetarian-type diet in western societies. Essentially though Shaw was probably right when he said, "... it is never cheap to live otherwise than as everybody else does; and that the so-called simple life is beyond the means of the poor."[11]

Most of that written above relates to all the diverse types of vegetarian diets practised in western societies. The sort of diet which would emerge from home food production, if agricultural changes suggested in the study were adopted, is a vegan-type diet. This, then, must be the main topic for the rest of the section. It is difficult in the first place to say precisely what a vegan in this country eats. The diet will vary from individual to individual, but in general it is probably fair to say that food is selected from the following groups; cereals, pulses, seeds, nuts, green and other vegetable and fruit[20]. The cereals are invariably whole grain. Vegans also tend to consume very little refined food or commercially prepared food, although some special manufactured foods are available for the vegetarian market, such as nutspreads and soya milks. It is worth pointing out that currently a high proportion of the "normal" constituents of the vegan diet is imported produce. The methods of cooking will also vary and have an effect on the nutritional worth of the diet. Many will cook using variations of traditional cooking techniques from this country; roasting, stewing, etc... The cooking techniques of Asia, where many are vegetarian, are becoming increasingly important, these include sautéing (or quick frying) and steaming[18]. Pressure cooking also seems to be common[18].

A number of studies have been done on the nutritional status of vegans. The approach can vary; either the diet can be examined to see whether it contains all the nutrients needed in high enough quantities or vegans can be examined for any symptoms of nutritional deficiency. Both types of study have been attempted, the first gives some idea of potential risk while the latter can reveal if there are any actual nutritional problems associated with the diet.

The nutritional content of a vegan diet will, of course, vary depending on what is included in it. The content of the average vegan diet was described above and the same sort of selection is given in most of the literature. As animal products are absent from the diet there are certain nutrients that may be susceptible to shortage, simply because they are supplied to a large extent by animal products in an omnivorous diet. These are according to Muller and Mumford[21]:-

Calories	(because the energy density of animal products is on the whole greater than that for vegetables and fruit of equivalent weight)
Essential amino acids	(vegetable protein usually has a lower biological value than animal protein)
Calcium	(a third of the calcium in the United Kingdom diet is supplied by milk)
Riboflavin	(as with calcium, a third of the riboflavin in the United Kingdom diet is supplied by milk)
Vitamin B_{12}	(only supplied by flesh foods in the United Kingdom diet. This vitamin is of bacterial origin)

Iron could probably be added to the list as a large proportion of the total in the average United Kingdom diets comes from meat. There is also evidence to suggest that the iron in plant foods is less readily available than that in meat*.

The energy content of vegan diets has been calculated from the diets of a number of different groups of vegans, from Korean Buddhist monks[22], to "pure" vegetarians in the United States[11]. Calorie intake ranges from 2,210 K cal to

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* see section 2.35

2,830 K cal per day[21], and depending on what recommendations for daily dietary energy intake* are adhered to, this is either too low or within an acceptable range for adults. Requirements for energy do vary between individuals and as none of the subjects in any of the studies (on energy content of vegan diets) were suffering from any obvious signs of undernutrition, it can be presumed that they were receiving adequate energy for their needs. Hardinge and Stare[20] studied, non-vegetarians, vegans and lacto-ovovegetarians and found the energy contents of all the diets to be similar, but that in a fair proportion of subjects from all the groups the energy intake was below that recommended. This work was published in 1954 and there has been considerable reappraisal of energy needs since then, so even these individuals may have had perfectly adequate amounts of dietary energy. The energy content of the diet is important though, especially in a high bulk diet containing items of low energy density. Many vegan diets include a large quantity of green vegetables and fruit necessary from the point of view of the vitamins and minerals they contain, but low in energy. If calorie intake is too low some protein will be utilized as an energy source, if protein is of poor quality and in relatively short supply in the diet, this energy deficit may lead to problems of protein deficiency. Vegans also tend to take less of their calories from fat and protein than individuals on a mixed diet. Table 2.2 gives the energy intake breakdown from a range of studies on vegans (reported by Muller and Mumford[21] and Ellis and Mumford[23] and the current situation for the average United Kingdom diet.

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* intakes reference: DHSS (67), NAS (10) and WHO (66)

TABLE 2.2

Percentage Of Energy Intake
Total Energy

/Source: Miller and Mumford[21], Ellis and Mumford[23]
MAFF (1977) "Household Food Consumption and Expenditure 1975"
HMSO/

As it is now being suggested that only 30 per cent of calories in the diet should be derived from fat[24], there maybe a case for some western vegans reducing fat intake too as the average is 35 per cent according to the studies noted in Table 2.2.

The protein content, or more particularly the essential amino acid content, of the vegan diet has probably received more attention than any other aspect in studies on vegetarian diets. In terms of the quantity of protein consumed vegans usually eat less than either omnivores or lacto-ovovegetarians. Hardinge and Stare recorded an average intake of 83 g per day for an adult vegan male compared with 125 g per day for an adult male non-vegetarian[20]. Results from other studies tend to confirm that the quantity of protein in vegan diets is lower than from other diets. However, as was pointed out in

Chapter 4, the average British diet supplies 71.9 g protein daily[68], well in excess of the recommended intake, which for adult men varies from 37 g to 56 g* of quality protein daily. The more important consideration is not the quantity of protein in the diet but its quality. Plant-protein is sometimes considered second class when compared with animal protein[25]. The concept of protein quality is based on the idea that the amount of each individual essential amino acids present in a protein is important. If the quantity of one or more of the essential amino acids is below a certain critical minimum the other amino acids will not be full utilized (i.e. absorbed during digestion) so some valuable protein is simply wasted. The limiting amino acid in cereals, for instance, is lysine and if this is not supplemented to a level above the critical minimum quantity required for maximal utilization of the protein by the individual, only a small proportion of the protein in cereals is available. However, few foods are eaten on their own and although individual plant-foods maybe deficient in one or other essential amino acid, this can be compensated for by supplementing with a complementary protein which can make up the deficiency. Thus a mixture of cereals and legumes gives a protein mix with higher value to the body than either of them individually. This is because methionine not lysine is limiting in legumes and therefore they can make up the deficit of lysine in cereals, while cereals, with adequate methionine can make up the methionine deficit in legumes. If careful attention is paid to the composition of meals for vegans the quality available in the diet should be adequate for maintaining positive

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* Intakes WHO 1974[66] and NAS 1974[10]

nitrogen balance.

Hardinge, Crooks and Stare[26], in a study on the essential amino acid intake from the diets of pure vegetarians, lacto-ovovegetarians and non-vegetarians, of both sexes, showed that the minimum requirements for each essential amino acid were met for both groups of vegetarians. If any amino acid was at a critical level it was methionine, but all the diets in the study had lower levels of this and cystine than the other essential amino acids anyway. Hughes[27] reached a similar conclusion in another study on the essential amino acids in vegan diets. He felt that the diet was providing the essential amino acids in amounts which could be regarded as "definitely safe". However, he did also say that it would be unwise to stress this point, given the incomplete state of knowledge on the availability of amino acids in food and the variability of protein content in plant foods. A study by Mumford[28] on vegan children in Britain suggested that the amount and quality of the protein consumed was perfectly adequate for their needs. Guggenheim, Weiss and Fostick[19], who studied the composition of pure vegetarian diets in Israel, noted that the nutritional value of the protein in the diet (measured as a protein efficiency ratio) was lower than that in another diet containing milk proteins. This is to be expected if all the protein is derived from plant sources because of the lower availability of this protein. It does not, however, mean that the diet was inadequate, rather it means that the efficiency of protein utilization is not as high as it might be in a mixed diet. If the total protein and energy content of the diet is high enough the problem of low protein availability can be overcome. Taking into account all the available information, therefore, it seems that a vegan diet is adequate (in terms of protein) if

a) energy needs are met;

b) if total protein is above the recommended intake allowance, to allow for reduced protein availability from plant sources;

c) if protein is derived from a mixture of sources which will supplement each other's deficiencies in essential amino acids.

The planning of vegan meals is important in order to take into account these conditions[29]. Certain items which appear in vegan diets have high energy value and good protein content, for instance, nuts, pulses and seeds, inclusion of these in the diet eases the problems connected with meeting the conditions mentioned above.

In the list of nutrients likely to be susceptible to shortage in the vegan diet, calcium, riboflavin, vitamin B_{12} and iron were also mentioned. Hardinge and Stare found, that amoung their pure vegetarian subjects, there were a number with intakes of calcium and riboflavin below the recommended level[20]. Similar findings were recorded for Israeli vegetarians by Guggenheim, Weiss and Fostick[19]. Calcium seemed to be less limiting than riboflavin. Brown and Bergan[18] also found low intakes of calcium and riboflavin in their studies on a group of "new" vegetarians in the United States. The calcium and riboflavin content of green vegetables is fairly high. On a weight for weight basis they are as good a source as milk. Register and Sonnenberg[15] therefore stress the need for ample green vegetables in the vegan diet to ensure adequate intake. Growing shoots and sprouting seeds are a good source of riboflavin. There is some evidence to suggest that calcium absorption from plant sources is not very high because of the antagonistic activities of oxalic and phytic acids which are often present in plant material [21]. The uptake of calcium from the gut is carefully regulated by a number of substances, the most important of which is probably vitamin D. Calcium deficiency is more likely to emergy as a clinical condition, such as rickets, if an individual has insufficient vitamin D present in his or her body rather than because of a lack of calcium in the diet. Adults are capable of synthesising all their own vitamin D by the action of sunlight on their skin. Children which are growing fast, however, have a greater need for calcium and may not be able to obtain enough vitamin D through the action of sunlight, particularly in winter months. Some other source of vitamin D is usually needed[29]. No vitamin D is found in plants[30], so the only extra source for vegans is synthetic vitamin D, which is added to some foods, such as margarine. Various studies have been made on the calcium status of people round the world living on mainly plant-based diets[21], these all suggest that individuals can adjust to a diet with quite a low calcium content. Most of these reports were concerned with populations living in the hot and sunny areas of the world which suggests that there is little likelihood of vitamin D deficiency and that the absorption of calcium from the diet is more efficient.

Iron is another element with a carefully regulated uptake. Although iron content varies from food to food, much of what is present appears, in some cases, to be unavailable for absorption. Iron deficiency anaemia is common in most populations, whatever the diet, and what evidence there is, suggests that vegans do not have a higher incidence of the condition than the rest of the population[4]. The availability of trace elements will receive fuller discussion in Section 2.34, as recent findings may be pertinent to the question of vegan diets.

Of all the vitamins, the two most likely to be in short supply in the vegan diet are riboflavin and vitamin B_{12}. The question of riboflavin has already been discussed above. Vitamin B_{12} is the one nutrient which it is impossible for vegans to obtain from their diet or any other natural mechanism (as with vitamin D). No vitamin B_{12} occurs in plants, the possible exception being comfrey. In fact, the vitamin is only manufactured by bacteria, although it can be found in most animal products. Requirements for the vitamin are not very great and fairly large amounts are stored in the body. Anybody switching from a mixed diet to a vegan diet is unlikely to show any signs of deficiency for a number of years, if at all. Most vegans are encouraged to take the precaution of supplementing their diets with vitamin B_{12}; by tablet or injection, or by eating foods fortified with the vitamin. Others do not supplement their diet but also do not show signs of deficiency. The possible explanations for this are that they have not been on the vegan diet long enough to deplete their storoes; or that their gut bacteria are supplying sufficient vitamin B_{12} for their needs, or even that their needs are so minute as to be easily met by bacterial contamination of foodstuffs[(4)]. Bacterially fermented plant foods are a possible "vegan" source of the vitamin.

Vitamin B_{12} deficiency is associated with three main conditions, megaloblastic anaemia, nervous lesions (which take the form of peripheral neuritis or subacute combined degeneration of the spinal cord) and mental disorders[(4)]. Some early accounts of vegans suggest that their health was sometimes impaired forcing them to return to consuming milk and eggs in order to recover. The sort of conditions they suffered from seems to suggest vitamin B_{12} deficiency. Badenoch[31] treated an adolescent male vegan suffering from subacute combined degeneration of the spiral cord with vitamin B_{12} and the boy recovered, indicating that this was a deficiency syndrome. Megaloblastic anaemia is rare in vegans despite the possibility of low serum levels of vitamin B_{12}, this is perhaps because of the high folic acid content of the vegan diet[4]. Folic acid can substitute for vitamin B_{12} in the formation of normal red blood cells. However, if megaloblastic anaemia occurs as a result of vitamin B_{12} deficiency, either because of malabsorption problems or insufficient intake, treatment with folic acid rather than vitamin B_{12} may cause neurological disorders to develop like the degeneration of the spinal cord noted above. Vitamin B_{12} deficiency can also cause mental disorders such as depression, anxiety, impaired memory, etc.. There are no reported incidences of these conditions in vegans, where vitamin B_{12} has been implicated. Ellis and Montegriffo[4] do report, however, that Badenoch saw two vegans in the early 1950's with a variety of health problems, including inability to concentrate and depression. They responded to treatment with vitamin B_{12}, but it is not claimed that the mental problems were in any way linked with vitamin B_{12} deficiency. Available evidence seems to suggest that individual requirements for vitamin B_{12} vary considerably. Some vegans, for instance, have reached adult life in good health without ever having consciously taken vitamin B_{12}. Their serum levels of the vitamin are also not abnormally low[4]. However, even accepting that some people appear to be able to manage without an obvious source of vitamin B_{12}, it is wise for vegans to take vitamin B_{12} to avoid the possibility of deficiency.

Most of the studies done on vegans in western societies claim that they are, on the whole, perfectly healthy. The recent concern, expressed by the National Academy of Sciences[13] in the United States, about the growth in odd vegetarian dietaries and the incidence of deficiency problems amongst infants with "pure" vegetarian parents, does not, however give any grounds for complacency. There is evidence though, to suggest, despite the worrying question of deficiency, that a well planned pure vegetarian diet can in fact be a benefit to health. A number of clinical and laboratory studies have been done to examine the health of vegans in terms of physical, biochemical and physiological parameters.

The general health of vegans has been investigated by conducting both laboratory studies and questionnaires. Non-vegetarians, age, activity and sex matched with the vegans, are usually used as controls. The clinical studies, by Hardinge and Stare[20], tend to agree on the general conclusion that the health of vegans differs little from that of omnivores. Hardinge and Stare[20] and other reserarchers have pointed out that vegans are often slightly underweight when compared with Insurance company reference weights, although some are within the range at the lower limit. There is no reason to suppose that being slightly underweight causes any health problems, in fact the reverse is probably true. Some children raised on vegan diets, particularly those with no vitamin B_{12} supplements, have been observed to have growth rates lower than average but otherwise healthy. A study[33] done on lung function and cardio respiratory response in vegan women doing submaximal exercise was unable to show any significant difference between the vegan women and selected controls. It is unlikely that the vegan diet impairs physical performance. There has been one odd physiological observation made about some vegans, the significance of which is unclear. Some but not all vegans show abnormal electroencephalogram (EEG) patterns[4]. The abnormality does not appear to be detrimental to health. A number of reasons have been put forward to explain it; previous low levels of vitamin B_{12} in the diet; the existence of some unknown deficiency factor or the possibility that the abnormality represents a metabolic readjustment to the vegan diet[4]. Careful investigation of the condition revealed a correlation between the EEG and the length of time on the diet and between the EEG and plasma cyanide levels[4].

Chapter 1.5 pointed out some of the health problems that occur in western societies which have been linked with the type of diet eaten by the majority. Interest in those on vegetarian and vegan diets has therefore increased as they eat diets similar to those eaten in the less developed areas of the world, where these "diseases of affluence" are less prevalent. Vegetarians would presumably make a good study group for assessing the importance of some of the dietary risks believed to be instrumental in the development of some diseases. As they are by and large exposed to much the same environmental conditions experienced by the majority, they may provide a better basis for comparison than groups from completely different societies.

The vegan diet is usually fairly low in fat (with a greater proportion of this being polyunsaturated than in most western diets), very low in cholesterol and contains no animal protein[34]. It also contains a high proportion of fibre, plant starch and unrefined carbohydrates. The high consumption of saturated fat, cholesterol and animal protein in the west has been linked with the incidence of heart disease. The belief is that these dietary items increase the levels of serum cholesterol and triglycerides, high levels of which are associated with cardiovascular disease. Studies have been done on vegans to determine whether the diet may confer some advantage for the postponement of heart disease. Ellis and Montegriffo[4], and Hardinge and Stare[20] examined fatty acids and serum cholesterol in vegans, lacto-ovovegetarians and non-vegetarians. Amongst subjects in the older age group studied they observed negative correlation between serum cholesterol levels, and total unsaturated fatty acids, and the linoleic and oleic acid content of the diet. In the same group there was a positive correlation between the amount of animal fat, unsaturated fatty acids 16 carbon atoms long, and serum cholesterol; as well as an inverse relationship between the ratio of polyunsaturated to saturated fatty acids and serum cholesterol. But in the younger group studied, which included adolescents and pregnant women, there were no significant differences reported, despite variations in dietary intakes of fat and fatty acids. Studies by Lee et al[22] on Buddhist monks and nuns in Korea, showed serum cholesterol levels to be low, much lower than those observed by the same team when examining both American army personnel and Trappist monks (who live on a lacto-ovovegetarian diet). Heart disease was unknown amongst the Buddhist monks. It is still not clear why serum cholesterol levels are low in vegans, although this is possibly related to the level of total fat in the diet, as well as the cholesterol lowering effects reported for polyunsaturated fats and some plant foods[35] (this latter effect not necessarily being related to the fat content and type). Ellis and Sanders appear to have had some success in treating patients[36] with severe angina by encouraging them to eat diets devoid of animal products, but no published details are available. There is no evidence available to suggest that the incidence of cardiovascular disease is less among vegan than the general population, except perhaps amongst female vegans[32]. There have been very few clinical studies on the prevalence of certain diseases, such as cardiovascular disease, in vegans. Nevertheless, the vegan diet does seem to protect against certain risk factors, such as hypocholesterolaemia and vegans are often fairly abstemious with regard to smoking and the consumption of sugar and other refined carbohydrates.

Dietary fibre is believed to offer some protection against certain diseases. Vegans consume a diet high in fibre and are, therefore, a useful study group for assessing the effects of fibre in the diet. Cancer of the large intestine and bowel are extremely common forms of cancer in western societies living on a mixed diet of low fibre content. Many researchers believe that bacterial metabolites of the bile acids, the breakdown products of the steroids, are the major cause of this form of cancer. Fibre in the diet may prevent the build up of carcinogens in the gut because of its effect on transit time. Other aspects of diet may also be involved, in terms of their effect on the metabolism of the bile acids or their effect on the bacterial flora of the gut. Aries et al[37] set out to determine the faecal flora and faecal steroid concentrations for vegans and to compare these with those observed for people on a mixed diet. They discovered that there were major differences between the two groups. Fewer of the species Bacteroids were found in the faecal flora of vegans and a species unrecorded in faeces from those on a mixed diet, anaerobic sarcinae, was found to be present in vegans. The bacteria isolated from vegan faeces were also less active at breaking down bile acids. The total concentration of bile acids was found to be lower in vegans, perhaps because of the lower fat content of their diet. The concentration of bile acids is believed to be related to the amount of fat in the diet. The main bile acids, cholic and deoxycholic acids, were also found in different proportions, far less deoxycholic acid being present in vegan faeces. This acid can easily be converted into a potent carcinogen. Similar changes in the proportions of bile acids were found by Hepner[38] when he examined lacto-ovovegetarians and omnivores. Total fat consumption for these two groups is similar. The major difference in the diets being the absence of meat from lacto-ovovegetarian diets. Hepner is therefore prompted to suggest that meat has an important effect on bile acid metabolism, and that lack of dietary fibre may not be the area deserving most attention with respect to this form of cancer. Nevertheless dietary fibre does seem to prevent the formation of other conditions and as it increases transit time it may well, if included in a mixed diet, reduce the risk of carcinoma formation by preventing the build-up of toxic substances. The evidence available suggests that the incidence of cancer of the colon and the bowel should be lower in vegetarians, but no reports are available to confirm this.

In summary then, a vegan-type diet can be perfectly adequate if careful attention is paid to its planning, to ensure that nutrient needs (as far as they are known) are met. The reduced likelihood of obesity and the possibly reduced incidence of cardiovascular diseases and cancer of the colon amongst vegans, suggests that the diet may, in this way, be beneficial to health.

The vegan in western societies cannot be described as an "average" individual and the motivation behind his or her adopted diet goes a long way (in most cases) in ensuring that it is balanced and wholesome. If the whole population of this country were to adopt this type of strict diet, given that the previous diet was omnivorous and problems of deficiency were still to be found, the need for nutritional and culinary education, and constructive dietary help from governmental, medical and industrial bodies would probably be enormous. In the section on "nutritional consequences" full account will be given to the question of whether the information available on present day vegans in western society can be used to evaluated the efficacy of the diet which would result from the novel cropping plan.

2.34 Trace Elements

The previous section discussed available information on vegan and vegetarian diets. Certain nutrients were noted as being potentially in short supply in the vegan diet. The most regularly cited possibilities are:

Calcium
Iron
Zinc
Riboflavin
Vitamin B_{12}
Vitamin D

Riboflavin needs can be met from vegan-type diets, as green leafy vegetables and yeast extract are rich sources[15]. The consumption of adequate amounts of these foods should reduce the risk of deficiency. Vitamin B_{12} to all intents and purposes does not occur in plants, therefore, to avoid the possibility of deficiency this vitamin has to be supplemented in the diet[21].

Vitamin D does not occur in plants either, but adults can synthesise their own supply through the action of sunlight on the skin[29 & 30]. The vulnerable groups, needing a dietary source of the vitamin, are growing children and those who get little exposure to sunlight. Supplements of this vitamin or fortification in appropriate foods is probably advisable to avoid the risk of deficiency emerging.

The question of minerals in the diet poses slightly different problems to those encountered with vitamins. The metallic element composition of plants depends to a great extent on the abundance and distribution of the element in soils[39]. The mineral content of plants will therefore vary depending on where the plant is grown. Some elements are found in abundance everywhere and therefore the content of a particular mineral in the daily diet maybe high. The body has therefore developed careful control mechanisms to regulate uptake and prevent toxic levels being reached, although this can happen. The three elements mentioned above, iron, calcium and zinc, are all found in plant foods but their availability to the human body can be affected by a number of factors, including the biochemical balance of the body at a particular time, and inhibitory, and mediating factors in the food which makes up the daily diet. The main part of this section will be taken up with a discussion on iron in the diet, particularly its availability from plant sources. In many ways the problems encountered with iron reflect those of the other two elements, calcium and zinc, but there are nevertheless differences which should be noted. It is also possible that other elements necessary for human health could be in short supply in the diet derived from the cropping plan as it is likely to differ from the vegan diets currently consumed. The possibility that this could be so should not be overlooked although it may be impossible to suggest what elements might prove deficient.

2.341 Iron

The human body contains 4g. of iron, most of which is bound to functional proteins, although some is found in the storage protein ferritin[40]. Ferritin is the emergency supply of iron for the body. The major iron containing protein is haemoglobin which transports oxygen in the blood. Other important iron containing proteins are myoglobin and the cytochromes. The body carefully recycles the iron present but losses inevitably occur[40]. The main losses are through natural wear and tear on hair, skin, nails, etc., and through blood and sweat loss. Iron is required in the diet to replenish these losses. Normally adult men will only have to replace very small quantities of iron but growing children and menstruating, pregnant or lactating women will have a greater requirement and consequently have a greater risk of developing a deficiency. The variability of need amongst different groups is reflected in recommendations for daily intake[41]. The World Health Organization recommendations also vary according to the type of diet eaten (table 2.3)[42]. The diet is assessed for this on the basis of the proportion of total dietary energy contributed by animal-based food. The more reliant a diet is on plant-based food as a source of calories the greater is the recommendation for daily intake of iron, this is because, on the whole, iron in plant foods is less readily available for absorption from the human gut than iron from animal sources. The mean iron absorption from vegetable foodstuffs has been calculated to be in the range of 3-8 per cent of total iron present, whereas for animal foods the mean is in the range of 8-16 per cent[43], only part of the iron in food is therefore likely to be liberated during digestion[52].

It is undeniable that iron in the diet is necessary for the maintenance of health, but the actual amount needed is a matter of some controversy. The problem arises because it is difficult to specify at what level of iron deficiency health is impaired. The condition usually associated with iron deficiency is anaemia, a condition characterized by a reduced rate of red blood cell production (erythropoesis) in the bone marrow which leads to a reduction in the amount of haemoglobin circulating in the blood[44]. Anaemia is a recognised clinical condition although criteria for diagnosis may vary. Often levels of circulating haemoglobin below that considered optimal are observed but the individual shows no noticeable sign of ill health and consequently shows no sign of an improvement in health after treatment[45 & 46]. There is, therefore, some confusion over how iron deficiency anaemia should be identified as the healthy levels of circulating haemoglobin can obviously vary between individuals. There is a suggestion too that "optimum" levels of circulating haemoglobin are below those that are "average" in western communities[47]. It is often the case within a generally healthy sample population that the "average" level of a certain nutritional variable, like the level of circulating haemoglobin, is taken as optimum or nearly so.

Iron deficiency anaemia is one of the most prevalent deficiency diseases in the world both in developed and in less developed countries[47 & 48]. The World Health Organization, therefore, believes the condition justifies high priority for research, treatment and eradication[48]. In Britain some

TABLE 2.3

Recommended Intakes Of Iron According To Diet

Iron requirements in mg.

Proportion of calories from animal-based foods

Aston University

Illustration removed for copyright restrictions

/Source: WHO (1970) Technical Report Series No 452. Requirements for Vit C, Vit D, Vit B_{12}, Folate and Iron/

10 per cent of women and a smaller proportion of men are reckoned to be affected by iron deficiency anaemia[48]. The proportion of a population affected will vary depending on the criteria used for determining iron deficiency anaemia and the sample of the population examined[44]. If reduced levels of circulating haemoglobin are used as the criterion this might lead to an overstatement of the problem if no attention is paid to actual symptoms of poor health accompanying the deficiency. As has been pointed out before, considerable individual variability exists in the levels of circulating haemoglobin necessary to remain healthy. The number of people thought to be affected by iron deficiency anaemia throughout the world is sufficiently high that even if it is accepted that there has been a possible

overestimation of numbers this is unlikely to detract from the importance of iron deficiency as a world-wide issue.

Although many individuals suffer no ill effects from slightly reduced levels of circulating haemoglobin, others do show adverse symptoms. The greater the deficiency of iron, the more severe the anaemia becomes and the worse the symptoms become. The development of anaemia is a relatively slow process which gets progressively worse when body stores of the element are used up and insufficient dietary iron is taken up to replenish losses. It is rarely, if ever, a cause of mortality as the sort of diet which provides so little iron that anaemia becomes worse and worse is likely to prove even more deficient in other nutrients which would cause death far sooner[47]. Iron deficiency anaemia is however thought to affect morbidity and as a result its treatment is important. The disease is usually characterized by symptoms such as fatigue, irritability and reduced work capacity initially[47]. Iron therapy to reduce the symptoms and restore balance should improve the sufferer's quality of life and health. However it is by no means certain that iron therapy, for iron deficiency anaemia sufferers with fatigue, always results in a positive response i.e., reduced fatigue[47]. The question of reduced work capacity is not straightforward either. In theory, reduced working capacity is due to the reduced oxygen binding capacity of blood with reduced levels of haemoglobin. In certain experiments on subjects suffering from mild anaemia, work capacity was not impaired, nor was it improved by iron therapy[47]. On the other hand, there does seem to be a direct relationship between the haemoglobin level in blood and recovery time after exercise[47]. In other work an iron supplement was shown to increase maximum work capacity in a random sample of individuals although there was no observed change in the levels of circulating haemoglobin[47]. These results tend to suggest that the relationship between the ability of blood to carry oxygen, iron status and work capacity are not fully understood.

Other symptoms appear when anaemia gets worse, cardio respiratory function is impaired, blood pressures fall and serum lipid concentrations fall[47]. To some extent the effect of anaemia on blood pressure and serum lipid concentration can be observed in mild anaemia as well. Little is known about the level of circulating haemoglobin below which the effects on cardio respiratory function start to occur. There is, therefore, a lot that is still unknown about iron deficiency anaemia[44 & 47]. On the one hand, there are effects which impair health and increase risk, for instance, anaemia in pregnancy increases the risk of premature delivery, although anaemia is not necessarily the causative factor[47]. On the other hand there maybe effects resulting from mild anaemia which reduce the risk of contracting other diseases. Some doctors believe that anaemic individuals have a reduced likelihood of contracting coronary disease[47]. This possibility is thought to be the result of reduced blood viscosity but both blood pressure and serum lipid concentrations are reduced in anaemia and high levels of both are believed to be risk factors in coronary heart disease.

Not only is the deficiency condition important in the determination of standard requirements for a nutrient but also the availability of that nutrient from food. The availability of iron from food is of particular interest in this project. Iron is a fairly abundant and well dispersed element, so most plant and animal-based food sources contain iron. The richest sources are organ meat, egg yolk, dried legumes, cocoa, cane molasses and parsley, whereas milk, white sugar, white flour, potatoes, fresh fruit and polished rice are poor sources(49). However the whole question of what are the best sources of dietary iron is complicated by the fact that the proportion of iron, in a particular foodstuff which can be absorbed varies quite considerably depending on its chemical form and its interaction with the foodstuff or with other foods consumed at the same time. Iron is absorbed from the gut lumen into the blood stream by a well regulated process involving fairly specific binding sites on the luminal wall which also bind a number of other metals(50). The amount of iron the body is prepared to take up is regulated and tends to depend on the iron status of the body, thus if the body is in a state of iron deficiency it will absorb more iron than when it is in a balanced state(51). Other factors can influence iron absorption(50):

1. The amount of iron presented to the intestinal mucosa; the amount absorbed increases with increasing quantity presented
2. Simple ferrous salts are better absorbed than more complex salts or ferric salts because they are soluble at the pH of intestinal contents
3. Absorption is affected by the food in which the iron occurs:
    * Food iron is in general less well absorbed than inorganic iron.
    * Iron in animal-based food is more readily absorbed (with the exception of the iron in eggs) than iron from plant-based foods.

The situation is further complicated by factors concerned with the diet as a whole. The iron content of the diet will influence absorption(50). The higher the concentration of iron in the diet the more the level of absorption is reduced whereas in a diet of low iron concentration absorption is enhanced. That is not to say that one would get more iron from a diet with a low concentration of iron than one would from a diet containing lots of iron, rather that the concentration affects the absorption.

Absorption from plant sources is often thought to be low because of blocking factors which prevent the iron being absorbed. Oxalate, phosphate and phytate have all been implicated as they react with iron to form insoluble salts and thereby reduce the availability of ionised iron suitable for absorption[50]. This view on the reasons for low availability from plants is sometimes contested as some feel that dietary fibre is the factor most likely to reduce the level of iron absorption from plant sources[53]. The possible explanation for this is two-fold. First fibre may not, because it speeds up transit time through the alimentary canal, present the available iron to the intestinal mucosa for long enough. Second the bulk of fibre may trap free iron preventing it from reaching the intestinal walls. Tea and certain other drinks also inhibit the absorption of iron[54]. The tannins in tea are thought to be responsible for this effect.

The iron in animal-based foods is on the whole more readily available than that in plant-based foods although this too can be affected by other dietary constituents. Plant foodstuffs in a meal will to an extent reduce the amount of iron which is absorbable from animal foods[43]. The iron in egg is largely unavailable because of the action of phosphoprotein in the yolk[50]. Haem iron found largely in red and organ meat is apparently unaffected by any of the blocking agents mentioned above[51].

As well as there being factors which inhibit iron absorption there are also factors which increase iron absorption. Animal protein apparently increases the absorption of inorganic iron and iron from some vegetable sources[50]. Certain amino acids seem to enhance the absorption of vegetable iron by forming iron chelates from which the iron is readily released. This effect has been observed for histidine, lysine and cysteine and other investigators suggest that glutamine, glutamic acid and asparagine may also have a positive effect[51]. Certain fruit juices, such as orange juice, improve the absorption of iron from various sources including egg[50 & 51]. This phonomenon is thought to be due to the acidic nature of many fruit juices which insures that more of the iron which is ionised in digestion remains in this form even in the intestine. The ascorbic acid in fruit juices may play an important part in their effect on iron absorption. It is known to have an enhancing effect on the absorption of non-haem iron[56]. Ascorbic acid is a reducing agent and this may mean that during digestion it reduces some of the iron present to the ferrous state in which it is most readily absorbed[50]. Another possibility is that ascorbic acid forms a chelate with iron[50].

It is clear from all this that the absorption of iron is affected by many factors and this tends to complicate the whole question of whether or not iron requirements could be met from the sort of diet envisaged in the novel plan for food production. If the daily dietary requirements are set to the level of the World Health Organisation recommendations for a diet in which less than 10 per cent of calories are obtained from animal sources and these are then compared with the likely quantity of iron in the diet, some conclusion can be drawn as to whether the diet would or would not have adequate amounts of this nutrient. If it does not, according to this criterion, it may be necessary to supplement the diet with iron in some way.

The whole question of iron fortification of certain foods, particularly white flour, has received much attention. White flour is fortified with iron in this country to a level similar to that which would be found in flour of 80 per cent extraction (the milling and refining process for flour reduces the original iron content of the whole wheat grain considerably)[55]. Many people doubt the efficacy of this public health measure designed to help reduce the incidence of iron deficiency anaemia. Early work by Widdowson and McCance[56] showed that despite lower iron content white bread yielded more iron for absorption than brown bread. Elwood[57] and others found that the iron in white bread was more readily absorbable than that in whole meal bread, but that given the differences in the quantity of iron present in each type of bread, in actual fact the amount of iron absorbed from both sources was roughly the same. In this experiment fortified white flour was used and it seems that the added ferric salt only restored the available iron content to that which would be found in whole meal flour, it did not fortify it to a level above that of whole meal flour. More work was done by Callender[58] and he suggested, that brown bread was a better source of iron than bread made from fortified white flour, after conducting dietary experiments with isotopically labelled bread. The rest of the diet of the volunteers was unstandardised in order that natural, normal eating conditions could be preserved. Recent work by Dobbs and Baird[55] found that the amount of iron absorbed from whole meal and unfortified white flour is roughly the same, consequently they suggest supplementation may be unnecessary. If fortification is the aim then they feel more work should be done to determine whether the added iron increases iron absorption. Apart from Callender's results all the other studies concluded roughly the same thing in a series of experiments which have spanned over 35 years, and no one seems nearer to understanding whether the fortification of bread with iron is a useful measure in the process of reducing the incidence of anaemia or which type of bread, one brown or fortified white, provides the most iron. One report on Bread suggests that it is a useless measure given the complicated nature of iron absorption and the confusion over the clinical and health significance of anaemia(59). The argument about bread has gone on a long time. If the likely diet, from the food production system under investigation here, proved to be deficient in iron, it would be difficult to suggest a better vehicle for fortification than bread but it would also be difficult to categorically say that the fortification would serve its purpose. The alternative approach, if the diet proved iron deficient, would be to provide iron supplements in some other form, such as tablets to guard against widespread anaemia within high risk groups like menstruating women. But this again depends on how critical a public health problem mild anaemia is perceived to be. It is obvious that should an all plant dietary be contemplated for the population of England and Wales careful note should be taken of the information which already exists and new investigations should be performed to establish whether it is an adequate diet and whether any particular problems should be guarded against. The availability of iron from a vegetarian diet is believed by some to be low(60), which strengthens the argument that considerable work would be needed to establish whether or not the diet is adequate.

2.342 Calcium

Calcium is an essential nutrient for man, both for the formation and maintenance of bones and teeth, and for other biochemical functions[61]. Lack of calcium results in rickets in growing children and osteomalacia in adults[61]. These diseases are nowadays believed to be caused by a deficiency of vitamin D rather than insufficient calcium in the diet, although it is difficult to say categorically which of the two is responsible for the deficiency conditions[48, 61 & 62].

As with iron, the absorption and availability of calcium from the diet is influenced by a number of factors. Vitamin D, the level of calcium intake, other dietary components, the age of the individual and hormonal activity, all play a part[61 & 62].

It is known that calcium intake varies widely depending on the type of diet eaten. Despite this calcium balance is usually maintained which suggests that many people have the capacity to adjust to different and even low intakes of the mineral[62]. It seems likely that this adjustment to low intakes of calcium is conditional on the presence of adequate vitamin D in the body. In a country like Britain, where sunshine levels are low, it is important that care is taken to ensure that adequate levels of vitamin D can be maintained, if the calcium intake is low, or problems of deficiency might arise. The main risk groups are likely to be growing children and the elderly. It is as well to point out that vitamin D deficiency (resulting in lack of calcium for major functions) is already a deficiency problem in certain groups especially Asian girls, in Britain[48].

Plant foods are not a rich source of calcium, although bread and green vegetables are important contributors to the calcium content of present day British diets. Calcium availability, like that of iron, appears to be affected by blocking factors such as phytic acid and oxalic acid(61). These two acids may reduce the availability of calcium from plant foods in which they occur. If calcium intake is high, the action of these blocking agens may not be critical but given that the diet under investigation contains no dairy produce (the major source of calcium in British diets) and that the calcium content is likely to be low as a result, phytic and oxalic acid may present a more serious problem to calcium absorption.

Certain writers suggest that the quality and digestibility of dietary protein affects the utilisation and retention of calcium by the body(63). In one study it was shown that in a diet containing moderate amounts of calcium and dietary protein of plant origin, the calcium is not effectively utilised and that quite considerable amounts of calcium are excreted daily(63). For one diet the amount of calcium excreted by some of the subjects was greater than the amount absorbed although this was not so for all the volunteer subjects. This diet contained protein that had poor digestibility and low quality(63). There does seem to be a case therefore for ensuring that the quality of dietary protein is good and that calcium levels are adequate for effective utilisation from the type of diet eaten. There does not appear to be any evidence to suggest, however, that vegans, who only eat plant protein, suffer from osteoporosis any more than people on other diets(63).

Bread has been used since the last war as a vehicle for calcium fortification of the average diet in this country(59).

The fortification of white flour was designed to counter the effects of possible low intakes of calcium at a time when supplies of dairy products were limited. It is now sometimes suggested that the fortification is unnecessary, as the average diet contains more than enough calcium for health and that if fortification were stopped the calcium content of the diet would not fall by an amount sufficient to cause any deficiency problems[59]. This maybe so when the diet contains more than enough calcium anyway but it is possible that in an all plant-dietary, where protein quality and digestibility might be questionable, calcium content low and blocking factors present, fortification might have to be continued. It must be remembered, though, that vitamin D status may be more critical than the calcium content of the diet in which case careful attention to this vitamin might prove of greater value than fortification of some particular foodstuff with calcium. It is also important to remember that blanket measures to supplement diets deficient in a certain nutrient may not be entirely cost effective and may even have adverse effects. The problem of mineral deficiency in most populations, where there is an ample quantity of food eaten, appears to be limited to the more vulnerable groups such as children and pregnant women. Although these groups may benefit from fortification in certain foods other members of the population may be ingesting a quantity of the supplemented nutrient far greater than they need. In the case of calcium, for instance, there is some evidence to suggest that osteoporosis is more prevalent in individuals consuming a diet with a high ash or mineral content[63].

The whole question of whether fortification of the novel diet might be necessary is at the moment rather open and depends on what the calculated calcium content of the diet actually is. Only then can any sensible estimate be made as to whether measures would have to be taken to guard against deficiency. It is, however, important to remember that certain limits to the utilisation of minerals from plant sources do exist.

2.343 Zinc

Zinc is a fairly abundant element but it is not widely dispersed[64]. The zinc content of plants will, therefore, vary considerably depending on where they come from. On the whole, plant foodstuffs are believed to be poor sources of zinc in the diet, so the diet under examination could possibly be deficient in zinc[64].

It is only fairly recently that zinc was identified as an essential nutrient for man. Two workers, Prasad and Halsted separately suggested, in the 1960's and early 1970's, that the growth and sexual retardation of certain dwarfs in Iran was the result of zinc deficiency[48 & 64]. The syndrome responded to treatment with zinc sulphate[48]. The symptoms of zinc deficiency are now fairly well reported. It is usually accompanied by severe iron deficiency anaemia, hepatosplenomegaly, short stature, infantile testes, open epiphyses, spoon nails, rough skin with hyper-pigmentation and often a history of geophagia (mud-eating)[64]. In milder forms it usually inhibits growth and the onset of puberty and impairs the sense of taste[64]. Truswell[48], reports that a number of children in the United States from middle class homes were shown to be suffering from zinc-responsive growth failure (mild zinc deficiency) and were found to be eating very little meat. They responded to supplementary doses of zinc. Zinc does have known biochemical functions. It is a cofactor in some enzymes and is involved in protein synthesis and possibly carbohydrate metabolism(64). The daily recommended requirement is not precisely defined as yet but about 15 mg a day is believed adequate(48).

Of all plant foods whole grains, nuts and legumes are the richest sources(48). The refining of cereals and of legumes, such as soy beans into textured protein products, reduces the zinc content. The preparation of foods also has an effect on zinc content(48). If water contains a fairly high concentration of zinc this may increase the zinc content of foods cooked in it, particularly if the food is acid in nature(64). The possibility of deriving much of the mineral from cooking pots is decreased these days because of the use of stainless steel and aluminium vessels(64).

As with iron, only a small proportion of the zinc ingested in the diet is actually absorbed(64). There are also factors which affect zinc absorption as there are with the other minerals discussed. These include body size, the level of zinc in the diet, calcium, phytic acid, vitamin D and some chelating agents(64). Phytic acid impairs absorption but this need not be a problem in the major zinc containing plant foodstuffs, whole grains, and legumes, if bread is leavened and legumes containing phytic acid are autoclaved(64). There is some evidence to suggest that the utilisation of soy bean protein is closely related to the zinc content of the diet(64). This suggestion may become important if the quantity of textured soy protein eaten were to increase(48). Calcium appears to antagonize zinc absorption but vitamin D increases zinc absorption which suggests that they have a similar uptake mechanism in the gut[64 & 65].

It would be difficult to determine whether the diet produced by the novel cropping plan contains sufficient zinc for health, given the incomplete state of knowledge regarding zinc in the diet. There is a likelihood, if care is not taken to encourage the consumption of unrefined cereals and legumes, that problems could arise as the zinc content of most other plant foodstuffs is low. Zinc is obviously a candidate for much further investigation into its availability from plant-based diets.

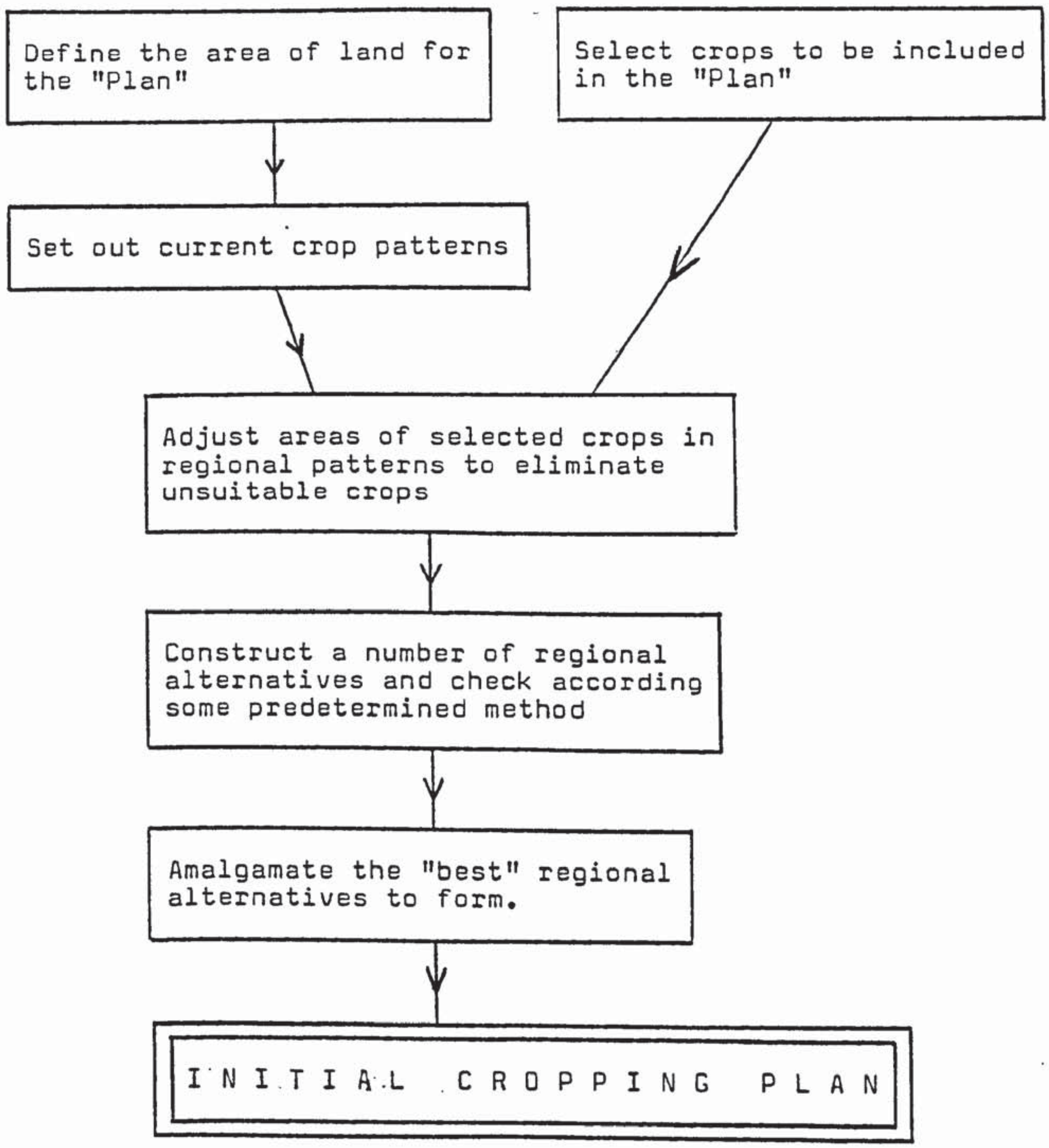
2.4 An Alternative Cropping Plan For Agriculture In England And Wales

2.41 Introduction

The purpose of constructing the alternative cropping plan was to provide a range of crops which gave a potential yield of food and nutrients capable of supporting the basal nutritional needs of the population of this country entirely from plant sources. In this project this has been called nutritional self-sufficiency. The general approach to construction is outlined in fig 2.2.

Once an initial "Plan" was constructed a comparison was made between it and the pattern of crops grown in 1944 during the Second World War. The reason for this comparison was that in the war some move was made towards plant-based agriculture and it was hoped that something relevant to the Plan could be learnt from this experience. The comparison did suggest a number of possible adjustments.

The important goal for the suggested agricultural alternative is nutritional self-sufficiency. After the initial Plan had been compared with the cropping pattern for 1944 it was necessary to determine whether or not the arrangement of crops was capable of producing sufficient output to ensure nutritional self-sufficiency. A particular population and individual nutrient needs were used to calculate, with due reference to the size and the sex and age structure of the population, the gross nutrient needs. The nutrient needs were then compared with the potential output from the Initial Cropping Plan. Only energy and protein output were dealt with at the whole country level. Attempts were made, using the Initial Plan as a starting point, Fig 2.2



General Approach To Construction Of Plan to optimise crop production for protein and energy output using a linear programming technique. Nutritional self-sufficiency is not simply a question of adequate amounts of protein and energy, other nutrients are also extremely important. In the final section of this chapter the potential weekly supply of food derived from the Initial Cropping Plan is examined both to see what sort of foods are likely to be available and to determine how far the supply goes towards meeting a wider range of nutrient needs than that examined earlier.

The approach, throughout the Plan's construction and manipulation, is extremely straightforward, being concerned only with a suitable area, a range of different crops and the recommended nutrient allowances for the population over a year. There are, of course, any number of factors which could confound the realisation of this sort of plan even at the most basic physical and biological level. The two previous chapters discussed in some detail the agricultural and nutritional constraints likely to be encountered with this sort of system which is based entirely on plants. In was also pointed out that it is not altogether possible to use the information which exists, on soils and climate say, as an integral part of the construction process. Although information on what can be grown in small specific areas exists, over larger areas the basic data either does not exist or is not comprehensive enough to be useful. A very simple approach is sensible as it avoids the need for complicated methodological gymnastics which under the circumstances would be neither any more appropriate nor accurate.

The broad, simple approach does have its drawbacks of course, for instance, it cannot hope to shed any light on the situation which might occur at the level of the individual farm, if such a shift in production were to occur. It is highly unlikely that all farms could make the change to an all cropping system for reasons that may vary from soil type encountered to the size of the holding. In part 3 of this thesis there is an appraisal of the potential for a change to cropping on a mixed enterprise farm in the west country, an area that is, mainly because of its climate, a "marginal" area for plant-based agriculture. The limitations of the simple method must always be borne in mind.

2.42 The Conditions Governing The Construction Of The Plan

It is essential when constructing a speculative system, which differs radically from the one in current use, to be sure that the conditions guiding the construction are set out in full. These conditions are what, in most cases, shape the final output or, in this case, Plan. Some of the conditions have already been noted, the following, however, constitutes a complete list.

1. In order to reduce the uncertainties of the Plan, it was decided that only crops currently commercially cultivated in this country were to be included in the Plan. "Exotic" crops, such as lupins and sunflowers, were not included as their potential here in Britain is largely unknown*.

2. The working area of the Plan and the initial cropping pattern from which the alternatives were constructed was the 1973 arable area and cropping pattern for England and Wales. It was possible to take account of the constraints imposed by soils, climate etc., by using an area which was already known to be capable of supporting commercial crops.

3. The acreages of fodder crops with vegetable counterparts e.g. turnips and other fodder brassicas, were recategorised as human food and subsequently adjusted to a desirable acreage in the Plan. No crops which

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* Another study being done in the Technology Policy Unit is concerned with the future of alternative non-animal sources of oil and protein for human food in Britain.

were purely for fodder were retained in the Plan*.

4. Attempts were made to ensure that alterations in the basic pattern of crops were kept to a minimum, even though all the crops grown had to be suitable for human use as food. The maintenance of cereals as the most important crops in acreage terms and the retention of temporary grass are examples of this attempt to preserve the basic pattern. It was hoped that transition to the novel system would be less complicated, in theory, if the changes in the fundamental cropping plan were kept to a minimum. This is, of course, a simplification of the whole problem of what makes change simple or difficult but the condition was imposed. If the required shift is seen to be fairly routine and to require no radical new crop husbandry approaches the whole concept in agricultural terms does become more credible.

5. Any cropping plans generated had to be checked according to a standard method which was based on, the MAFF Agricultural Land Classification. This 'check' method involved an assumed link between certain crops and certain types of land; certain special crops would, it was decided, be limited to specific areas. The special crops were taken to be wheat, beans, sugar beet and field vegetables. These it was assumed were confined to MAFF Grades 1 and 2 land, the "best" land. If this best land is assumed to be currently in arable production, a simple check is possible by comparing the percentages of grades 1 and 2 land in the Plan area with the percentages devoted to the "special" crops in each alternative. Alternatives were discarded if "special" crop percentages were greater than "best" land percentages.

2.43 The Construction of the Initial Cropping Plan

The alteration of cropping patterns was tackled at the level of the Ministry of Agriculture region. The time involved in doing the analysis at farm or county level made these approaches impractical. Analysis of the whole country at once would have made integration of regional variation far more complicated. Using regions, account could be taken of soils

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* Temporary grass is one exception to this, it is included to preserve soil structure and to give a break in the cropping sequence - see 2.44.

and climate as they affect cropping. This proved the most realistic scheme.

The 1973 crop patterns, for each region were arranged in tabular form[1]. The alternatives were then formed by shifting acreages from non-food to food crops. (For an example of a shift to produce an altered pattern see Appendix II). Fodder crops were reduced to a minimum. Note was taken, in each shift, of a regional conditions and suitability for a specific crop as far as this could be judged. Three alternatives were drawn up for each region. The construction of these was based on a number of varying assumption which were to act as loose guidelines.

Thus, alternative 1 assumed:

1) a continuation of bread wheat imports. As animal feed grade wheat would not be required home production of wheat could fall and the acreage be reduced by about 400,000 hectares.
2) a continuing demand for sugar and improved levels of self-sufficiency which would require an increase in the acreage of sugar beet.
3) a reduction in all animal feed crops.

Alternative 2 assumed:

1) a discontinuation of bread wheat imports which would encourage an increase in home production of either soft wheats or some of the newly developed hard wheats suitable for British conditions.
2) a reduction in sugar consumption. As Britain is far from self-sufficient in sugar a reduction in consumption may still provide room for increasing output and acreage of sugar beet.

3) a reduction in all animal feed crops.

Alternative 3 was constructed bearing in mind the same assumption as for alternative 2 but taking them further to create a more extreme alternative. The assumptions were useful for shifting acreages of crops from one use to another but they did not affect the choice of alternatives as this was achieved using the "best" land-"special" crop check. The selection can be seen in Table 2.4. When the selected alternatives for each region are amalgamated into a countrywide plan the assumptions which guided the construction of the alternatives become invalid. The method used for selecting each regional alternative does not take into account the construction assumptions, consequently it is unlikely that the choices will all appear under one alternative heading.

The amalgamation of selected alternatives provides the Initial Cropping Plan, which is shown in Table 2.5.

TABLE 2.4

The Land Classification Check

A comparison of the percentage of "special" crops areas with percentages of Grades 1 and 2 land in each region and the regional alternatives.

Region	% not to be exceeded	Current Proportions	Alt. 1	Alt. 2	Alt. 3
Northern	15.4	9.9	9.45	14.8*	23.0
Yorkshire/Lancashire	54.3	26.4	25.8	27.8	28.8 *
Eastern	52.8	41.1	50.4 *	54.3	56.0
West Midlands	40.0	19.9	20.7	22.7	24.2 *
South west	22.1	11.8	12.6	15.3	14.98*
South east	27.0	23.5	24.8 *	28.9	30.4
East Midlands[A]	33.7	37.4	37.8 *	39.7	40.8
Wales	14.0	2.4	3.8	7.8 *	12.4

* selected alternatives

A The selected alternative for the East Midland region exceeded the "best" land check limit, as did the present proportion of "special" crops in the region. However, as the selected alternative percentage and the present percentage were so close it was decided to accept alt. one for the E. Midlands. The problem largely disappears on amalgamation in any case.

TABLE 2.5

Initial Crop Plan For England And Wales

Total Area 5,641,098 hectares

Crops	Hectares	% of Arable Area	% of Arable in 1973 A	% of Arable in 1944 B
Wheat	1,378,270	24	19.8	21
Barley	1,565,130	27.7	33.2	12
Oats	305,573	5.4	3.4	15.3
Rye	41,549	0.7	0.1	
Maize	3,686	0.06	0.02	
Early potatoes	24,597	0.4	0.4	6.7
Main crop pts.	176,669	3.1	2.7	
Field beans	82,978	1.5	1.1	
Turnips and swedes	24,510	0.4	0.8	3.3
Cabbage	22,407	0.4	0.04	
Oilseed Rape	47,569	0.5	0.2	
Sugarbeet	202,012	3.6	3.4	2.8
Hops	6,899	0.1	0.1	0.1
Orchards	57,446	1.0	1.0	1.8
Small fruit	13,317	0.2	0.2	0.2
Open Air Vegetables	264,357	4.7	3.2	2.7
Glass house crops	1,928	0.03	0.03	
Flowers, bulbs etc.	15,116	0.3	0.3	
Other crops	18,203	0.3	0.2	11.6
Lucerne	29,365	0.5	0.2	
Grass (temp)	1,301,652	23.0	26.0	20.4
Fallow	57,853	1.0	1.0	

A. 1973 figures from MAFF (1975) "Agricultural Statistics, England and Wales: 1973" HMSO

B. 1944 figures from MAFF (1967) "A Century of Agricultural Statistics 1866 - 1966"

Large percentage in other crops includes fodder crops not now in lists.

2.44 War Time Food Production: Its Relevance To The Plan

Food production over the six crisis years of World War Two moved towards the production of more plant foods for direct human consumption and a decline in livestock numbers[23]. It was decided that an examination of the wartime situation might prove useful as it was an actual shift in production in the general direction envisaged in the Plan. There was no move to remove animals completely from the wartime food production scheme because as much use as possible had to be made of every method of food production.

The most interesting point that emerges on examination of the wartime food production effort is that of a critical tillage area. The lynchpin of the agricultural effort to produce more food was the ploughing up of permanent grassland to increase the area under crops[2]. This went on throughout the War, but the area being tilled actually reached a maximum in 1944[4]. The reason given for this critical point was that land which had been intensively cropped for 4 or 5 years was suffering from reduced fertility and soil structure problems[2]. This meant that quite large areas had to be resown as leys thus negating the cropping advantages of newly ploughed up permanent pasture.

There is no way of knowing whether with a more determined plough-up campaign this threshold could, in fact, have been raised, because the war ended. There is, however, a limit to the amount of permanent pasture that could be usefully ploughed up for arable and consequently a limit on the area of tillage possible with present cropping techniques, even allowing for the advances which have occurred in the past 35 years. Developments may perhaps occur in the future, which will enable intensive cropping to be carried out indefinitely and still preserve the soil's structure and fertility, both of which can so easily deteriorate under intensively cropped systems. Initially the area examined in the Plan did not include any land which was not currently in arable use, but should insufficient food be produced from this area it might be necessary to enlarge it. This would entail ploughing up permanent pasture. If this were necessary it would be important to remember that the potential area under edible crops would still be less than the total new arable area because of the need for breaks in cropping on some soils to reduce the risk of declining fertility and deteriorating structure. It has been suggested that between 1.5 million and 600,000 hectares(6)* of permanent pasture could be ploughed up for arable.

In Table 2.5 the crop pattern for the Plan and that for 1944 were both included. Comparison of the two may suggest ways in which the Plan could be further adjusted. The percentage of the Plan area devoted to cereals is considerably higher than that in 1944 but as it is similar to the current percentage this was not considered a problem. The difference could probably be explained, at least in part, by the improvement in the technology of cereal production over the past 30 years or so which has increased the potential area on which cereal growing can profitably occur. The main cereal problem in the Plan concerns barley. A large proportion, in the region

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* the figure of 600,000 hectares is a rough estimate based on Blaxter's figure of 2 million acres of permanent pasture which would need to be ploughed up under his scheme for the whole of Britain. Presumably, this 2 million acres is potentially arable land.

of 80 per cent, of the barley crop is grown for animal feed at the moment, and the greater part of the remaining output, which is for more direct humun use, goes for malting(7). Only very small amounts of barley are currently consumed by humans in this country as a food. Under the novel dietary regime either a taste for barley as a food must be cultivated (a taste for beer is already well established) or the acreage must be reduced. In 1944 the acreage of barley was much smaller than now or in the Plan and that of oats was much greater. Although oats are perhaps more acceptable than barley as foodstuff now, it must be remembered that the large acreage of oats in 1944 was mainly for animal feed, not human food. In food and nutrition terms, a substantial acreage and output of cereals is important for the Plan as they will provide the most likely source of fairly concentrated energy and protein in the diet which is likely to emerge. Pulses are a rich protein alternative and have amino acid profiles which complement those found in cereals so that spare land resulting from a reduction in the barley acreage would ideally be filled with them. However, suitable pulse crops for the damp temperate climate of England and Wales are few and far between. Potatoes might be a more likely possibility for taking up any slack resulting from a dramatic reduction in the barley acreage. Nuts are another fairly protein rich alternative but these, if suitable cultivars which crop regularly in this country could be found, are unlikely to be an alternative suitable for occupying land formerly down to barley.

Comparing the 1944 pattern with the hypothetical pattern of the Plan also raises the question of the need for temporary grass and what area of this would be most desirable. The proportion of temporary grass in the Plan exceeds that of 1944. Leys are an integral part of the rotation on many soil types. It has already been noted that the tilled area in 1944 was at a critical level as the ploughing up campaign designed to release more land for arable was counteracted by much re-sowing to grass. The level of temporary grass in 1944 therefore represents, to all intents and purposes, a threshold percentage which could be safely aimed for under a scheme for plant-based agriculture, especially if it is remembered that 35 years have passed and considerably technical improvements have occurred which might suggest that an even lower percentage is possible. Fallow and crops for green manure are also included in the Plan for reasons related to the maintenance of soil structure, organic matter levels and fertility.

The fact that wartime food production shifted in the direction it did, does present some precedent for the moves suggested in the Plan. However, it must be remembered that the moves which occurred then were the result of national crisis. Direct comparability, between the situation in 1944 and a theoretical alternative for food production in this country now, is perhaps something which should not be belaboured.

2.45 Potential Nutrient Output And Nutritional Self-sufficiency

The size of the population assumed in this work was just over 49 million, the population of England and Wales in 1973[(8)]. Protein and energy requirements for this population were calculated from World Health Organisation tables of recommended nutritional requirements[(9)], taking into account the age and sex ratios of the population and making an allowance for pregnant and lactating women*. The yearly requirements for protein and energy were calculated as being:-

approximately 186.2 MGJ energy

and approximately 700,000 tonnes of protein

The energy and protein output from the initial cropping plan were determined from food composition tables(14). The output and level of nutritional self-sufficiency are shown in Table 2.6. Losses occur throughout the food production system, so levels of energy and protein self-sufficiency are also included in which an allowance is made for loss.

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* WHO estimates for pregnant women in a population assume 10% more pregnant women than infants aged 0 - 12 months. Number of lactating women is related to number of infants under 12 months(10).

TABLE 2.6

Potential Output Of Energy And Protein From Plan And Level Of Nutritional Self-sufficiency

Crops	Energy ($MGJ = 10^{15}J$)	Protein (tonnes)
Wheat	75.6	738642
Barley	86.0	442650
Oats	19.41	141712.5
Rye	1.7	9744
Maize *	0.4	1615
Early potatoes	1.47	7241.4
Main crop potatoes	18.73	105736.4
Field beans *	0.47	53352
Turnips and swedes	0.7	8692
Cabbage	0.6	15115
Oilseed Rap (as oil)	1.5	-
Sugarbeet (as sugar)	20.02	-
Brussels Sprouts	0.4	9075
Cauliflower	0.2	5832
Carrots	0.8	5688
Beetroot	0.3	3092
Broad Beans	0.2	3957
French and runner beans	0.1	2445
Green peas	1.02	20857
Dried peas	1.29	22970
Parsnips	0.3	2535
Onions	0.4	3899
Lettuce	0.1	1874
Watercress	0.01	543
TOTAL (rounded)	232	1607267
with 30% wastage ** factor removed	162	1125087
Self-sufficiency (with waste removed)	125% (87%)	230% (161%)

This table does not constitute a complete list of the crops in the Plan but includes those occupying the largest area and those with fairly high energy and/or protein content.

Protein and Energy composition of crops largely from Paul, A. A. and Southgate, D. A. T. (1978) "McCance and Widdowson's: The Composition of Foods" HMSO

* Composition from Watt, B. K. and Merrill, A. L. (1976) "Handbook of the Nutritional Contents of Foods" for USDA Dover Publication.

** The figure of 30% wastage is a compromise figure based on a number of estimates for wastage in the food system which are noted in Roy, R. (1976) "Wastage in the UK Food System" Earth Resources Research Publication. p. 3 and 4.

The potential levels of self-sufficiency in energy appear far more critical than for protein in the initial plan. The output of protein is so large, that at least in theory, there seems to be little need to take account of its nutritional quality at the macro-level. However, attempts were made to construct a simple model to maximise protein output in terms of total quantity and nutritional quality, and to maximise for energy output, which was more obviously critical to the feasibity of the Plan. A linear programming model was originally envisaged which would permit considerably manipulation of the Plan. This did not, however, prove feasible as the system had too few quantifiable constraints. The alternative adopted consisted of two simple iterative calculations, one to maximise for energy output, and the other to maximise for high quality protein output. The approach still used a linear programming technique but not one of sufficient sophistication to warrant the use of a computer. The constraints imposed on the maximisation calculations were in part the same as those which guided the construction of the initial plan; the total area was set at 5,541,098 hectares, the "special" crops were confined to the 1,486,948 hectares of grade 1. and 2 land and all the crops appearing in the initial plan had to appear in the maximisation examples to ensure as wide a variety of crops and hence dietary constituents as possible. This final constraint meant that lower limits on the acreage of all crops had to be set. Some crops were given a fixed acreage which to all intents and purposes excluded them from the calculation. These included hops, flowers and bulbs and miscellaneous categories such as other vegetables. Certain crops such as wheat, had upper limits set by physical constraints, in this case the best land constraint. In order that single crops without upper limits on their acreages did not end up with all the remaining acreage, when lower limit and fixed area acreages had been accounted for, upper limits were set on most crops.

The object of linear programming is to minimise or maximise the value of a function such as ⓪, subject to certain constraints.

$$Z = \sum_{a_n x_n}^{a_1 x_1} f(x_n). \quad . \quad . \quad . \quad ⓪$$

In the calculation attempted $x_1 \ldots x_n$ represented the acreages of the various crops and $a_1 \ldots a_n$ were the coefficients which conditioned the eventual size of $x_1 \ldots x_n$ and the size of Z. The maximisation of energy output required the coefficients to be the yields of energy per hectare for each crop. In order that the calculation could be simplified these yields were indexed on a 1 - 10 scale. The maximisation of protein output on the basis of the quality of the protein required a slightly different approach. The output of protein per hectare for most of the crops considered was remarkably similar, so that choosing which crops to increase in area would have been entirely arbritary. An index was therefore developed based on both the yield of protein per hectare for a crop and the chemical score of the protein in that crop. The numbers generated in this index acted as the coefficients to the crop acreages in the objective function. Full details of both calculations are given in Appendix III.

The energy maximisation attempt improved self-sufficiency in food energy by 4 per cent. If the waste factor was again included, food energy self-sufficiency still fell below 100 per cent. The maximisation was a very cautious attempt to improve the situation as the mix of crops was not changed very significantly. If it were absolutely imperative to increase the energy output, either the arable area would have to be expanded and greater amounts of high energy crops, such as cereals, potatoes or sugarbeet, planted, or it would be necessary to increase the area of high energy crops at the expense of other crops of lower energy content.

The protein maximisation calculation gave an increase in protein self-sufficiency of 17 per cent and when an allowance was made for wastage the figure was still well over 100 per cent.

Neither of the maximisation calculations resulted in any major changes in the initial Plan. If more were known about the type and quantity of land suitable for growing each crop the constraints could have been more scientific and the model more sophisticated. The problem with studying the whole country is that the data, if it exists at all, is so dispersed that collecting it and doing all the other background work would be impossible for a three-year study. Nevertheless, the two calculations do give some guidance as to what crops would have to be grown in greater quantity if the country were to achieve self-sufficiency in food energy and protein. The crops which give the highest output of both energy and protein are the cereals and potatoes. High energy crops such as sugarbeet contain no protein which is currently recovered, planting more of this crop would boost energy output but perhaps not in a form which many nutritional experts would recommend. Peas and beans are rich in protein and have a reasonable energy content when in the form of dried seeds but the production of dried pulses is difficult, in all but the most climatically well favoured parts of England, and yields are often low.

The fact that nutrient output from the Plan has only been assessed on the basis of energy and protein also means that other crops should not simply be dismissed because they are not rich in protein or full of energy. They will have their own advantages in terms of their nutrient content or their acceptability and desirability as foodstuffs. The potential nutritent content of a week's food supply per head will be examined to determine whether serious adjustment is needed in the cropping plan to produce a nutritionally adequate and palatable diet.

2.46 The Weekly Supply Of Food Possible From The Novel Scheme

The average weekly supply of foodstuffs per person would weigh about 10 Kg. This gives a daily supply of 1.4 Kg. per person, of miscellaneous vegetable foods. These figures do not make any allowance for processing or seasonality and are consequently very rough approximations. The bulk or total weight of the diet would probably be increased in the cooking of cereals. The most important single contributors of weight to the diet are the cereals and potatoes. The 2 Kg of barley, available in the weekly supply, would probably be substantially reduced as much of the barley produced would go for brewing.

An attempt was made to compare the weekly supply of food produced in the Plan with the food, buying pattern in 1974. This comparison is shown in Table 2.7, unfortunately, the figures are not really directly comparable. However, certain broad comparisons can be made to give a better idea of the amounts of food provided by the novel scheme.

TABLE 2.7

Comparison Of Calculated Supply With Current Weekly Buying Pattern

[Source: 1974 figures from MAFF (1977) "Household Food Consumption and Expenditure 1975" HMSO]

The amount of sugar produced in the Plan comes to just over 0.46 Kg, which is larger than the amount purchased weekly per person in 1974, although the figure for 1974 does not include sugar incorporated into other foodstuffs such as jams and confectionery. The potential weekly supply of most vegetables, except glass-house salad crops, exceeds that purchased in 1974, but it is not clear whether the 2.1 Kg of vegetables available would be sufficient to provide interesting and varied meals over the whole week. The total visible fat produced in the Plan is only a fraction of that currently purchased. Fat is one of the main problems in this sort of all-plant scenario for agriculture in temperate climates. There are too few oil bearing seeds suitable for the climatic conditions found in England and Wales. The only really viable oilseed at the moment is oilseed rape which already occupies 47,000 hectares in the Plan. If this area were doubled or even trebled it would not significantly improve the situation with regard to the amount of visible fat available, which in the initial plan was estimated as being 0.01 Kg per person, per week. The problem of novel plant sources of oil and protein is being investigated by a colleague, Richard Stanley (in the Technology Policy Unit) who hopes to extend the Plan for plant-based agriculture to include crops which are believed to have some future potential for British agriculture. The 1974 figure for total fat purchases per person in a week was 0.3 Kg. It must also be remembered that rape oil contains antinutritional factors which currently limit its inclusion in most oils, compound fats and margarines(11). Any attempt to increase the oilseed acreage, although it would improve the fat situation, is likely to result in a cut-back in the acreage of other crops and in fact, a reduction in food energy producing potential. Although fats have a high calorific value, the yield of oil per hectare is low and the energy yield per hectare under oilseed rape is poor compared with cereals or potatoes. The energy output for oilseeds can be improved if account is taken of the protein rich oilseed residue after oil is extracted, this has food energy value if it can be processed to form some sort of protein product. The weekly supply of food would also contain less fruit than the amount currently purchased. Bread, cereals and potatoes would however be more important and the amounts purchased would have to be greater than at present. The mainstay of the diet would, in fact, be cereals and potatoes with a mixture of vegetables.

It is difficult to compare the 1974 food purchasing pattern realistically with the calculated supply of food from the Plan. For one thing the food purchasing pattern in Table 2.7 only represents a fraction of the complete food purchasing pattern for 1974. Animal-based foods such as meat, milk and eggs, and beverages for instance, are excluded. It has been argued that the diets eaten in western countries (including Britain) are too rich, in protein, fat and refined carbohydrate, for good health which indicates that a more frugal diet would be beneficial to health (see section 1.4). The diet derived from the Plan is certainly more frugal in terms of the variety of food available and also in terms of fat content.

The energy, protein, iron, calcium, vitamin B, and vitamin C content of the weekly supply of food from the Plan were calculated to determine the nutritional adequacy of the diet. The content of certain vitamins such as vitamin D and vitamin B_{12} is so small as to be unmeasurable in plant foods

TABLE 2.8

The Potential Supply Of A Range Of Nutritional Factors From A Week's Supply Of Food Derived From The Plan

	Energy (kj)	Protein (g)	Iron (mg)	Calcium (mg	Vit B (mg)	Vit C (mg)
Cereals	69857	509.59	119.06	1206.7	14.74	-
Potatoes	7849	44.3	10.6	169	2.32	295.4
Vegetables	3832.7	66.24	20.03	916.2	2.20	506.3
Fruit	415.7	0.97	0.98	25.3	0.12	41.2
Vegetable oil	369.6	-	-	-	-	-
Sugar (White)	7728	-	-	9.2	-	-
TOTAL	90052	621.1	150.7	2326.4	19.4	843
Adjusted total including 30% waste factor	63036	435	105.5	1628.5	13.6	590
Requirements of Average individual A	72800	269.2	87-115 B	3880	6.54	199
Actual average intake per week (1974) C	67900	496.3	81.2	7070	8.05	350

Notes

Food composition values taken from Paul, A. A. and Southgate, D. A. T. (1978) "McCance and Widdowson's: The Composition of Foods" 4th Revised edition HMSO 4th Revised edition HMSO

A. These figures are for an average individual in the population as noted in 2.45 and are based on requirements from WHO (1974) "Handbook on Human Nutritional requirements" Monograph Series No. 61.

B. Iron requirement: an average of all age and sex requirements for iron in diet containing less than 10 % of calories from animal sources. WHO (1970) Tech. Report. Series No. 452 "Requirements for Vitamin C, Vitamin D, Vitamin B_{12}, Folate and Iron"

C. MAFF 1977 "Household Food Consumption and Expenditure: 1975" Table 29 HMSO according to food composition tables. The calculated nutrient content is given in Table 2.8 along with the weekly requirements of an average individual in the population for these nutrients. There is, if no loss factor is taken into account, adequate amounts of all the factors in the table except calcium. If account is taken of wastage, there is insufficient energy, calcium and possibly iron, if the recommendations for diets deriving less than 10 per cent of their calories from animal sources are adhered to. Adequate energy levels are required to improve the utilisation of the other nutrients, particularly protein, by the body, so it is important when the margin between the calculated supply of protein and the requirement for it is not very large that energy needs can be seen to be met(12). The margin between the adjusted protein supply and the requirements of an individual in the sample population would seem to be adequate even if the protein is of plant origin, but this adequacy must be in doubt if the supply of energy cannot be increased. However, it has been noted previously in 2.44 that to ensure nutritional self-sufficiency it will be necessary to expand the Plan area by ploughing up permanent pasture and cropping it with cereals, say, to make up the shortfall. In 2.33 and 2.342, evidence was presented which suggested that individuals can adjust to low calcium intake but this probably only occurs where adequate levels of vitamin D can be guaranteed. The diet derived from the Plan supplies no vitamin D, all this vitamin would have to manufactured by the body under the action of sunlight. In northern Europe sunlight levels are not sufficient to ensure that vitamin D deficiency would not be a problem. It, therefore, seems likely that some supplementation procedure to boost calcium and vitamin D levels would be needed if the diet derived from the Plan were to be considered adequate. It is also of course possible, as was noted in 2.3, that other nutrients maybe deficient in the diet derived from the Plan.

If the calculated weekly supply of nutrients is compared with the actual average intake of nutrients for an individual in 1974 (see Table 2.8) it can be seen that the Plan derived diet compares quite well with all the nutrients mentioned except calcium and to a lesser extent energy and protein.

2.5 A Comparison Between The Present System And The Novel Cropping Plan

The rationale for doing a study like this hinges on some of the criticisms levelled at the current agricultural and food situation in this country. The study has applied itself most particularly to the problems of over reliance on imported supplies of food and feed and those of diet, in so far as the present diet is related to the rising incidence of certain health problems. It is however sensible to try and determine whether the alternative system does alleviate any of the other perceived problems of modern agriculture and what measurable differences there are between the systems.

One of the assumptions made for the construction of the Plan was that current agricultural technology would be used. This made it easier, for example, to calculate output as current yields could be used with a fair degree of certainty. It would not have been possible to do this if a change in technique had been envisaged as well, for instance, if a fully organic system had been proposed. The detrimental effects of certain agricultural practices, such as spraying, on the environment are therefore unlikely to be alleviated to any great extent unless a change of course towards more biologically sound methods occurred. Developments of this kind were outside the study brief, so it must be assumed that the novel system will not improve the situation in this respect. It is fair to say though that the problems of environmental damage resulting from the use of agricultural chemicals need not be increased under the novel plan as set out in 2.4, if only because the area covered by the initial plan is precisely the same as that currently cultivated for crops. If the Plan area was increased by ploughing up some permanent pasture, a situation which would be necessary if it were truly the intention to provide basal nutrient needs for the whole population from home plant-based agriculture, then the extent of agricultural chemical usage might be marginally greater, thus increasing the risk of environmental damage from this source.

The use of fertilisers would be affected by the change. Certainly the use of fertilisers on permanent pasture would cease when they become agriculturally redundant and as temporary grass would not be required to produce maximum output little or no fertiliser would be required for this. Current usage of fertiliser suggests that some 50 per cent of nitrogenous fertiliser, 40 per cent phosphate and 30 per cent of potash are applied to grass, both leys and permanent pasture(1). If no more fertiliser were applied to grass, inorganic fertiliser usage would be significantly reduced even if some extra was needed on arable land to compensate for FYM and other animal waste which may have been applied prior to the shift. It should be pointed out that there would be considerable quantities of plant waste produced in the Plan. Some of this could be composted on farms and used as an organic fertiliser thereby saving on expensive inorganic fertiliser. A significant proportion of the plant waste produced will accumulate beyond the farm gate at food processing factories etc., and here other solutions to the problem would have to be sought. Possible uses for plant waste range from paper production(11), to mushroom growing medium(12) or single cell protein substrate.

A system wholly devoted to crops is likely to have considerably effect on the appearance of the countryside. The disappearance of livestock is likely to make many farms unviable in economic terms and thereby increase the area of "marginal" agricultural land. The viability of the whole proposed shift to a large measure depends on finding other uses for this land which are of equivalent or greater benefit to England and Wales than livestock farming. The redeployment of the land resource is bound to have widespread repercussions on a range of considerations from landscape to land ownership.

Resource use is perhaps the one area where a reasonably sensible comparison can be made between the present and the alternative systems. The removal of livestock from the agricultural system in England and Wales, even though it may result in improved self-sufficiency in food, is primarily a move which would decrease the size of the industry. This means that the comparison cannot always compare like with like.

The first resource to consider is land. The area covered by the Initial Cropping Plan which would be the agricultural area under the novel system, is only the present arable area. This area would be increased slightly by ploughing up suitable areas of permanent pasture to achieve the goal of nutritional self-sufficiency. The agricultural area under the novel system is with or without the addition of the 600,000 hectares* of potential arable land on top of the Initial Cropping Plan area, only roughly 50 per cent of the current agricultural area. It is energetically more sensible to produce crops than livestock for food which means, according to energy use criteria, that the reduced area makes more efficient use of our land resource. The argument is, however, fallacious unless something which is both beneficial to the nation and less energy consuming than livestock

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* See 2.44

farming, is done on the released land. Suggestions are made in chapter 3.1 as to alternative forms of land-use to replace agriculture in areas where, under the novel scheme, it could no longer be carried out.

The integrated nature of livestock and crops in the agricultural indistry of England and Wales could mean that although the land area in agricultural use is cut by a half the economic performance of the industry, in terms of output, is cut by an even greater proportion. This is very difficult to estimate realistically as a shift in production of the type suggested is likely to change the economics of agriculture radically and the estimate would have to be more of a "guesstimate". However, if the situation is examined very simplistically by looking at the contribution made by crops to total agricultural output in this country, an indication of the extent of the reduction in the size of the economic output can be achieved. In 1974/75 crops contributed about a third of the total United Kingdom agricultural output in money terms(2). The proportion for England and Wales alone is likely to be higher because of the greater proportion of arable land in these two countries compared with the whole of the United Kingdom. A shift in production towards a situation where much more of the arable area is devoted to saleable crops (in this case for human food) is, even without changes in price, likely to increase the output of crops in money terms. Bearing these last two points in mind it seems possible that under the novel system agricultural output in money terms will be somewhere between a third and a half of present output. Now this is not necessarily a bad thing if the industry is inefficient, producing goods people do not want or costing the country more money than it feels justified in paying but a lot depends on what replaces the part of the agricultural industry which disappears and what value the country places on the non-economic benefits of agriculture. The rationalisation of the industry might be a sensible or even an essential move in certain circumstances.

If the health of an industry is measured by the financial performance of businesses in it, crop production may lead to a healthier industry. Gross margins per acre and return on capital for cereal, general or intensive cropping farms were higher, for 1973 and 1974 at least, than for any other type of farm(3). This is, however, a little misleading. A farmer currently has some choice as to the sort of farming he or she will practise. This choice will depend on the particular nature of the farm, the availability of capital, the expertise and inclination of the farmer etc. Even if the only goal were to maximise returns, given the diversity of farm size, differing soil types and weather patterns a farmer is unlikely always to choose cropping as other enterprises maybe more financially rewarding under the circumstances. The shift to plant-based agriculture would severely restrict the range of choices open to the farmer. Now as all the land in the Plan is arable it might be possible to argue that cropping is the obvious choice. The problem here is that the location of this arable land is not known, does it, for instance, exist as viable packages suitable for farming as a unit. The likelihood is that some farms on which some cropping is currently carried out would, in the even of a shift, be unable to shift to cropping to an extent which would enable them to remain financially viable. Other farms will be able to shift but only by cropping land of inferior quality for crop production. The problems encountered with cropping poor quality land are likely to reduce both the gross margins achieved per hectare and the returns on invested capital. The possibility exists, therefore, that within the smaller agricultural indistry there will still be farmers struggling to make a living off the land but nevertheless vital to the achievement of nutritional self-sufficiency. It is likely that income support of some sort to farmers on financially marginal holdings would have to continue in the event of such a shift.

There are resources used in agriculture other than land which can be usefully compared in the present and novel situation. The labour requirements for the Plan can be calculated using standard man day estimates for the various crops, but this does not guarantee a realistic estimate of the type and number of employees. The calculated labour requirement for the crops in the Plan is 286,466 man years*. In 1976, 543,300 people were working in agriculture(4). This includes 231,000 who were classified as farmers, partners, directors and managers. The calculated labour requirement represents about 53 per cent of the current total workforce.

It is difficult to give an actual estimate of the number and type of workers that would be needed in the Plan. The arable areas of the country are characterised by a greater number of employees on a unit area basis than the livestock regions**, this is perhaps because of the differences in the average size of

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* Based on SMD's in MAFF (1977) "Farm Classification in England and Wales 1975" HMSO

** Calculated ratio of employees per unit area, using statistics from MAFF (1977) "Agricultural Labour in England and Wales 1976" HMSO and MAFF (1975) "Agricultural Statistics for England and Wales 1973" HMSO holdings. In livestock areas holdings are on the whole, relatively small and can often be run by the farmer and his family without employed help, except at busy times in the season; in arable areas the size of holdings tends to be large on average and beyond the scope of the farmer to work alone, consequently there are more hired workers. The proportion of seasonal and casual workers in the employed workforce varies throughout the country but they are usually most important in areas where there are vegetables or fruits to be harvested(5). The type of employment is therefore going to depend on the size of holdings, the involvement of the farmer himself and the types of crop grown. If the breakdown of the total labour force was similar to that for England and Wales at present**, where 13 per cent are classified as seasonal and casual workers, 43 per cent as farmers, directors, partners and managers and 44 per cent as full and part-time hired workers the workforce would be, very roughly, as follows:-

Farmers, partners, directors, managers	123,000
Full-time and part-time hired workers	126,000
Seasonal and casual workers	37,000

As the type of farming will be cropping of one sort or another it is likely that the number of employees (full-time, part-time and seasonal) will exceed these figures and that there will be fewer farmers etc. Much, however, depends on the structural organisation of farming under the novel system. The criterion of no change in agricultural technology is likely to encourage structural change under the novel scheme but is not likely to alleviate significantly the criticism, noted in 1.5, that modern agriculture

** calculated from data in NEDC (1977) "Agriculture into the 1980's Manpower" NEDC is putting too great a distance (in a spiritual sense) between most people and the growing of their food, as labour involvement overall will be reduced. On a unit area basis in agricultural regions an all cropping system will, however, increase the demand for labour slightly. The greater need in some areas for seasonal and casual workers may create problems if no pool of suitable labour is available. This situation is likely to give impetus to labour-saving innovation in the industry. The relative costs of labour and machinery also play a part in technological development. The whole question of agricultural labour is intimately tied up with the problems of rural decay and deprivation. Rural employment is seen as one of the ways in which country areas can be revitalised(7). Agriculture's contribution is vital to rural employment levels both directly and indirectly in the agricultural services, but this importance continues to decline in terms of actual numbers as people leave the industry(4). The effect, of the proposed shift in agriculture, on the labour situation in rural areas will vary. In farmed areas employment opportunities in farming may be marginally improved but in those areas where farming would no longer be a practical possibility alternative forms of rural employment would have to be found. Even in areas where agriculture could continue the security of work might be reduced if seasonal and casual requirements were high. It is possible, though, that the changing social mix in villages will reduce the availability of seasonal and casual workers locally(8), thus employers would have to choose between a mechanised replacement if available, a full or part-time worker or seasonal labour from urban centres or roving gangs of workers.

The use of energy in the novel system can also be examined but rather than calculate an energy budget for the Plan, it is perhaps as well to view the energy situation as simply as all the other resource situations which have been examined. Leach[9] notes that the energy ratios (energy out: energy in) for cereals; potatoes and sugar beet in the United Kingdom are all greater than one. The processing of crops to an edible product is likely to lower the energy ratio below one. Vegetables tend to have fairly poor energy ratios under agricultural systems of production; Brusselsprouts have an E_R of 0.19 but carrots have an E_R of 1.1[9]. Despite all this, the energy ratios for crops are far better than for livestock. See below in Table 2.7.

TABLE 2.9

Energy Ratios For A Range Of Outputs From UK Farms

Aston University

Illustration removed for copyright restrictions

[Source: Leach, G (1976) "Energy and Food Production" IPC Science and Technology Press p. 97]

It has already been noted that fertiliser usage would fall under the Plan and as only half the current agricultural area would be farmed machinery and building needs would be markedly reduced. These, together with agrochemicals, account for about 57 per cent of the current energy input to United Kingdom farming[10]. The change in agricultural system envisaged is likely to substantially reduce the amount of energy input needed for agriculture and the fact that the system would be plant-based means that the efficiency of energy utilisation in agriculture, based on the ratio of output to input, would be greatly improved. However large the savings in energy are, if such a Plan for agriculture were adopted, they could be negated by inefficient energy-intensive use of the land released from agriculture. On the other hand the release of land might provide scope for reducing the country's dependence on non-renewable energy sources.

PART 3

Uses For Redundant Agricultural Land; The Dairy Industry And The Single Farm Study

3.1 Potential Uses For Agricultural Land Not Involved In The Plan For Food Production

3.11 Introduction

The Plan for agriculture discussed in Part 2 does not make use of all the land currently in agricultural use. There is between 5 and 6 million hectares of poor quality land with limited potential for crop production. The redundant agricultural land generated by the Plan is unlikely to be less than 5 million hectares even if the cropped area is maximised by ploughing up suitable permanent pasture. The likelihood of the Plan being considered, in any way, a realistic goal for food production in this country depends on the use to which the spare land is put.

At the present time decisions on land use tend to be partially based on the potential returns from different uses on a particular area. Agriculture is the major land use in this country so the extension of other types of land use tends to encroach on the agricultural area. The comparative returns are, therefore, estimated for agriculture and the proposed alternative use. A complete shift to plant-based food production renders a considerable proportion of the current agricultural area of no agricultural worth. This means that the potential return from farming on this land is zero. Any other use is, therefore, likely to provide an equivalent or improved return. Under a plant-based system the choice would depend on the comparitive costs and benefits of, and the demand for the non-agricultural types of land use. The possibility exists that land could be allowed to fall into complete disuse with no productive or beneficial output or function. This seems a great waste of a valuable and currently stretched resource but the release of 5 million hectares may so reduce the demand on land that the creation of odd unproductive areas would, possibly, not matter. No attempt has been made in this study to do a complete economic analysis of the land-use situation. The discussion is largely confined to the assessment of possible alternatives, taking into account the social and environmental repercussions of change, as well as the economic.

The area for which new uses must be found is considerable and this tends to limit the potential alternatives. Much of the spare land will be in upland areas, but some will be dispersed in areas where agriculture will still be possible under the novel scheme. The problems connected with suggesting alternative uses for spare land are compounded by the inability to precisely locate where it will be and will be different depending on whether it exists as large areas or as pockets in arable areas. The potential uses of the unused land would seem to be as follows:-

1) Forestry and possibly other forms of biomass production
2) Recreation and amenity
3) Mining, quarrying and water supply
4) Urban and industrial development

The first two are the only ones which could hope to cover a large area and these will be discussed in detail. Recreation and amenity are essentially secondary forms of land-use. They are rarely the only use of land except when it is used for golf courses, football pitches etc. Nevertheless, there is rising demand for rural recreational space which suggests that there might be considerable potential for recreational development on released land under the novel scheme. Mining, quarrying and the supply of water do not usually cover large areas and they are omitted from the discussion.

The potential for urban development needs some discussion. The liberation of considerable areas of land should in theory ease the problems of urban encroachment onto farmed land. However, it is possible that the reverse is true. Most major urban sites are situated in lowland agricultural areas whereas much of the spare land will be in upland areas. If nutritional self-sufficiency is to be achieved the protection of croppable land will be fundamental importance and this might mean that very stringent controls would have to operate to prevent development on farm land. The main scope for new development on the spare land is unlikely to be around current large centres. The possibility for new development on land which is currently remote from existing population centres i.e., in upland areas, therefore, exists but the difficulties of doing this should not be under estimated.

3.12 Forestry

Britain imports vast quantities of timber, semi-processed and processed wood material. The contribution of home production to total consumption of wood is only 8 per cent(1). Paper is by far the most important use of wood in terms of volume. Twenty-one million m^3 of wood raw material out of total supply of 43 million m^3 in 1972 was used for paper manufacture(1). Demand for paper and board has risen steadily over the past 20 years or so. Apparent consumption of paper and board in 1954 was about 74kg/hd, by 1972 this had risen to 129 kg/hd(2). It is reasonable to suppose that demand for wood will rise steadily in the foreseeable future even if alternative materials are available, especially as many of these alternatives are petrochemical products. The Forestry Commission predicts that even if home production of wood were to rise by 150 per cent between 1970 and 2000 and consumption were to rise by an estimated 80 per cent, the level of self-sufficiency would only be improved by 3 per cent(1).

The area of forest and woodland in this country is small by comparison with most other countries, except the Netherlands where the forest cover as a proportion of total area is similar. Only 8 per cent of the land area of Britain is forested compared with nearly 30 per cent in West Germany, 21 per cent in France and an average of 20 per cent for all the 9 countries of the EEC together(3). The area and ownership of forest in England and Wales are shown in Table 3.1.

The Forestry Commission concentrates on the production if soft woods; 65 per cent of home production of soft woods comes from Forestry Commission Woodlands(1). Hardwood from broad-leaved species is largely derived from privately owned woodlands and hedgerows and this situation is expected to continue(1).

The encouragement of forestry in this country is based on a number of considerations: strategic, economic, social and physical. The main agent of forestry production and development is the Forestry Commission, which was originally created to purchase land and plant and manage trees for strategic reasons after the First World War, when timber reserves in this country were stretched to the limit(4). In the period between the 1919 Forestry Act, which called for the appointment of Forestry Commissioners, and the present day, the objectives of the Commission have been extended to include economic,

TABLE 3.1

Area and ownership of forest and woodland in England and Wales: 1973
('000 hectares)

/Source: "British Forestry" Ed. D. B. Rooke (1974) Forestry Commission/

environmental, social and research considerations. Private forestry has been encouraged too, particularly in the last 5 years or so, through grants and other direct assistance measures. In recent times public awareness of trees in the environment has been encouraged through tree planting schemes and heightened as a result of the ravages of Dutch Elm disease on the English landscape.

The lack of forest cover, relative to other countries, and the poor level of self-sufficiency this country achieves in wood material tends to suggest that forestry is a desirable use for some of the land which cannot be included in the Plan.

The two main types of wood are softwood from coniferous species and hardwood from broad-leaved species. The former is faster growing and reaches a croppable condition sooner, for these reasons it is a more economic choice for large scale production. However, hardwood species are more in keeping with most lowland landscapes and can be planted in smaller plots destined to mature in many years time. The need to produce socially acceptable plantations which blend with the landscape has prompted the Forestry Commission to mix the tree species found in large-scale plantings, so even in upland areas where softwood species predominate there is a case for hardwood planting as well[4]. If some of the spare land is to be afforested, the greatest scope exists in upland areas. The problem with suggesting that all upland areas, which could no longer be farmed, be put down to trees is that there is a direct conflict here between forestry on a large-scale and current concepts of amenity and landscape in this country. Much of upland England and Wales is National Park. These parks are all areas in which the character of the landscape is unique and considered worthy of protection as part of the National Heritage. The encroachment of forestry into these areas has been met with considerable opposition and any future plans to extend forestry into them would presumably also be opposed[4]. There are two possible situations which might prevail if the reorganisation of land-use in upland areas was necessary. First governmental and public opinion may insist on the preservation of the unique character of landscape in National Parks. A situation which would prevent any appreciable level of afforestation, or any other intrusive land-use, taking place there. Second, the timber supply situation could be considered of sufficient importance to override the need to preserve particular landscapes or environments. That is not to say that new, but different, beauty or aesthetic appeal could not emerge, in time, with sensitive planning. If it is assumed that forestry could not replace hill farming or other types of agriculture in National Parks then a problem emerges as to what can be done to preserve the unique qualities of these areas when the main source of income and the main shaper of the landscape, i.e., agriculture, is no longer a productive proposition. This problem is not exclusively one for the National Parks, there are also the areas of Outstanding Natural Beauty and many other areas in which the appearance of the landscape is treasured. The change in farming suggested would have repercussions on much of the landscape of England and Wales and the acceptance of these changes would have to be part of the whole move to this novel food production alternative. Landscape in this country is changing all the time and the time period involved in bringing about such a radical change in agriculture would be likely to soften the impact of the specific changes in the appearance of the countryside. It is unlikely that most landscapes in the farmed parts of this country can be protected even now unless they exist within the confines of National Parks or other specifically protected areas, but it is to be hoped that change can produce a landscape as pleasing as that which it replaces. The whole area of amenity and recreation will be discussed more fully in 3.13.

It is possible to calculate, very roughly, the potential area for afforestation on released land. In order to do this a number of assumptions have to be made, particularly if National Parks are excluded from any forestry plan. The main scope for large scale forestry is likely to exist in upland areas where all the agricultural land can be assumed to be unsuitable for food crops, so the calculation will initially be confined to this area. There are no reliable figures for the extent of the upland agricultural area in England and Wales, where crop production potential is limited. This was estimated by a square counting method to establish the amount of land over 600' above sea level and with more than 40" rain per year and all land of 1000' or more above sea level east of the 40" per annum rainfall zone*. This came to about 2.6 million hectares. The area of the National Parks, which are all assumed for argument's sake to

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* Map used was "The atlas of Britain and Northern Ireland" Clarendon Press 1963

be in upland areas, is 1,352,610 hectares*.

The Plan only releases agricultural land so it is important to adjust the areas calculated above to account for this. It was assumed that the proportion of agricultural land out of the total in uplands would be the same as it is in the country as a whole, 77 per cent. The potential for upland forestry on land released by the Plan can now be calculated both including and excluding the National Parks:-

Upland area from square counting	2,600,000 ha
Upland in agricultural use, 77 per cent of previous figure is	2,000,000 ha

Thus, if all agricultural land in upland areas were released for forestry roughly 2 million hectares of trees could be planted.

Upland in agricultural use	2,000,000 ha
National Park area used for agriculture (77 per cent of total)	1,041,510 ha
If no forestry occurs within the National Parks the potential planting area is reduced to,	958,590 ha

With or without the National Park area there is considerable opportunity for large scale planting in upland areas if agriculture became impossible. The lowland spare land could also be expected to support more trees and presumably some of this land will be in reasonably sized areas allowing for intensive planting in plantations. The Plan releases between 5 and 6 million hectares of agricultural land of which at least 2 million is in upland areas. By implication this means that 3 to 4 million hectares is in lowland areas. It is very difficult to be sure how much of the lowland area would be suitable

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* National Parks occupy 9 per cent of the area of England and Wales. Patmore, J. (1972) "Land for Leisure" Pelican

for forestry but it would be reasonable to assume that at least a million hectares could be devoted to forestry and probably more. In total therefore between 2 and 3 million hectares would become available for forestry if agriculture shifted to a plant-based system.

The very rough estimate for potential forest area still leaves 2 to 4 million hectares of spare land. Small scale plantings of copses and small woods might reduce this area and could prove a useful extra enterprise on agricultural holdings with a proportion of uncroppable land. There are problems connected with mixing trees and arable farming because trees act as a habitat for potential crop pests, and tend to attract moisture and shade growing crops, causing uneven maturation. The encouragement of this sort of mixed farming would depend on the demand prospects for timber and possibly on environmental and landscape considerations. Trees are very important in lowland landscapes and arable farming tends to encourage their removal. Growing demand for renewable energy sources and other raw materials may encourage coppicing or the production of some sort of vegetation for conversion through fermentation or pyrolysis into energy or chemicals. The release of poor quality agricultural land may provide more scope for the development of this sort of energy source than seems likely at present in this country.

The problems of afforesting 2 to 3 million hectares of land should not be overlooked. In most studies on forestry now the decision to plant trees depends on the relative returns from forestry or an alternative land-use, usually agriculture. In this study the decision does not rest on this comparison because only released agricultural land is considered. However, comparison might be drawn between forestry and other non-agricultural land-uses if agricultural change generated spare land.

The capital investment involved in large scale afforestation on a 2 to 3 million hectares of land would be enormous and the burden could be expected to fall largely on the state unless the returns from forestry improve dramatically. Even if returns improved it must be remembered that there is a very considerable lag between investment and returns in forestry if no initial forest capital, or another source of capital off the particular area of land, exists. The current rotation period for softwood production is in the region of 50 to 60 years and the return on investment is low, 3 per cent in real terms in 1972[5]. A 1972 report[5] suggested that even with shorter rotations the returns are not greatly improved, although much inevitability depends on the future state of the economy and the price of timber.

Forestry can provide a range of benefits. These are usually considered to be:-

1) a strategic reserve of timber
2) a source of employment in rural areas
3) a potential source of recreational space
4) an improvement in amenity value
5) an eventual economic return
6) assistance to the balance of payments

Strategic considerations are now often dismissed but the value of a home supply of any resource at a time when so many factors can interrupt import supplies should not be overlooked, even if war is not envisaged.

Most comparisons of the employment provided by forestry compare it with agriculture. For instance, it was estimated that forestry in North Wales employed one man per 150 acres whereas hill farming employed one man on every 370 acres[5]. A lowland comparison is likely to show less of a difference in employment per area of land in the two occupations. The loss of farming as a potential employer in rural communities resulting from a shift in agriculture, as described in this study, is likely to cause considerable problems as the availability of employment is of fundamental importance to the viability of any community. Forestry is a possible solution to this problem in upland areas under the novel scheme. Already communities in these areas are threatened by declining population and a shortage of basic services[6]. The provision of jobs in forestry is however costly, in Exchequer and resource terms it is considerably more costly than the provision of jobs in hill farming[5].

The recreational and amenity value of forestry is only realised when forests are fairly mature. Nevertheless, once mature, forests can provide opportunity for a range of pursuits and enhance the landscape they are found in. In recent years the Forestry Commission has made considerable efforts to open up mature forests to the public and to provide facilities both for the casual day tripper and for visitors with special recreational requirements. The use and provision of facilities on Forestry Commission land has increased steadily and can be expected to do so as long as people have the opportunity to travel into the countryside. In 1968 the Forestry Commission estimated that there were 15.5 million day visits to their plantations over the summer period (June - September)[5]. Expenditure by the Commission in 1969/70 on recreational facilities far outweighed receipts but this deficit is considered to be offset by substantial social benefits[5]. Certain facilities already finance themselves, particularly campsites and specialist pursuits such as shooting and fishing[1].

Amenity value is a very subjective quality. Forests certainly radically alter the appearance of the countryside and not always for the best. Much of the Forestry Commission's early planting was criticised because so little attention was paid to blending new forest into old landscapes. Now the Commission pays more attention to the landscaping of plantations. In this way forestry can enhance the landscape or produce one which, in time, is as pleasant as it was before trees were planted. The planting of trees on a large scale will also have environmental and ecological effects, on water status and the local flora and fauna, which need to be considered for each individual site.

Increasing the area of forest will eventually create a need for an expansion in the timber processing sector. Primary processing facilities in this country, saw mills and pulp mills, use home grown timber only, as most imported timber is processed or semi-processed and does not, therefore, impinge on the home industry's primary processing capacity(1). The massive increase in forest area would lead to a massive increase in the volume of timber produced eventually and it is unlikely that current capacity or projected capacity in the industry could cope. In time this could provide much needed employment in rural areas as the primary processing plants are usually fairly near to where the timber is produced.

It is impossible to interpret precisely where, geographically, the changes in land-use would need to occur. In certain areas, for example the uplands, it is straightforward to at least suggest alternatives but for much of the area in which change would occur under the novel system the location and alternatives available are less clear cut. It is the areas in which agriculture will not be viable and in which forestry is perhaps not desirable on a large scale nor practical on a small scale, that pose the biggest problem.

3.13 Recreation, Amenity And The Environment

Recreation and amenity land (which includes unique protected environments), covers a considerable area, although most of this land will have another primary use. About 40 per cent or 6 million hectares of England and Wales is designated as land of special value because of the beauty of the landscape, its recreational value or its special scientific interest(7). The primary use of this land will not always be agriculture. However, the proposed shift in the agricultural system would be likely to affect many of the special areas, either because the type of agriculture in the area changes or because agriculture could no longer be carried out there. If a substantial increase in forestry accompanied the change in agricultural practice the threat to special areas would be even greater.

The conservation of particular areas has been advocated for some time. The 10 National Parks in England and Wales were set up between 1950 and 1955 following legislation in 1949(8), and other smaller areas have subsequently been identified as being of some particular value. The purpose of the Parks is to preserve and enhance the beauty of the landscape within the Parks and also to provide and improve facilities for people to enjoy them(8). The continuation of rural life and industry is also important to the maintenance of the intrinsic character of the Parks. There are, therefore, numerous considerations to be taken into account ranging from the aesthetic through to the encouragement of particular ways of life. These diverse considerations can lead to conflict as, for instance, conservation is not always compatible with the aspirations of people who work in protected areas, such as farmers, or the needs of those who seek recreational opportunity there. Agriculture is of fundamental importance in most of the National Parks and other special areas of any size. Not only does it provide local employment, which is considered important for the life of the Park, it is also perhaps the major determinant of landscape appearance.

The proposed shift in agricultural practice is liable to have effects on the National Parks and other areas especially if they cover areas inherently unsuitable for food crop production. The removal of the most significant primary land-use in the Parks is bound to create problems. Decisions would have to be made about the future of specially protected areas. The decision rests not simply on the value placed on the aesthetic appearance of an area but also on the social value of rural communities and ways of life, particular ecosystems and recreational opportunity. Not all of these factors need be affected by a change in primary land-use, some may in fact benefit. The section on forestry, for instance, suggests that this could provide greater employment opportunities in upland areas than farming can. It is also possible, though doubtless very expensive, that the unique appearance of some of these areas could be maintained. Sheep are the main shapers of much of upland Britain and perhaps some new approach to their management could be adopted. One study about a vegetarian system for this country suggests that sheep could be retained in a feral state[9]. This situation would require considerable stage management to preserve the landscape appearance and to prevent any undue animal suffering. It would provide some employment and could provide some revenue if wool is permitted. It could not, on the other hand, be economically self-sustaining and would require specific financial support (probably at a higher level than hill farming does at present).

A number of alternatives do exist for special protected rural areas and the choice is dependent on the value society places on these areas and on their current appearance. The possibilities for preserving living communites in rural areas where agriculture and forestry might be of limited acceptability seem to be remote even if the areas are used for recreation.

At present demand for recreational access to rural areas is high. The majority of people who use the countryside for leisure do so in a fairly passive way by going on pleasure drives, picnicking and strolling. These people probably need fairly rudimentary facilities but much depends on the individual, his or her age, choice of destination, attitude to the countryside etc[7]. There is considerable growth in the area of more active outdoor rural-based leisure pursuits, such as mountaineering, horse-riding and nature study[7]. These activities tend to have specific needs in terms of location and facilities. It seems likely that, unless personal mobility decreases (a not impossible situation) people will wish to spend an increasing amount of their leisure time in country areas[7 & 11]. On a positive note then, the generation of spare land by the Plan may provide scope for recreational development. The release of farm land may also offer some scope for nature conservation, particularly on pasture land, one of the most threatened wildlife habitats in the country[12]. Conservation of this habitat under the scheme for totally plant-based agriculture would require specific and careful management.

It has been noted before that economic returns from recreation in rural areas are not high, largely because of the nature of pursuits carried out. However, the provision of facilities or amenities can improve returns if people can be attracted to the location. Specialist activities or attractions like safari parks offer greater opportunity for making money than the provision of facilities for passive visitors on a weekend drive(1 & 7). The location of the spare land and the sort of environment encountered will also affect the potential for recreational development(7). The daytripper, the most numerous visitor to the countryside, will apparently only consider a fairly short round trip so recreational sites offering little other than picnic places at a great distance from centres of population are unlikely to attract people(7).

The scope for recreational development exists but very careful and sensitive planning would be needed to realise that potential on the Plan's spare land. Careful consideration would have to be given to the problems of adopting recreation as a large scale primary use of land in rural areas. So many factors impinge on recreation in country areas that it is impossible to cover them all here. However, it does seem that a shift to plant-based agriculture could provide considerable opportunity for developing forestry and recreation, and for preserving wildlife, although the problems of maintaining rural settlements, preserving specific landscapes and actually developing the alternatives are considerable.

3.2 The Dairy Industry

3.21 Introduction

Milk is an extemely important product both in terms of its role in the British farming system and in its nutritional contribution to the diet of many people in this country. It is also a foodstuff acceptable to many vegetarians. These considerations prompted a special investigation into milk production in England and Wales to see if it was in any way compatible with the novel system examined in the project. This took the form of a Delphi study.

Milk production is of great importance in the structure of British farming. Not only does dairy farming produce milk but also beef and veal calves for other sectors of the industry. A substantial proportion of the agricultural land area of England and Wales is occupied by farms on which it is an important enterprise(1). In 1975 roughly 30 per cent of all holdings had some dairying interests(2). The current trend in British farming towards greater specialisation on farms has meant that the proportion of holdings involved in dairying is in fact declining(2 & 3). This decline in the number of holdings is compensated for by increases in both the average size of dairy herds and in average milk yields(3). In 1975, 81,000 holdings had some dairy interests, but by 1977 the figure had fallen to 74,000(2). The average herd size had risen over this period from 40 to 44 dairy cows(2). Over 50 per cent of the total number of dairy cows in the country are in herds of 60 or more(2).

In monetary terms the output of milk and milk products from British farms is very important. It accounts for 22 per cent of the total output from all farm products(2). If the contribution from dairy beef and veal were added to this the proportion would be even higher(4).

In Britain the production of milk has been promoted because of milk's value as a food and because dairy farming was an appropriate system of farming in many parts of the country, particularly where grass grows abundantly. The size to which the industry grows is however largely politically determined(5). The 1947 Agriculture Act states that the Nation's agriculture should produce "... such part of the nation's food ... as in the national interest it is desirable to produce in the United Kingdom". External considerations have always had to be taken into account. When our trading ties with the Commonwealth were strong it was politically desirable to limit the size of the home industry to the production of milk predominantly for the liquid market and to import milk products from countries such as New Zealand which had an exportable surplus. Now in the EEC similar considerations have to be borne in mind. Despite the political expediency evident in the imposed limitation on the size of the home dairy industry British farmers often express the opinion that more milk products could be home produced and the liquid milk market satisfied at the same time.

Britain is a country of liquid milk drinkers, unlike its European neighbours. The average consumption in the United Kingdom is 4.5 pints per week(6). If the consumption of other dairy products is added to the quantity of liquid milk it has been calculated that the average weekly contribution of milk and dairy products to the diet amounts to 30 per cent of calories, 30 per cent of protein, over 100 per cent of the calcium, 50 per cent of the riboflavin and 65 per cent of the vitamin A. (These percentages being based on average nutritional requirements)[6]. This analysis does not take into account many important factors but it is fair to say that the consumption of milk is highly significant nutritionally. Milk is of high value nutritionally and is for most people easy to digest[7]. Its major deficiencies are iron and vitamin D. Its value as a source of protein and calcium for young growing children has been recognised for a long time.

The present high level of milk consumption in Britain is significantly different from the consumption levels at the beginning of the century. A 1902 survey by the Royal Statistical Society found that when compared with a selection of European countries, Britain was the heaviest meat eater and smallest milk drinker[8]. The average consumption per head per year was estimated at 15 gallons compared with about 29 gallons nowadays. At around about the same time as this survey was being carried out concern was beginning to be shown for the plight of the lower income groups in the country. The 1904 report on Physical Deterioration[9] noted the increasing use of tinned sweetened condensed skim milk as a substitute for the breast feeding of infants. This defective diet, rather like the tragic use of dried milk formulas for feeding babies in parts of the Third World at the present time, resulted in extremely high mortality rates; one in four dying within the first twelve months of life. The Report went on to find that out of the population studied, 33 per cent of all children were undernourished in the sense that they went hungry. After this report many other studies were done on the nutritional health of the population. In 1906 this concern over the health of children resulted in an Education Act which made it mandatory for grant-aided schools to provide meals and milk[10]. Concern over the Nation's health increased between the two World Wars. More surveys were done, the most famous probably being the one by Sir John Boyd Orr. By the time the Second World War broke out there was some indication of which groups in society were in most need of food and some idea of what sort of foods would be most valuable for maintaining some degree of nutritional adequacy in the diet. Milk was designated a high priority food[11 & 12] and was provided free in schools from 1946 (although the free milk scheme was temporarily stopped in 1968). Milk was involved in special distribution schemes during the war for children of pre-school age and nursing and pregnant mothers. It was a rationed food as the opinion was that the need for protein foods, milk and fats varied less between different sectors of the population than for some other foods, e.g. cereal-based foods. It has maintained its welfare value to the present day.

It could be argued that the pattern of milk consumption in this country would have been very different at the present time if it were not for our unique marketing and distributing system. The role of the MMB and the familiar milkman has done much to preserve the pattern of liquid milk consumption. Government intervention in the form of subsidies has also contributed to the consumption pattern as it has directly affected the price of milk to the consumer, generally keeping it lower than its true market price. Milk has therefore remained a relatively cheap and nutritious food available to just about everyone. Other items in the diet, for instance, precooked Breakfast cereals, may also affect the consumption of liquid milk.

Milk can also be processed to form many products, some of which are important items in the diet. It was noted earlier that the bulk of these dairy products are imported but the importance of milk processing within the British Dairy Industry should not be overlooked. As long as milk production continues on British farms, some milk will have to go into processing, because some areas of production are too remote from the main distribution centres for liquid milk to make transportation worthwhile. Surplus milk is also produced at certain times of the year. The processing of milk in remote areas produces products of higher value, better keeping qualities and also provides local employment.

This introduction has only briefly sketched out the agricultural, political and dietary importance of milk. However it does show why a special investigation into milk is called for in the project.

3.22 Possibilities For Integrating Dairying Into A Plant-based System Of Agriculture

This section is primarily an attempt to describe how dairying might be integrated into a system of agriculture based on the production of human food derived, for the most part, directly from plant sources. The foremost consideration of most vegetarians is the exclusion of meat from their diets, however, some are not averse to including animal products such as milk and eggs. The integration of enterprises producing milk or eggs, into a system of agriculture which concentrates on providing plant foodstuffs for direct human use, is complicated by the fact that these enterprises have accompanying outputs which do not fit into the meat-free ideal. Dairy farming depends on cows having calves. These calves are both male and female. Most male calves go for veal and beef production and the number of heifer calves far exceeds the yearly replacement needs of the dairy herd, consequently many of these are also destined for the meat market. Egg production poses similar problems. When the laying flock is replaced some of the hatched eggs are bound to be cockerels. Surplus calves and cockerels could be disposed of at an early stage, for pet food or fertiliser for instance, and never enter meat production as such. This would be one possibility for continuing milk and egg production without meat production, and is in fact currently used in Jersey. Some people might feel this was a waste of potential food or simply find the idea abhorrent. There maybe potential developments which could avoid the needless slaughter of young animals.

Milk production from permanent pasture and temporary grass is often justfied because it is one of the most efficient ways of using this resource. Other schemes for agricultural change give milk production priority for this very reason. In the system examined in the project these areas are not producing direct human food. Perhaps, therefore, utilization of grass in this way could be seen as a half-way stage to full transition to totally plant-based food production. If this were to be the case and vegetarianism the motivation, the accompanying meat production would have to eliminated. A dairy herd of virtually fixed size which satisfied the demand for milk but did not produce surplus calves would create the desired situation. For this to be possible, each cow would have to produce only one female calf to replace it in the herd (allowances being made for a certain number of bull calves and unforeseen fatalities in the dairy herd) and be induced to lactate as though it were following the normal dairying practice of calving once a year throughout the economically productive period of its life. This theoretical situation would preserve a steady herd size, produce no surplus calves and satisfy the demands for milk in the novel system.

Certain technical developments would be needed for this situation to be attainable. These developments are firstly some method of ensuring the offspring will be female and secondly techniques for inducing lactation in order to prolong the working life of the cow.

Techniques for ova-transplantation already exist; if it were possible to sex the fertilised ovum before transplantation the gender of the offspring could be guaranteed. Another possible technique is the selection of sperm before following normal established aftificial insemination procedures. Either one of these two techniques, if they were possible, would make it possible to select the sex of the offspring at will.

If the dairy cow was required to follow normal lactation patterns but not to have calves regularly, some method of artificially inducing lactations would have to be developed. Hormonal methods for inducing lactation do already exist but are rather crude and would need substantial improvement to make them generally acceptable.

The combination of some method for determining sex prior to conception and another for inducing lactation would make milk production feasible in the "no meat" system. This approach may however raise other objections.

One of the objects of the project is to examine an agricultural system devoid of animals. Perhaps therefore milk-like substances could be produced from plant material. This would by-pass the dairy cow and remove the need to interfere with its normal biological functions. Ideally the substrate for producing these "milk-like" substances would be grass, as large areas of this are available but unused within the project scheme. This then is the final alternative for "milk" production in a plant-based agricultural system.

To summarise briefly, the alternatives, and the technical developments needed to implement them, are:-

Alternatives	Required Technical Developments
1. Dairy farming without the accompanying meat production.	1. Sex-determination of offspring prior to conception.
	2. Methods for inducing lactation.
2. "milk" prodution in the absence of animals	1. Acceptable plant milks. (Preferably made from indingenous plant sources).

In an attempt to predict the time required to develop the above techniques and thereby establish which alternative becomes a possibility first, the Delphi method of forecasting was used. The order of development might well alter the scheme of transition as it was originally envisaged for the shift from the present to the novel system. The time scales generated may also give some indication of the time it would take to change the system, if such a change were considered desirable and if milk retained its importance in the diet.

3.23 Induced Lactation

A cow starts to lactate after the birth of a calf but many changes occur during pregnancy before lactation will take place[13]. The udder has to develop and specific hormonal actions must occur. In the first five months of pregnancy there is in general little udder development but in the twentieth week the cells of the alveoli grow and start to secrete a globulin rich fluid. This is a critical stage, if the cow abhorts at this time, lactation will start but the milk yield will be small as the udder is not completely developed.

Many hormones seem to play a part in the development of the udder and the secretion of milk(13, 14 & 15). Oestrogen and progestrone are generally thought to be the hormones which control the lactational cycle. Changing levels of these two hormones apparently synchronise udder development, completion of pregnancy and onset of lactation. High sustained concentrations of oestrogen and progesterone are needed to develop mammary glands capable of producing the level of milk yield normally associated with the species. After the calf is born the level of these hormone drops. Progesterone appears to inhibit the onset of lactation. The inhibition, Erb[15] postulated, occurs, at one of the stages in the development sequence for secretory cells. Other hormones, apart from the two mentioned, play a part in this development of the secretory cells and in the promotion of casein and lactose synthesis. Most of the evidence for the particular roles of other hormones in this development comes from in vitro studies where in the first stage insulin was found to be necessary to stimulate initial division of the latent secretory cells. The second stage which was the formation of organelles within the new cells formed in Stage One required a corticosteroid for initiation. The final stage was the promotion of the biosynthesis of casein and lactose and this needed prolactin. The blocking of the onset of lactation by progesterone is postulated as probably occuring at the second stage. Progesterone concentrations appear to decrease shortly before parturition and this or an increase in levels of corticosteroids may lift the inhibition of stage 2 and allow prolactin to take effect at stage 3. A relative increase in oestrogen may also have an effect possibly by stimulating the release of corticosteroids as well as prolactin. Other hormones too may well be involved in the complicated lead up to, onset and maintenance of lactation but overall opinion would indicate that all hormonal action in this situation is mediated by the levels of oestrogen and progesterone(13. 14 & 18).

The reason for wishing to develop a technique for inducing lactation is that, at present dairy cows which fail to breed are culled from the herd(14). It would, therefore, be economically desirable to initiate lactation in these animals. However, as yet, no truly reliable method has been achieved which induces milk yields of normal or near normal levels. Individual response to hormone treatment varies considerably. The problems seem to stem from the fact that the whole process of lactation is only understood on a relatively rudimentary level. Not enough is known about just what factors control udder growth and lactation. For the technique to be worthwhile economically the milk yields must be of a reasonable level. Milk yield is believed to depend on the number of secretory cells in the udder as well as the intensity of lactational stimulus(2). Any method of inducing lactation must therefore promote good udder development and provide the right conditions for milk secretion.

Research into methods of inducing lactation started as long ago as the late 19th Century(15). Many researchers working on all sorts of animals from guinea pigs to goats achieved udder growth and some lactational output. There was an increase in effort though from 1939-1946. One example from this period comes from Hammond and Day in 1944(13) when they implanted tablets of synthetic oestrogen into maiden heifers. Within 3 weeks the heifers were in milk. After 60 days the implant was removed. The lactational pattern was similar to the normal pattern, yield increases initially and then falls off[14]. Current procedures involves treatment with oestrogen and progesterone together to promote udder growth and then treatment with oestrogen alone to stimulate prolactin secretion. Oestrogen treatment only in the first stage, does not seem to give the required amount of udder development necessary for good milk yields, although some development does occur. The combination of oestrogen and progesterone seems to work better. A number of techniques have been tried, the hormones can be administered by smearing onto the udder, subcutaneous injection of solution or crystals, subcutaneous implants of tablets or pellets, or by feeding[14]. The most practical method, used until the early 1970's, seemed to be subcutaneous implants. One problem was the difficulty of controlling the absorption rate. Using this method milk yields were highly variable and the treatment time varied from 60 - 180 days. The type of oestrogen used seemed to be a controlling factor, different forms of oestrogen had different degrees of potency when administered.

In 1973 Smith and Schanbacher[16] looked at the possibilities for shortening the time of treatment. It was also hoped that the method would be cheaper. They used large doses of 17β oestradiol and progesterone injected subcutaneously over a period of 7 days and induced lactation, in 7 out of 10 cows involved in the experiment, within 21 days. Yields of milk were on average approximately 82 per cent of that achieved for their best normal lactation. The period of lactation was roughly the same length as would be expected under normal conditions. However, the overall conclusion was that the method was still producing very variable responses between individuals and was far from perfect. Other experiments using the same method were unable to produce the same level of yields as Smith and Schanbacher[17]. An accumulation of results from many experiments using this method gives an average yield per cow of only 70 per cent of her best normal lactational performance. Most of the other experiments have been done to establish why response to this method is so variable. Work by Erb[17] and others on hormonal levels during and after treatment gave no indication. The only noticeable difference from normal lactation was slightly lower plasma oestrogen and prolactin levels at the start of lactation. Narendran[18] and fellow researchers studied the effect of the treatment on the histology of the mammary gland. They observed a large number of immature or developing ducts and alveoli but were unable to say whether this did or did not have an effect on the success of induced lactations. They did however feel that more work was needed as a follow-up to these observations.

One of the drawbacks to all the treatments is the possibility of side effects[14 & 16]. These are as variable as lactation responses. Shortly after withdrawl of treatment oestrus activity is often noticeable. This is accompanied by a raised tail head and alterations in the pelvic structure. In the newer methods described above these effects are still apparent but the symptoms of nymphomania, evident in earlier treatments[1], seem to have been eliminated[16]. Nymphomaniac behaviour, a tendency to mount or be mounted can result in fractured pelvic bones. Previously therefore cows undergoing treatment to induce lactation had to be kept separate from the herd to avoid injury.

On the other hand the treatment may well have a beneficial spin off. In a number of experiments previously barren cows have conceived again after treatment[16]. Some evidence also exists to suggest that a cow maybe treated more than once without harmful effect[16].

It is possible that the composition of the milk could be affected by artificially inducing lactation. If it is, then this would be a major cause for concern. The most likely problems would seem to be either elevated hormone levels or actual changes in the relative proportions of the constituents of the milk[17, 18 & 19]. However, it seems that for the most part administered hormones are excreted via the urine and faeces. Levels of hormones in milk from cows induced to lactate is not significantly different from those in milk from a normally lactating cow. The levels of protein, fat and lactose have also been shown not to be significantly different from normal cow's milk[18]. Whether other important nutritional factors in milk are affected does not seem to have been researched. On the face of it though it seems unlikely that the treatment is having an effect on milk composition.

Induced lactation, as a technique for widespread use on dairy farms, is not yet sufficiently developed. The major problem is the unreliability of the response from cows and the lowered milk yields. Other problems such as nymphomaniac behaviour seem to have been largely overcome. Any concern over abnormal hormone levels in the milk would seem to be unfounded. For the time being however a question mark must hang over the nutrient composition of the milk, most particularly vitamin and mineral content which have not been determined yet, protein, fat and lactose content are essentially unchanged[18].

3.24 Ova-transplantation

The technique of transplanting fertilised ova in cattle has been promoted, in recent years, as a possible way of improving stock and increasing efficiency in various ways[20]. The idea is that by utilizing the best genetic material available from both male and female animals spectacular improvements can be made in genetic potential.

It is not a technique that has yet found widespread application and would still be regarded by some people as being in the experimental stage. Briefly, according to Church and Shea[1], the technique involves inducing a donor cow to produce many eggs, a process called superovulation, which are then fertilised by artificial insemination. The fertilised eggs are then removed by surgical or non-surgical means from the donor and transplanted into a recipient cow. Pregnancy in the recipient cow should then proceed normally. Using this method eggs from a superior donor, fertilised with semen from a good bull, can be implanted in a number of inferior cows. In this way one cow can have a far greater number of offspring in any one year than was previously possible. It is therefore possible to speed up the rate of livestock improvement previously impeded by the slow rate of female reproduction. In a normal situation a livestock breeder can only expect 4 to 5 daughters per cow in its natural reproductive life-time. Ova-transplantation makes it possible to produce several daughters from specific matings in a single year. This may help to increase the selection possibilities and certainly increases the rate at which selections can occur. However despite the benefits that seem, in theory, to be possible, there are many problems still to be overcome. Little is known about what makes some cows better donors than others. Much has still to be learnt in order to perfect the techniques for inducing superovulation as well as those for removing eggs once fertilised and ensuring their viability for transplanting into recipient cows.

Certain criteria have been put forward to help in the evaluation of potential donor cows for fertilised ova[20]. It is apparently important that the cow:-

1) Commenced regular oestrus cycles at an early age.
2) Required no more than two services per conception.
3) Had her first three calves within two years.
4) Has superior individual performance for characteristics of economic importance. eg. rapid growth rate or very high milk yield.
5) Has offspring with above average productive performance from the same sire.
6) Has no reproductive irregularities or calving problems.
7) Has no detectable genetic defect or conformational abnormalities.

If these facts are borne in mind cows can be selected for ova-donation but even these criteria cannot guarantee success. It is also apparently not sufficient for the cow to have a history of regular reproduction as this may be more a reflection of good management than any inherent reproductive superiority. Cows may prove to be unsuccessful donors for a whole variety of reasons, including, failure to superovulate, failure to come into heat and because, for some reason, some implanted eggs do not develop.

The supply of fertilised ova has to be produced in vivo at the present. In some species, for instance the rabbit, fertilization of ova can be achieved in vitro[21]. This bench top fertilization of bovine eggs maybe a development in the future. In order to make the technique worthwhile and also to ensure a proportion of viable eggs, it is essential to encourage the donor cows to produce more than one egg a piece. The cows are in fact required to superovulate. The most usual agent for inducing superovulation is pregnant mares serum gonadotrophin (PMSG), but other agents have also been used[20]. The superovulating agent must stimulate follicular development, without unwanted side effects, yield a good number of follicles and result in normal ovulation into a uterus in the right condition to receive sperm. It is normally administered by subcutaneous or intramuscular injection on the sixteenth or seventeenth day after a previous oestrus, but there do not seem to be hard and fast rules governing this timing. The important factor seems to be when the next oestrus will occur, an interval of 3-5 days between the injection of PMSG and onset of oestrus seems to be most desirable. To achieve this prostaglandin $F_{2\alpha}$ is administered a couple of days after PMSG treatment, this brings on oestrus activity in another 2 days. It is important for the commercial application of this technique that events generally occur in an order guaranteed to achieve a predictable result. The onset of oestrus is very important in this respect because insemination and the removal of the fertilised eggs has to occur at this time. Variations have been reported, in the effectiveness of superovulation techniques which seem to be governed by the season and the geographical area. Fertilization in some situations, is more variable in winter and more predictable in summer and autumn. The regional variations might, it is thought, be due to naturally occurring oestrogens in forage grown and fed at different times of the year.

Fertilised ova are recovered from donors by surgical or non-surgical means[20, 21 & 22]. Alternatively, the donor can be slaughtered before the eggs are recovered. Variable conception rates have been achieved with eggs from slaughtered donors but the technique is simple. If however the object is maximal use of individual genetic material, there is little merit in slaughtering the animal, so one of the other methods has to be used.

The surgical method introduces a cannula into the oviduct, or oviduct and uterus, under general anaesthetic[12]. The eggs are then flushed out of the womb or oviducts by injecting plenty of physiological salt solution (or Tissue Culture medium) into the womb. The eggs are collected in special glass cups, where they settle to the bottom and can easily be identified. The timing of the operation is important, for instance, it is easier if the eggs are removed before they reach the uterus i.e., within 4 days after oestrus. After this time the operation is not impossible but it is less efficient. Various methods are now also available for non-surgical recovery of eggs. These usually involve introducing a large cannula into the uterus through the cervix. Again the eggs are flushed out, but a lot of debris can also be included using this method, this tends to make egg identification and separation very difficult. Newcomb[21] in his paper states that the problems are essentially technical and that development of a more practical method is probably possible.

Before any egg can be transplanted into a recipient animal it must be properly evaluated to establish whether it is likely to develop normally[1]. In superovulated cows the eggs produced occur in many morphological forms and often have abnormalities, presumably due to interference with normal conditions of ovulation. The right forms of egg have to be selected. This is done under a microscope but as definite morphological characteristics, for eggs likely to lead to pregnancy, are not known precisely, this is a rather arbitrary selection and maybe one cause for low response rates to transfer. Only certain egg types such as unfertilised and very abnormal eggs can be readily identified.

In any transplant procedure success will also be dictated, to an extent, by the recipient[1]. Consequently, recipient management is an important factor in ova-transplantation techniques. Cows for use as recipients should be free from disease, any reproductive tract problems and should show regular oestrus cycles. Better results are achieved if the recipients are young animals. Adequate nutrition is also important. It has been found that for good pregnancy rates exact synchrony of oestrus in both recipient and donor is desirable. If the two differ by even a day the pregnancy rate can fall by nearly 40 per cent. To synchronise oestrus in donor and recipient, the recipient can be treated with progesterone $F_{2\alpha}$. This method is however reported as not being entirely foolproof by Church and Shea[1].

The interval between oestrus and the transplanting of the egg into the recipient also seems to be an important factor[1]. Conception rates are better if transfer occurs on day 4-7 of oestrus in the donor to a recipient at the same stage. The effect is not thought to be caused by the uterine conditions but the age of the eggs. However, it is also apparently true that the expulsion rate of eggs from the womb in the early days after oestrus is high.

The transfer of fertilised ova can be achieved surgically and more recently non-surgically. The non-surgical methods do not seem very successful yet. A reported simple surgical implantation technique giving 52 per cent conception rate is described by Alexander and Markus [22]. This method only requires local anaesthetic whereas most previous surgical methods required general anaesthetic. The success of implants, measured by the number of pregnancies, varies from 40 to 90 per cent, with non-surgical methods being at the lower end of the range[1].

Up until recently, all breeding effort to improve stock has concentrated on the male blood line. The technique of artifical insemination is well developed and supply of semen plentiful. The technique of ova transplantation may eventually lead the way for exploitation of the female bloodline as well, as it increases the reproductive potential of the superior female. However, the method still has far to go before it can be justified at anything but scientific or highly specialised breed improvement level.

In the improvement of dairy cattle the technique is not thought to have much potential for increasing individual milk production level, as milk yield does not seem to be a guaranteed heritable trait and can only be measured in females[1]. A 1976 study[23] costed the technique, for a variety of potential uses, to see what investment per transfer would have to be made and to establish what return was likely on this investment. The calculated cost of transfering a single ovum was at least £10 and this assumed an organised ova-transplantation service rather like the present AI service to spread costs. The calculated worthwhile investment for a single transplant to provide a reasonable return was £7. At the time this article was written therefore the technique, could not be justified on economic grounds. Rounding of figures and under estimates in conception rates or over estimates in rearing losses may mean that the worthwhile investment is not completely accurate, but the discrepancy between cost of technique and theoretical returns would seem to indicate that the technique is not currently viable except in certain cases. It may be that in time the prohibitive cost of the technique can be lowered by simplifying aspects such as recovery and evaluation of eggs, and implantation into the recipient. Even if cost were only marginally reduced but conception rates improved the technique might have more widespread possibilities. This seems to be the case as a commercial ova-transplantation company now exists. Fertilised ova do offer a way of transporting superior genetic stock internationally for more easily than it could have been done formerly. Despite the present cost, which prohibits the widespread use of the technique by many farmers, some highly specialised farms producing top-class beef bulls may be able to risk the investment. The technique may also prove useful for scientific studies on such subjects as reproduction in cattle[23].

The technique has been cited as being potentially beneficial in other areas such as increasing the productivity of beef suckler production by making twinning a possibility[20]. The study mentioned above which costed the technique for dairy cow improvement at farm level, suggests that this too may not be truly viable for a number of reasons, such as greater food needs for cows bearing 2 calves, smaller nature of calves requiring longer to reach marketable weight and poor conception rates. Currently the proportion of successful twinnings is only 23 per cent of total implants attempted.

If the technique is to benefit a large number of commercial farmers rather than just the elite breeders, the potential improvement that it offers must be such that it outweighs the costs involved. Current herd improvement for the average livestock farmer is achieved, at the breeding level, by the use of the AI services. These services keep top quality progeny tested bulls whose semen is used for many services on the national herd. A good bull in this service is worth a lot of money, and his value might offset the costs of producing him through increased selective breeding from a top-class sire and dam using a combination of ova-transplantation and artificial insemination[20]. A greater number of offspring from this union could be achieved more quickly in this way and the best selected, the value of these offsetting the costs incurred and the poorer quality offspring. The main possibility in this area would seem to be for beef bulls, especially those for crossing with dairy cows. A top-class beef bull needs to produce progeny with good live weight gain, as the foremost consideration at the present time. The combined genetic potential of his sire and dam for this characteristic can be assessed and the trait is generally heritable. It may therefore be possible to speed up the improvement of beef bulls for the AI service using this method, without enormously increasing the eventual cost of services to the individual farmer. With the production of dairy bulls the situation is somewhat different, the object here would be to increase the milk yielding potential of any female offspring. The problem here is once again the heritability of milk yield potential. Even if the dairy bull's sire and dam had excellent progeny records with respect to this characteristic, there is apparently no way of guaranteeing that the bull will pass on this potential to his offspring. The genetic potential in this direction is, in any case, watered down by the fact that only heifers can be expected to manifest it. The speed of improvement that could be expected with dairy bulls using the technique is therefore theoretically less rapid than for beef bulls. The investment in the technique for this purpose may be less justified and the costs which would filter down to the farmer make the proposition less attractive.

The reason for including a discussion on ova-transplantation in the project was to assess the current state of research in the area. Its role in milk production was seen to be in conjunction with the possibility for sexing the fertilised ova before transplantation. The method envisaged would involve either removal of a single egg from a normally ovulating cow which had previously been fertilised by artificial insemination, or a number of fertilised ova from a superovulating donor; the sexing of these fertilised eggs, selection of only female ova and then reintroduction of the egg into the original cow or transplantation of the donated eggs into a number of recipient cows. The aim being to ensure only female offspring and remove the need for accompanying beef or veal production from surplus calves. It may however be easier to determine the sex of offspring through the selection of sperm rather than through identification of the sex of a fertilised egg. This method was suggested by a contributor to the Delphi study. Sperm exist as two types, one of which carries the X chromosome, the other the Y chromosome(24). Ova, on the other hand, contain only X chromosomes. When the ovum is fertilised two combination possibilities exist, XX or XY. The pairing XX will result in female offspring, as female cells carry two X chromosomes while male cells carry an X and a Y chromosome. Thus if sperm could be separated into all X containing and all Y containing types, fertilisation only with the X containing type would result in female offspring. A technique for sexing semen was reported recently in Livestock Farming(25) which uses both gravitational and electrical separation accompanied by a visual distinguishing technique to determine, without recourse to testing on cows, which sperm bear X and which Y chromosomes.

3.25 Simulated Dairy Products

This section attempts to present a picture of the current state of affairs regarding simulated dairy produts, rather than give a brief description of plant milks that could be produced from leaf protein or other readily available indigenous plant protein source. (The development of milk substitutes from leaf protein is in any case very much in the future(26), current techniques are usually dependent on the soya bean). A close look at all the interrelating factors involved in this sort of food innovation is valuable to the project as it helps to give perspective to many critical issues raised, on international, national, agricultural and nutritional levels.

Information on simulated dairy products abounds with a mass of confusing terminology, but essentially there are two distinct types to be considered(26):-

1) Those products containing a milk derivative e.g. casein, which are technically described as non-dairy products. These include filled milks and some simulated dairy products e.g. coffee whiteners, non-dairy cheeses etc.

2) Those products which have only vegetable origins, the true synthetic milks. Also included here are the protein concentrate beverages.

3.251 The History of Simulated Milks

Stimulus for the research necessary to by-pass the cow came originally from a number of directions. Food shortages particularly of high protein supplements for emergency infant feeding in wartime Europe resulted in experimental combinations of vegetable products to produce milk substitutes[27]. Milk itself being unavailable in sufficiently large quantities. Another impetus for research was the plight of children who for one reason or another were allergic to milk. Milk substitutes would enable them to have a more varied and nutritionally sound diet without the problems of allergic reaction. Some development was also prompted by the particular needs of a number of vegetarians.

At the present time the overriding stimuli for research are the undernourished of the third world[28 & 29]. "Milk" is an acceptable and familiar foodstuff in many areas of the world but there are many problems associated with producing milk from traditional sources in sufficiently large quantities to make a significant impact on the nutrition of the population[4]. Milk substitutes might be one way of countering this problem. In areas of the developing world where milk is not a traditional dietary component efforts are being made to produce liquid protein beverages, which may or may not be milk-like, to improve the protein content of the diet, most particularly the diet of children[4]. In the developed world, research into milk substitutes is directed not so much at feeding the hungry but at producing a greater diversity of products. Substitute dairy products in this way mirror textured vegetable protein meat substitutes, they are an attempt to provide a cheaper alternative to products which are becoming increasingly expensive but are regarded by many as either important dietary items or as luxuries.

The major substrate for most plantmilks is the soya bean. In the Far East, particularly in China, there is historical precedent for this situation[30 & 31], the existence of an ancient process for producing soy milk. The chinese grind soybeans in water and then filter the slurry, this produces a soya milk which is protein rich but has a strong flavour which most people find unpleasant. Even the chinese seem to use it more as a starting point for other foods, such as a soft curd cheese (Tofu) and a fermented curd cheese (Sufu), rather than as a protein drink[31]. The earliest record of Sufu production dates back to the Hang dynasty (179 - 122 B.C.) but the process remained relatively obscure until 1929 when it was reported in the West, since that time efforts have been made to produce commercial soya-based cheese analogues. The production of Sufu was a domestic activity rather as breadmaking was to many housewives in this country before the advent of large scale bread distribution[30].

The process for making Sufu is outlined on the next page. To a large extent it parallels the processing of milk into cheese, turning a highly perishable food into one with a longer life.

Washed soya beans
soaked in water

↓

Ground with water
and strained → Insoluble residue

↓

SOYA MILK -------------------- Milk

↓

Heated with calcium
carbonate and cooled. This
promotes curd formation.

↓

Pressed to remove water

↓

TOFU -------------------- Cream cheese

↓

Innoculated with mould
(Actinomucor elegans)

↓

Fermented, salted
and aged

↓

SUFU --------- Soft ripened cheese

This ancient process provides the basis for much of the current technology for synthetic milk production. Most soya milks are still just a suspension of soluble soya proteins and soya oil in water produced by much the same grinding and straining technique.

The first modern patent for the production of vegetable milks was filed in Germany in 1911[30]. The process used soya beans which were de-hulled, soaked in water, mashed or milled, and then filtered (as in the chinese method). The resulting juice was then fortified with vitamins and non-fat milk powder. In Italy during World War II a milk substitute called Maltavena was developed as an emergency protein supplement for infants(27). It was a combination of soya protein and malted oats in powder form. The idea spread to England where a similar product emerged which substituted malted barley for the malted oats and added 10 per cent National flour plus some calcium carbonate to give a calcium content similar to that of milk(27). Clinical testing, in Germany, of these products did not produce very good results, infants involved in the test showed poor growth and had digestive disturbances. These problems were thought to be due to the presence of a trypsin inhibitor recently shown to be present in soya beans. Two methods emerged as possible ways of destroying the trypsin inhibitor either heating the beans or allowing the inhibitor to be destroyed by enzymes in the barley malting process. The method used for the heat treatment proved unsuccessful. Refinements were made to the heat process in Germany.

Ovaltine the British manufacturing company involved in the Maltavena project however turned its attention to producing a product for infants with allergies to milk, in conjunction with Great Ormond Street Hospital(27). Wanderlac the resulting product contained none of the malted cereals found in Maltevena, the carbohydrate source was replaced with dextrin and dextrose. This product was supplemented with methionine, calcium, vitamins A and D, and the B vitamins. Quite successful results were achieved with milk intolerant infants, although some infants deteriorated on a diet of Wanderlac. It seems unlikely that one product would relieve all conditions of this type anyway.

Clinical trials were also carried out on Velactin (actually Wanderlac under a different name) in Germany[32], the reported results showed favourable response by milk allergy sufferers. In America similar work was carried out to provide infant foods from soya. Early work favoured a soya flour gruel rather than a "milk". But in the late 1930's a true soya milk was developed by a researcher familiar with the technique used by the chinese[30]. This process was improved at the International Nutrition Laboratory, Mount Vernon, Ohio and the product eventually marketted under the name of Soya Lac. It came in a number of forms, powdered, canned and flavoured with chocolate and malt.

Attempts have also been made over the years to produce "milks" from other plant sources[30 & 33], some more successfully than others. Peanut, coconut, sesame and leaf protein have all been tried. The main reason for this examination of other possible substrates was that soya beans were not always the most abundant protein source in the area where the research was carried out. Peanuts for instance were used in India as an alternative. Nowadays, the soya bean is becoming more ubiquitous and will probably be used in preference to other sources simply because a rudimentary technology already exists.

This then describes some of the early history of simulated dairy products. The efforts were all relatively small scale but in the 1950's and 1960's mass feeding programmes using totally plant-based milks and filled milks were initiated[30]. These will be discussed in greater detail in a section on the current and future role of simulated dairy products. First, some mention must be made of the problems which beset the production of milk from plant sources.

3.252 Problems in the Development of the Production Technology for Simulated Milk

Both the products mentioned in the previous section, Wanderlac and Soyalac, despite the glowing accounts of them in the literature cited must still have had the disadvantage of being strongly flavoured. This flavour is commonly described as "beany", "painty", "throat catching" or "bitter"(34), and most people find it distasteful. If a product is to be a substitute for milk, in most cultures it must aim to be bland in flavour. The removal of the "beany" flavour has therefore been the major concern of scientists working on soya milk.

The flavour is believed to be due to aldehydes, ketones and alcohols (most particularly ethyl vinyl ketone) which are formed during the grinding process by the action of a lipoxidase on the fats in the bean(30 & 34). The enzyme only acts when the beans are crushed, so it is in the grinding process that the problem arises. A variety of approaches have been tried(30 & 33), heat deactivation of the lipoxidase; methods using bacteria and other enzymes as well as chemical treatments such as soaking the beans in acetic acid. Most of these methods reduce the beany flavour but secondary problems can arise. If the beans are heat treated before grinding for instance, much of the soluble soya protein is denatured and will not go into solution in a soya milk. An alternative approach, to de-bittering completely, is to mask the flavour with other flavourings.

The most concerted effort to combat the problem came from the Food Technology Group at Cornell University(30 & 34) who started work in the early 1960's. They identified the troublesome compounds and the mechanism of formation but not until 1967 did they devise a simple technique for the production of an acceptably bland product. Wilkens' method was to grind, de-hulled beans in hot water (80° - $100^{\circ}C$); the temperature being maintained for 10 minutes to inactivate the lipoxidase. This technique was adapted for large scale production in the early 1970's by a U.N. sponsored team working in the Philippines(34). Their object was to devise a low cost technology for the production of soya milk of high nutritional content and low price for the Philippino people. The product was bottle sterilised too so that it kept without refridgeration. Interestingly, the process has not been patented so it is available free to anyone wishing to use it.

Peanut "milk" is another potential milk substitute which has been investigated(30, 33, 35, 36, 37 & 38). The most basic method of preparation is to grind decuticled peanuts then add water and mix. The milk is then filtered off and fortified with calcium and vitamins once the pH has been adjusted; it is then steamed for 30 minutes. The product has no unpleasant flavour problems, its smell is described as nutty and is acceptable to consumers when sweetened. Despite this, attempts have been made to deodorise the milk. One method involves emulsifying a suspension of finely powdered solvent extracted peanut cake in water with peanut oil and lecithin(33). The lecithin improves the stability of the emulsion. Instability is another problem with many plant milks, the oil and water phases tend to separate if no attempt is made to stabilise the mixture.

Coconut milk is obtained from the squeezed juice of coconut flesh as distinct from the coconut water found inside the kernal(30, 33 & 38). The juice obtained in this way is rich in oil but has a low protein content. A skimmed product i.e. one with a reduced fat content, has a better protein content. However, the process for producing skimmed coconut milk is complicated, the best method to-date gives 91 per cent recovery of oil and a dried skim coconut milk[38]. Another problem with it is that it coagulates on heating, it cannot, therefore, be used in a sterilised product[30]. Combinations of soya milk and coconut milk do not suffer from this problem, when sterilised they remain fluid. The addition of coconut milk to unflavoured soya milk also apparently improved the latter's acceptability[30 & 39].

Plant milks derived from other sources are less well developed[33] but most seem to suffer from similar problems to the ones mentioned. Listed, the main problems for the production technology of plant milks are:-

1) Unpleasant or strong unmilk-like flavours.
2) Proteins which are unstable when heated, this makes sterilisation a problem.
3) Poor colour, if the product is to have a truly milk-like colour this would prove a problem.
4) Instability of the emulsions.

Interestingly, some of the problems do not arise if the final objective is not complete milk-likeness. Problems of colour and flavour could be reduced if the products were accepted as a completely new protein rich food rather than as a substitute for milk.

3.253 What role do simulated dairy products play now and in the future?

It has already been mentioned that the major effort to develop and promote simulated milks has occurred in the underdeveloped countries. In a world where many go short of food there is great incentive to improve the general nutrition of the population. In Asia and Latin America the staple foods in critical areas are generally grains, pulses, rice and fish[29]. Milk is not an established foodstuff but demand for it is rising. On the other hand other vulnerable areas such as the Near East and Africa already have an established pattern of milk and dairy product consumption. There is therefore demand for milk but insufficient supply to satisfy it. Many problems aggravate the establishment of a dairy industry in developing countries[33]. The milk yield of indigenous cows is usually low and they are extremely prone to disease, as well as this, there is an acute shortage of cattle fodder. These three problems combine to make the resulting product expensive and scarce. Efforts are being made to improve conventional milk production but progress is slow. For quite a long time now an alternative has been advanced; the production of milk directly from plant sources. Most of the early work was carried out in China and the Far East where the product was entirely based on oilseeds. This is in line with the regional lack of familiarity with milk, but taste for the soy bean. Consequently, the technical problems associated with flavour were not so inhibitory here. A famous Indian project adopted a different approach. The scheme here was to extend the milk that they had by adding plant protein to it. Other countries have started to produce filled milks. These are products based on skim milk powder and a vegetable oil.

To begin with there are the totally synthetic milks, based in most cases on soybeans. Smallscale production and distribution occurs in Indonesia, the Philippines, Singapore and other South East Asian countries. These projects are often launched with the backing of International agencies. The most successful project so far has been "Vitasoy" which has proved satisfactory both nutritionally and financially. This product was marketed in Hong Kong as bottled sterilised soya milk, in 1967 the two plants were producing nearly 57,500 litres a day[33, 34]. Other plants in Indonesia and Japan are producing a dried product which needs reconstituting with water, these are often blends of soy bean and another protein e.g., sesame and soy bean. While writing about plant milks it is worth mentioning protein concentrate beverages. These make no obvious attempt to be milk-like. They are being produced increasingly in developing countries and invariably use ingredients indigenous to a particular country. The products are aimed at the young and are often flavoured or carbonated. It is hoped that increased use will fill nutritional gaps in an acceptable way. A wide variety of ingredients are used depending on where the products are produced, soy bean, cottonseed, wheatflour, fish powder and peanut. The Coca Cola Company markets one such product in Brazil called 'Saci' which is chocolate flavoured and contains 3 per cent soya protein (cf. cow's milk 3 - 4.2 per cent protein[40] although it must be remembered milk protein is of slightly better quality). One imagines that in all commercial ventures of this kind the factor which inhibits any true impact on the nutritional status of vulnerable groups is the cost. Even if the product is marketed at a low price, the potential benefits are not maximal on a nutritional level. Other benefits such as the provision of employment in the construction and running of plant must however be of some importance in a developing country. Progress in the field of protein concentrate beverages is by no means as rapid as some developers had anticipated but some progress is discernible[29].

"Miltone"[26, 30 & 33] is an interesting case in that it is not a true protein concentrate beverage nor is it a filled milk. It was developed in India as a possible way of stretching the supply of milk. The product is composed of "toned" buffalo milk (buffalo milk standardised to 2 per cent fat) and peanut protein. The flavour is apparently quite good if not milk-like being slightly nutty, but its acceptability has been marred by its grayish colour. The merit in the approach would seem to be that it is not dependent on imported products but seeks to extend indigenous supplies of food in an acceptable way.

Filled milks[26, 29 & 41] are products based on skim milk to which some form of fat other than milk fat is added. They retain all the properties of whole milk and have proved very acceptable to consumers. In many developing countries projects to encourage the production of filled milk have been going for many years. The two most famous projects are those in the Philippines and Mexico[29]. The project in the Philippines started in 1957. An evaporated filled milk was produced from imported skim milk powder and home produced coconut fat. The product was manufactured under licence from a dairy farmers' co-operative in the United States, a large Los Angeles dairy and a Dutch dairy co-operative. By 1975 the filled milk had captured 85 per cent of the canned liquid milk market in the Philippines. Prior to this evaporated milk was the standard form of milk consumed in the Philippines and the government, by opting for filled milk is also far cheaper than evaporated milk and reaches a greater proportion of the population. When the product began to prove it would be a great success, the medical profession began to become worried about the possible detrimental effects to children of a high proportion of coconut fat, with its high saturated acid content, in the diet. The government therefore decided that a mixture of coconut fat (90 per cent) and corn oil (10 per cent) should be used instead and stated that the corn oil had to be home produced.

The Mexican filled milk project started in 1954[29]. The product is again made with skim milk and coconut fat, but this time is homogenised, pasturised, and bottled for distribution. All the product is sold to the poor of Mexico City under a social welfare scheme.

Many other countries such as Thailand, the Khymer Republic and Malaysia also have on-going projects to develop filled milk production[26].

All the attempts by developing countries to produce milk substitutes are attempts to become more self reliant. As far as is possible the ingredients are home produced. With filled milks there is a dependence on imported skim milk powder of which there is a surplus in many parts of the developed world[28 & 29]. It is therefore relatively cheap at present. The future for filled milks, because of this dependence may look dubious. Although at present skim milk powder is abundant, concern about this overproduction is widespread in the developed world. It is possible that either agriculture in the developed world will be rationalised to prevent gross over-production or developed markets may start to absorb the surplus in time.

The success of the projects seems to depend on the attitudes of the people to which the product is directed[29]. This may be one reason why many products are aimed at the young, they probably have fewer prejudices or set ways when it comes to adopting novel foods[39]. However, unless the product is part of a nutritional welfare scheme, its adoption must depend on its cost and the income levels of the consumers even if it is highly nutritious. The proportion of a family's income in the developing world which is spent on food is very high. It is probably fair to say that the foremost consideration is the purchase of the essential traditional dietary items, any novel foods are, therefore, going to be extra expenditure and no doubt beyond the resources of many people. If, however, the purchase of milk is a regular expenditure for a family, a switch to milk substitutes may reduce the food bill. Precisely what pattern these new products follow in a country, is dependent on the people's habits and incomes. If a product is acceptable, nutritious, cheap, hygienic and plentiful, it can perform a valuable role in a developing country, both in improving nutrition and in providing employment.

In the developed world milk is extremely important from an agricultural, commercial and dietary point of view. The development of simulated milk and dairy products is therefore fundamentally different in this part of the world than it is in the developing world. This difference was neatly stated in a paper by Call in 1960[42].

"Generally speaking in the developed areas of the world when we talk about a fluid milk substitute, we are talking about a substitute for an existing product which is consumed in fairly large quantities. But in the developing countries of the world we are talking about a substitute for something that really isn't available to the bulk of the population."

He goes on to explain that in the developing world the production can be seen as a protein intervention programme but in the developed world it is a commercial profit and loss venture aimed at cutting in on a large, attractive market.

Nevertheless, simulated dairy products are being produced in developed countries and the range of types is even broader than in the third world. Totally plant-based milks still have limited distribution being mainly directed at vegetarians and people with milk allergies. Filled milks on the other hand are directed at a wider section of the community. Two companies in the United Kingdom have recently launched dried filled milk products: Unigate with its St Ivel "Five Pints", and Cadbury Typhoo with its "Pintsize". It is cheaper for these two companies to produce a dried filled milk than a dried whole milk and the product quality seems to be superior. Dried filled milks reconstitute well and have a creamier taste than dried skim milk. Apparently, 50 per cent of households in Britain run out of fresh milk at least once a month there may, therefore, be a substantial demand for a product with good keeping qualities which sits in the store cupboard until just such an eventuality. Keeping quality and a cheaper price are nowadays important to the housewife who visits the shops less frequently than previously and has a fixed budget for her food purchases. Products such as the coffee whiteners and cream toppings have been successful partly for this reason being cheaper than cream and certainly longer lasting. These are described as non-dairy products but in many cases the ingredients include some milk derivative such as casein[41 & 43]. The major constituents are usually vegetable fats and glucose syrup. Some products of this type have been extremely successful, for instance, mellorine from which 75 per cent of this country's ice-cream is made[26].

In the United States, more simulated dairy products are on the market than in the United Kingdom. Work is being done on simulated cheeses. One product consisting mainly of wheat flour, whey, buttermilk, maize syrup and soya flour plus a few minor ingredients is extruded and formed into small cubes either of imitation cheddar or blue cheese, for use as a salad garnish[43]. Another product prototype[44] is formed entirely from non-dairy constituents. The process is described as uncomplicated and a wide range of cheese varieties can be produced, Cheddar, Parmesan, Mozzarella, and Swiss. The developers of both these products claim that they can be used in cooking and food processing just as cheese might be used. One advantage suggested concerning the second process is that "cheese" could be tailored to meet specific dietary needs, for instance, for a cheese low in unsaturated fats. If the constituent materials are cheap and the process economical then this type of product may well substitute for real cheese especially in the food processing industry.

Widespread proliferation of simulated dairy products is likely to meet quite a lot of opposition from dairying sectors especially as in the developed world these are relatively powerful[28]. Coupled with this are governmental policies in many countries to protect the home dairy industry through subsidies and a whole range of dairy product regulations laid down over many years. The presence of these will have some affect on the development of milk substitutes. In the United States where more of these products are on sale than elsewhere, there is a growing body of concern over the nutritional merits of these products[26 & 41], particularly those which are substitutes for milk. If these products do not meet the standards expected then no doubt regulations will be adopted concerning their production, composition and sale which may have an effect on their future, whether this would be positive or negative is impossible to say. The next section will concern itself with looking at the nutritional status of milk substitutes.

3.254 Nutritional Aspects Of Simulated Dairy Products

In the third world one of the main factors in the development of simulated milks has been nutrition. The aim was to supply protein in an acceptable and cheap form. Consequently, much attention was focussed on the nutritional content of the resulting products and rigorous trials were carried out. The filled milk project in the Philippines has already been mentioned, as has the controversy over the fat used. The fear was that coconut fat would supply too much saturated fat to the diet and not enough essential fatty acid and polyunsaturated fats(29). Government stepped in to right this potential imbalance by stipulating that the fat should be a combination of coconut and corn oil.

It is also apparent from the literature that the protein content of the various imitation milks distributed in the third world has been carefully monitored in most cases(32, 33 & 36). Many clinical trials have been carried out showing that the imitation milks produced from soybeans or peanuts support good growth in young children especially when fortified with dl melhionine, calcium and vitamins. Little work seems to have been done on the use of these imitations as substitutes for breast milk in the developing countries, one can only hope use of these products for this purpose is not encouraged in the absence of further tests.

The quality of protein from soybeans and peanuts is good especially when fortified with dl methionine, a PER of approximately 3.0 is regularly reported[33, 34, 35, 36, 37 &45]. This figure compares favourably with milk protein. The quantity of protein in the imitation milk formulations is quoted as being on average around 3 per cent although some have a lower percentage[34]. This figure too compares favourably with the protein in milk percentage of 3 - 4 per cent. Fat content of soybean milk is often lower than cows' milk but other fats can apparently be added in without problems[34].

As a contrast to the rosy picture painted of imitation milks available in the third world, medical and particularly paediatric experts in America have become increasingly concerned about milk substitutes on the market[26, 41 & 42]. Their greatest worry is about the potential danger of feeding young infants these imitation milks. The American Academy of Paediatrics, Committee on Nutrition[41] published a report on Filled Milks, Imitation milks and Coffee Whiteners. Filled milks they felt were invariably equivalent to milk in protein content but the fat content and type might lead to essential fatty acid deficiency. The fat in filled milks is usually chosen on the basis of its cost, availability, taste and stability. The most common fat used is coconut fat and this is low in linoleic acid, the essential fatty acid. Some filled milks do include some unsaturated fats to overcome this deficiency.

The committee also studied commercial imitation milks available in the United States. Their conclusion was that these imitation milks usually derived from soy protein were inferior to cow's milk with regard to their protein, vitamin and mineral content. This opinion was substantiated by Ashworth[40] in another study. A recommendation is made by the Committee about the use of imitation milks in the diet of very young children:

"Milk is a major component of the diet of the very young child, and the indiscrimminate use of imitation milk in the mistaken belief that similar quantities and qualities of essential nutrients are being supplied by imitation products must be guarded against".

In 1969 the Food and Drug Administration in the States published proposals for standards of Identity and Quality in Imitation milks, but these were never made mandatory because of a decline in the trend of use of imitation milks[41]. However, the above recommendations should be borne in mind when considering feeding infants with commercial imitation milks. If the use of milk substitutes became more widespread in the developed world no doubt regulations would be imposed on the quality and quantity of nutrients in the products. A desirable goal from the nutritional point of view would be that the imitation contained all the nutrients found in milk in similar proportions, that the protein content was equivalent or superior to milk and that the fat supplied ample linoleic acid[26].

It is difficult to reconcile the reported findings of the American Academy of Pediatrics with evidence from studies done in the third world. But it must be assumed that special formulations can be produced which will support infant growth[46]. Commercial imitation products available in the United States may be designed for broad acceptability and may, therefore, contain less soya protein in order to achieve a bland flavour than do proprietary formulations designed for nutritional reasons. It is only to be hoped that the nutritional standards of third world imitation milk products remain high as their potential benefit will be severely reduced if they follow the pattern reported in the United States.

3.255 Simulated Dairy Products in the United Kingdom

Mention has already been made of certain products now available in this country which are substitutes for dairy products. Mellorine is very important in the manufacture of British ice-cream. Dried filled milks, coffee whiteners, cream toppings and imitation creams can all be found on the supermarket shelves. There are even a few brands of soy milk on the market although their outlet is usually through health shops and their market is therefore more restricted.

In a country with a large dairy sector it is difficult to predict what future these products, and other products of a similar type, will have. As long as imported vegetable oil remains cheaper than butter fat filled milks, maybe a cheap and useful alternative or stand-by for fresh milk. If the amount of processing of milk increases, there will be increased problems of whey and skim milk disposal. Animal feed has so far been the usual course but milk proteins have useful properties and are becoming increasingly incorporated into manufactured foodstuffs. Other products may well arise from these sources which could be described as "non-dairy". In many cases these products will have advantages over the dairy alternative, such as better keeping qualities and cheaper price.

The future of totally synthetic milk is far more dubious in this country. Firstly it may not be politically desirable or justified in resource terms to run down the large home dairy industry and replace it to any great extent with a simulated milk industry based on imported vegetable protein; even if the cost of imported animal feed is included in the calculation. It is doubtful whether even if leaf protein from grass could be used to manufacture a milk substitute it could be produced anymore cheaply or efficiently than cows' milk. Resistance to the product would also probably be high as Britain is a country where fluid milk consumption is given high priority by consumers. Whether consumption is high because of the relative low cost of cows' milk to the consumer and the highly organised distribution service is a matter for debate. Any comments on the future of milk substitutes in Britain can only be conjecture but maybe more can be learned from the comments expressed in answer to the Delphi Study.

3.26 A Special Study: To forecast development times for technologies needed to integrate dairying into a plant-based food production system

3.261 Introduction

The reasons for attempting a forecasting study at all were two-fold. Firstly, it was important to gauge opinion in general on the potential for dairying without cows and in consequence gain some insight into feelings about the whole system under study, even if only from a small body of people. Secondly, some perspective was needed for the whole question of transition to the hypothetical system. The time scales generated by the study, it was hoped, would give some indication of how long such a change in agriculture might take, given the right conditions of social desirability and incentive. In other words, if there was a widespread desire for a new food production system, what time-lag would be likely before required technologies had been developed, which would enable the new system to become fully viable.

Milk production was chosen as the area of study for all the reasons previously mentioned, such as, its importance in British agriculture and the National diet. It was assumed that in the novel situation some sort of "milk" foodstuff would be demanded.

The Delphi method of forecasting was decided on as the most practical method available for generating the time scales (full details of the method are given in Appendix IV). A small scale postal survey could easily be conducted from the Technology Policy Unit as it required relatively few resources.

A conventional Delphi was attempted using a panel of experts and a series of postal questionnaires. It could not be conducted along strictly conventional lines because to a great extent the scenario for the system into which the developments under study had to fit was already defined. It was hoped that the Delphi would be an integral part of the study and provide answers to precise questions, which was why the panellists were not given a free hand in building their own picture of a novel system based on plant foodstuffs. They were also bound in their predictions by a set of conditions imposed by the scheme for the novel system. Consequently, this Delphi was very unlike many other Delphis in that it did not ask respondents to predict the time the technical developments might take from the base line of the present but from a hypothetical base line drawn by the researcher. There are obvious inherent difficulties in an approach of this nature which will be discussed at length later. In other respects though the Delphi followed normal procedure.

3.262 Method

3.2621 Round 1. and the selection of experts

In the section 3.22, the major technical developments needed to facilitate various stages of dairying without accompanying meat production, were delineated. To briefly summarize, these involved, techniques for inducing lactation in cows, methods of determining the sex of offspring prior to conception or, as an alternative a technology for producing "milk" not using animals at all, from plant sources. The questions were designed to cover each of these potential developments. Thus in the first questionnaire there were three questions.

The two questionnaires sent out can be found in Appendix V. Both were checked for ambiguities of style by a psychologist. The respondents were asked to indicate the probable time-scale of development for the various techniques by ticking in the appropriate answer column. Three time ranges were used in the first round, 0-10 yrs., 11-30 yrs. and more than 30 yrs. Space was also left for comment on each question and for general comments. The questionnaire was kept short as there were only a few items to be covered and because it was felt that a short questionnaire would be less of a burden on our panellists time, especially as it was not possible to offer any remuneration for contributing.

The questions were of a highly specialised nature and covered widely differing topics. Experts with knowledge of induced lactation and the possibilities for sex-determination of fertilised ova would possibly not know all that much about plant milks and vice versa. Consequently, choosing experts was a problem. It was hoped that as many relevant experts as possible could be involved. A list was drawn up, which included dairy technologists, dairying experts, animal physiologists, manufacturers of plant milks, other scientists involved in novel products, farmers, milk marketting men and scientific advisers to the vegetarian society. Twenty-two questionnaires were sent out. In retrospect it would probably have been advisable to widen the net to include a greater number of experts on the panel. A list of all those to whom a questionnaire was sent is included with the questionnaire in the appendices. The questionnaire was also accompanied by a covering letter explaining the Delphi method, giving reasons for the particular study and encouraging the respondents to predict the time-scales from the position of a need to move to plant-based agriculture.

3.2622 Second Round

When all the replies from the first round were received, the predictions were examined and the comments reviewed. A second questionnaire was drawn up. The format was roughly the same as the first but an extra question was added, concerning the possibilities for sperm selection for sex-determination, and the time ranges redefined. In the second questionnaire there were five time ranges; 0 - 5 years, 6 - 10 years, 11 - 15 years, 16 - 20 years and 20 years plus. Questionnaire number two was sent to 12 people, along with a list of respondents and a copy of the respondent's previous answer.

At the end of the second round, after all the replies had been received it was decided that no third round would be attempted.

3.263 Results

3.2631 Round One

From the initial 22 questionnaires sent out, 16 replies were received. Twelve of these gave usuable answers. Out of this 12, three did not feel "expert" enough to comment on questions one and two. There were therefore nine answers to questions one and 2 and twelve for question 3.

	Up to 10 yrs	10-30 yrs	30+ yrs
1. Induce lactation	5	4	-
2. Sex-determination	5	4	-
3. Plant milks	8	3	1

The answers to questions one and 2 show near equal division amongst two time ranges and no obvious consensus. Question 3 had more marked movement to consensus.

As a result of these answers it was decided that the time ranges were too wide, consequently these were narrowed in the second round. It was hoped that this would give a better chance for deriving reasonable time scales and possibly a greater peak in opinion.

Participants contributed many useful comments. There was a general feeling of dissatisfaction over the topics considered and also in some cases over the Delphi method itself. Much of the difficulty with answering questions one and 2 particularly, stemmed from the fact that the techniques are not presently under development in any major way. There was therefore a a general feeling that one had to imagine that the impetus for research existed and then speculate on the time needed to bring about the required development. Interestingly, the same problem was not apparent for the question on plant milks, even though little development work seems to be on hand in the United Kingdom.

In general, it must be said that the philosophy behind agricultural developments would have to be different for any of these developments to be realised for the purposes proposed in the study. Both induced lactation and sex-determination could become important under present conditions but for different reasons to those proposed; specifically to increase the viability of dairying by extending the working life of some infertile cows and in the case of ova transplants to produce multiple births and improve stock using selected genetic material.

On the question of induced lactation most participants were aware that this was already possible at a laboratory level, but felt that milk yields would decline if the technique was used reguarly on a cow. A couple of people felt, as has already been mentioned, that development would occur as a result of work done with other objectives in mind (e.g. for very special intensive production). One person felt that the development would increase the price of milk. Another that there could be concern over effects on nutritional quality and possibly hornonal residues in the milk.

On the question of sex-determination in cattle, again most participants were aware that work has already been done on this subject which showed that sex ratios could be influenced but that results were difficult to repeat. One person felt that in time cows would react adversely to ova-transplantation and fail to breed. A participant suggested that the development of semen selection at AI would be a more likely course. As a result of this remark, a new question was added to the second questionnaire.

Plant milks, particularly made from soybeans, already exist. The general feeling of the panel was that their use and production would depend on social and economic factors. Many participants felt that pricewise, the products would be less economical than cow's milk. The cost of distribution, being at least half the cost of cows' milk to the consumer at present, would not be altered by producing milk from other sources. The fact that the major substrate for fluid milk substitute is the soybean and that this does not grow in the United Kingdom, was a point against widespread development of milk substitutes here. One participant however felt that in the long term, the production of plant milk substitutes would prove more efficient in the use of plant resources and enable improvements to be made in quality control.

On the issue of the nutritional and organoleptic qualities of milk substitutes there was a feeling that it was difficult to define nutritional equality or superiority. The specific properties of milk that contribute to its organoleptic character raised some comments. Firstly, from one participant, that high enough standards of "milk-likeness" could not be achieved and secondly, from another, that if whiteness was required then this would cause problems if a product cheaper than milk were to be developed.

The opinions expressed by those who differed strongly in their predictions did not differ strongly from other panellists who offered other predictions. Consequently, no analysis of particular arguments put forward to account for a particular prediction could be used for re-evaluation. Because of this the remarks were just editted and pooled as a whole to be resubmitted in the second round. It was possible that some issue raised had been over looked by some participants which might cause them to reassess their original prediction.

3.2632 Round Two

Eight replies were received in reply to the second round questionnaire compared with twelve in the first round. Only four participants answered questions one, 2 and 3, and six replied to question 4. This was insufficient for carrying out any meaningful analysis. However, it can be said that opinions expressed in this round did not differ significantly from the previous round and no greater degree of unanimity had been achieved. One respondent remarked that this division of opinion may provide a conclusion of as much value as that provided by a consensus. The results are set out below.

Question	Development Time Divisions (years)				
	0-5	6-10	11-15	16-20	20+
1. Induced lactation	-	2	2	-	-
2. Sex determination using fertilised ova	-	1	3	-	-
3. Sex determination using selected sperm	-	2	1	1	-
4. Imitation milks from plant sources	1	4	1	-	-

A certain amount of re-evaluation must have taken place as now no development was thought to take longer than 20 years to achieve and most required less than 15 years. However, because of the different time ranges between the two rounds it is not possible to draw firm conclusions about this.

Very tentatively the results showed that it was believed that acceptable plant milks could be introduced relatively quickly, within the medium term upto 10 years. Although certain participants implied that if plant milks are to be equivalent to cows' milk in every way i.e., the same colour, the development might prove impossible. The body of opinion would suggest that the other developments, induced lactation and sex determination of offspring, would most likely be long-term developments. The derivation of a more precise estimate than that from the results would be of little value.

3.264 General Comments On The Delphi Study

The Delphi study did not succeed in its original objective to suggest development time scales for the issues under study and consequently not much could be ascertained about the course that transition to a totally plant-based system might take. There were however, useful insights gained from doing the study. It highlighted many of the problems involved in doing a Delphi study and has provided many useful comments from the participants. To some extent it was possible to deduce from these comments what the faults of the study were.

The first of the mistakes was to choose a range of topics in which there was little current research effort. There was also no indication that this would be a future course of development in this country. This meant that participants, with a high degree of specialist knowledge on the topics, were few in number.

A larger panel might have eventually led to a more meaningful conclusion in terms of predicted time scales. As it was, although over a quarter of the original number of people to which a questionnaire was sent survived to the final round, this only amounted to 8 panellists, too few to establish a reliable conclusion in any statistical sense.

Another problem was that the study insisted on a particular scenario as a frame of reference for the time scale estimations, this was that the country would adopt a policy for food production based on plant foods with a possibility for dairying, with modifications, in the transition stage. This theoretically seemed the logical course to adopt for a dairy industry in this situation (first the decline of dairy beef, then the possibility of dairying without beef and finally the production of milk and dairy produce by methods which by-passed the cow). This posed two problems for the participants. It was obvious from the replies that it was difficult to project development times from a hypothetical base. There was a conflict between the situation as it is now, and the interpretation of a radically different situation based on a theoretical idea for an alternative system of agriculture. It may be that the description of the alternative was not sufficiently comprehensive. It was, of course, also subject to the personal interpretation of the participants.

It is obvious that the reasons for the development of the topics in question was fundamentally different depending on which system was examined. Under present conditions the development of induced lactation might be prompted by a desire to bring barren cows into milk production rather than culling them from the herd. The techniques of ova-transplantation and sex determination are being developed, but for multiple births and stock improvement using the best genetic material available rather than to ensure a static herd size as suggested for the alternative. The development of plant milks to a level of acceptability such that they could replace cows' milk was not as confused an issue although the current development situation is somewhat static in this country.

The other cause of confusion related to the implied chronological order of the developments, that is, a move from the integrated dairy and beef, through an all dairy situation to a dairy industry based on plant milks. The problem being that it was generally agreed that plant milks could be developed first, presumably negating the need for the interim stage. This of course could be taken as a useful conclusion but probably also served to confuse the issue, if only because the study had already suggested an order of events.

The answer here would seem to be that a Delphi study would work better if it sticks to attempting to forecast developments that seem likely when considered in the light of the current situation. It also seems advisable for the investigator not to stipulate or suggest the order of development objectives. Despite the fact that it was the object of the study to provide answers to questions raised by the whole project, which dictated to some extent the subjective approach of the Delphi, it might have been advisable to have conducted a probe round. The object of which would have been to generate roles for dairying in a plant-based system of food production and necessary technical developments. If the participants had had a hand in the formulation of ideas they may have been more predisposed to the whole concept of the study. A greater degree of understanding and involvement could only have helped the exercise. This however is just one of the pitfalls in doing a Delphi and its easy to be wise after the event. Other methodological errors were made which may also have contributed to the poor outcome.

Firstly the time periods used to assist answering were too wide and too long range. Narrow time bands are more likely to lead to some sort of polarisation of opinion, although it is arguable whether they are any more accurate. The time scale should be kept within reasonably foreseeable limits too, as participants invariably seemed to feel that for periods over 10 years they were shooting in the dark and that what forecasts they were prepared to make were of limited value because of the future's unforeseeable nature.

Another error which may well have had a damaging effect on the study, and which could easily have been avoided, was to include with the second round questionnaire a list of first round respondents. Despite the fact that all opinion was anonymous, there was no doubt that some participants were intimidated by the presumed erudition of other members of the panel. Whether this had an effect on the confidence of their replies it is impossible to say, but it is obviously not good policy to put anyone in the panel in a position where they may feel less worthy than other members, however untrue that may actually be. It might also have encouraged some respondents to drop out from the second round.

In this study it would also have been useful to have had some incorporation of a self-rating of expertise by the participants. Even though, as some critics of this addition to the method have said, this might be construed as contrary to the spirit of the method and may also work in effect like the provision of a list of participants. In that is raises the question in the individuals mind of just what worth the investigator places on his opinion anyway. The reason for suggesting that this rating should have been included in this study is that because of the widely different topics covered some people just did not feel competent enough to answer them all, some on the other hand even in a self-expressed absence of expertise had a go. It would have been preferable in fact for everyone to have had a go at answering in this study because not only was the study seeking to provide time scales it was also seeking opinion on the developments. An individual who is ignorant of the details of the topic may still have opinions relating to the subject which can allow him or her to judge subjectively whether they think the development is desirable or not, without considering whether it is possible or not. These predictions are also valuable but maybe should not be given so much weight in a technological forcasting exercise. If the self-rating facility had been incorporated to encourage the answering of all the questions in this study, extra benefit would probably have resulted because of the need to get some feel for the reactions to the ideas behind the study. These subjective estimates may have helped in this respect. Doubtless to obtain a balanced appreciation of peoples feelings towards the subject a greater number of individuals would have had to be included on the panel and these need not all have been experts. It is important to stress that this possibility for predicting time scales and also indirectly for gauging opinion on novel situations was not and does not seem to have ever been exploited, although opinion from a number of writers now suggests that forecasting should move towards the assessment of desirable goals. Wills and others in their book "Technological Forecasting" go so far as to say that, "without doubt it is a wrong allocation of energy that results in an obsession with feasibility and a neglect of desirability."(47) These comments are retrospective and the study was, in fact, more concerned with possibility within a given situation rather than desirability within that situation itself. It is undoubtedly true that if more time had been spent examining the method and its potential, and the objectives of the specific study a more valuable outcome might have been achieved.

3.3 A Single Farm Study

The single farm study was carried out to investigate whether or not a farm, with minimal crop interests at present, would find it possible to shift to plant-based agriculture. The answer to this question was sought by assessing the potential for cropping and by deciding on a range of crops and suitable rotations for the particular farm. A cropping pattern for the farm was drawn up. Much of this part of the study relied heavily on the farmer's personal knowledge of the land and his opinion as to which crops would be a viable proposition.

Once a cropping plan was devised an attempt was made to examine other aspects of the farm business under the novel regime, such as the labour needs, and some other costs.

3.31 A Description of the Farm

The farm is a mixed enterprise business with livestock and animal by-products accounting for 96 per cent of its gross output*. The only cash crop grown is wheat. Barley is also grown on the farm but this is retained as feed. The pattern of farming is representative of farms in the area, the main enterprise being dairying and the main crop being grass.

Many would consider the area in which this farm is found unsuitable for plant-based agriculture. This makes it a useful farm to study in the context of a shift to plant-based agriculture as it could be considered to be a marginal type of farm within the novel scheme. Another reason for choosing this particular one was the ready access to the required information.

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* All information on farm taken from farm accounts and census returns.

The total area farmed is 593.3 hectares which makes it larger than the average farm in the area (the average size of a specialist dairy holding in the area is 95 hectares[1]). The larger than average size is a result of the amalgamation of a number of smaller farms into a single business.

Table 3.2 gives a breakdown of the pattern of land-use for 1977. Something in the region of 35 per cent of the crops

TABLE 3.2

Pattern of Land-use on Study Farm: 1977

(Data from June census returns for 1977)

	hectares	as % total agric. area	as % total crops and grass
Total Crops and Grass:	577.5	97.3%	
Wheat	11.3		2.0%
Barley	61.5		10.6%
Grass; Leys up to 4 yrs old	134.5		23.3%
5 yrs and older	370.2		64.1%
Rough grazing	8.1	1.4%	
Other land (roads, yards, etc)	7.7	1.3%	
TOTAL	593.3	100.0%	100.0%

and grass area is regularly tilled. Table 3.3 gives some physical data on the farm, concerning soils, climate, altitude etc.

It was noted before that the study farm is really an amalgamation of a number of farms. Four of these have associated land and each is a dairy unit. One of the farms

TABLE 3.3

Physical Data On Study Farm

Soil	Mostly free draining medium loam derived from carboniferous limestone. In some parts parent rock near surface - cultivation problems
Altitude	Most of farm lies between 500' and 1000' above sea level.
Rainfall	50" per annum (approx.)
Growing season	Mid-April to mid-October. (Return to field capacity can be earlier if autumn wet)
Temperatures	mean July temperature 59° - 60° F
Sunshine figures	1400 - 1600 hours per annum
Land classification	MAFF grades 3 and 4
Water supply	mains

[Source: Climate figures from Concise Oxford Atlas second edition (1978); land classification from MAFF (1971), land classification maps sheet 165]

lies on high ground at between 800' and 1000' above sea level and a flock of sheep are kept there along with the dairy enterprise. Three other "farms" are also part of the company. They, to all intents and purposes, have no land associated with them. On these farms there is a pig unit, a cheese making dairy and a calf rearing unit.

In all the farm supports 919 head of cattle, 852 pigs, 381 sheep (ewes and lambs) and a small poultry flock of 50 hens. Four Hundred dairy cows were in milk at June census 1977 and there were up to 240 in-calf cows and heifers as well as young replacement stock. The major output from the farm is farmhouse cheese made with milk produced on the farm.

Table 3.4 gives a breakdown of the labour situation on the farm. The employed workers include cowmen, tractor drivers, a shepherd, a pigman and cheese making staff.

TABLE 3.4

The labour situation on the study farm

Director (concerned with farm full-time)	1
Salaried manager	1
Regular whole-time male hired workers	20
Regular whole-time female hired workers	5
Regular part-time male workers	1
Regular part-time female workers	2
Total number of employees	29

3.32 The Cropping Possibilities On The Farm

The range of crops that could be grown is relatively unrestricted provided the stucture and organisation of the farm is appropriate for the job. The crops which are likely to be unsuitable for the area are those which require dry weather in the late summer and early autumn e.g., maize and dried peas. Otherwise, virtually all crops were thought to be suitable.

Orchard fruit might not give regular yields as there is a danger of frost damage until fairly late into spring.

Two flexible rotation schemes over 5 or 6 years were put forward for use on the farm.

- Potatoes - wheat - oilseed rape - barley - ley
- Oats - legumes - wheat - brassicas - lupins - potatoes

Certain items in these rotations can be changed easily and have been in the cropping plan. Ley has been replaced by multiple cropping at various opportunities in the novel crop pattern. Potatoes have been replaced by carrots and onions in certain instances, when the soil is sufficiently stone free to encourage carrots to keep their shape. The brassicas in the rotation can be any suitable variety, cabbage, turnip, swedes, etc.. A good gap between brassicas in the rotation sequence is essential because of the risk of club root. Oilseed rape has never been grown on the farm so its performance is difficult to predict.

Lupins are included in the rotation as a novelty with green manuring potential now (as in the classical Suffolk rotation on poor land of rye - lupins - potatoes). The need for other oilseeds in the overall plan for the country to boost potential self-sufficiency in vegetable oils has already been noted. Lupins are a crop which is currently receiving some attention as a potential oil-bearing crop[2]. They were included in the single farm study rotations to show where they could be useful if suitable varieties were developed.

The rotation pattern devised is intentionally diverse to try and establish the whole range of possibilities for the area. It is not possible to say precisely what a farmer under the novel system would choose to grow but it is likely, given the "marginal" nature of the area under the system, that he or she would choose to be fairly diverse in order to allow for failure in some crops in some years. A very high level of crop husbandry would be needed to achieve reasonable results from cropping on this land. It is therefore suggested that organisational changes in the current farm arrangement would be needed to facilitate easier management and hopefully to improve potential output.

3.33 Proposed Organisational Changes

The present field structure on the farm has evolved for keeping livestock. Fields are often odd shapes and some contain stands of trees. Some are small paddocks for holding stock. If cropping is to be a practical and efficient alternative, it would be necessary to alter field boundaries.

The land on the farm is essentially based on four centres; A, B, C and D. The croppable area associated with these centres varies:-

TABLE 3.5

Croppable Land
Associated With Each Centre

		Number of plots suggested
A	122.9 ha	(3 plots)
B	158.0 ha	(3 plots)
C	93.6 ha	(3 plots)
D	78.4 ha	(2 plots)
TOTAL	452.9 ha	

[These figures are an estimate of the area suitable for cropping calculated with the help of the farmer]

These areas of land were hypothetically divided into croppable plots which would involve removing some of the present field boundaries to form roughly even-sized pieces of land. The plots would be between 40 and 50 hectares in size. These plots could be further sub-divided into rotational sections. Boundaries such as roads and steep sided coombes are permanent and these have been used to mark out divisions where this is practical.

Not all the centres can be split up easily into plots. Centre B for instance consists of land of fairly poor quality and the three plots projected for it may in fact be scattered patches of croppable land. A large proportion, nearly 40 per cent, of this centre is unusable for cropping at present. Centre D is a small compact centre but the land is criss-crossed with roads and a natural coombe; it does not therefore divide easily into large cropping plots.

Although the land would be capable of supporting diverse crop production the shift would not be without problems. The weather and the quality of the soil both make cropping a rather challenging proposition. The relatively high rainfall and low level of soil moisture deficit in late summer mean that timeliness of cultivation will be critical, particularly considering the number of crops contemplated.

Some of the land which is currently unusable for crops could be improved if there were a large input of resources. Improvement is currently carried out by grazing livestock and the occasional application of lime and fertiliser which eventually produces a better sward and improved soil properties.

The division into plots was proposed to ease the management problems. These plots are envisaged as being self-contained cropping units or farms. The number of production units within the company would increase from 7 to 11. The maps in Appendix VI

3.34 The New Crop Pattern

Each centre was handled individually and the crops included in the rotation, although essentially the same as in the proposed rotations, were individually assessed for suitability on that site.

Plot One on Centre A is given as an example of the pattern envisaged over the page in Table 3.7.

3.35 Fixed Cost Considerations

A change of this type, from nearly wholly livestock-based to plant-based, is going to demand changes in fixed and variable costs. The fixed cost which can be most easily considered for the novel system is labour.

The probability is that the labour needs of the farm, if it shifts to plant-based production, would increase. If the situation in areas where general cropping is currently carried out is examined it can be seen that there exists a tradition of casual and seasonal labour for harvesting and post harvesting operations. This is because at certain times in the year the labour requirement is very high compared with the relatively low needs in the remaining time. The need for extra labour at key times in the year can be reduced, in some cases, by using sophisticated labour saving technology. This technology tends to be expensive and any farm adopting a broad crop pattern is unlikely to be able to justify the investment for all the relevant equipment. There exists a choice then, even if some investment in labour-saving equipment is anticipated, between employing large gangs of extra labour and hiring contractor services and smaller numbers of extra labour (or none depending on the extent to which

TABLE 3.7

Five-Year Rotation On Plot 1, Centre A

Sections of plot \ Years	1	2	3	4	5
1	Potatoes	Wheat	Oilseed Rape	Barley	Green Manure or Ley
2	Wheat	Oilseed Rape	Barley	Green Manure or Ley	Potatoes
3	Oilseed Rape	Barley	Green Manure or Ley	Potatoes	Wheat
4	Barley	Green Manure or Ley	Potatoes	Wheat	Oilseed Rape
5	Green Manure or Ley	Potatoes	Wheat	Oilseed Rape	Barley

[Sections are roughly 8 hectares in size] the equipment reduces the labour requirement). Which of these alternatives is chosen depends on the job concerned, the relative costs and efficiencies of the alternatives and the availability of labour or contractor services in the area.

The present situation is that little casual or seasonal labour is used on the farm and this seems to be the case for most farms locally. Contractor services do exist and are used for harvesting the small cereal acreage. The area under wheat and barley does not warrant the investment in a combine harvester, but at any time a balance has to be struck between the costs of the contracted service and the availability of this service at a time of high demand, and the cost of buying, running and maintaining a combine and training an employee to operate the machine for the farm.

The calculations for labour requirements were done on the basis of field work and crop handling requirements. Other jobs on the farm, such as routine maintenance, must be assumed to be done on days unsuitable for field work. Only a certain number of days in any year are available for field work. Table 3.8 gives a breakdown of labour requirements on Plot One, Centre A, over a year with estimated available days and calculated standard man days. The critical times for this plot, when timeliness of operation will be all important, are early spring cultivation, and early autumn potato picking and cultivation for winter sown crops. From the table it can be seen that, in theory at least, only one man would be required to do the field work over most of the year. The regular labour requirements for all the plots on Centre A work out to be similar, so the total full-time work-force would need to be three. However, if timeliness is all important, and as other jobs apart from field work will need to

TABLE 3.8

Monthly Labour Requirements on Plot I, Centre A.

Month	Season	Tasks	Available Days	Calculated S.M.D's	Men Needed
March	Early Spring	Potatoes - seedbed cultivation, fertiliser, planting; Wheat - top dress and roll; C-s-R - Top dress	18	19.5	2
April	Early Spring	Barley - Top dress and roll; Leys - seedbed cultivation and sowing	20	14.5* or 28	1 or 2
May	Late Spring	Potatoes - tractor hoeing and moulding up; Wheat & Barley - spraying	22	10	1
June	Early Summer	Potatoes - hoeing and moulding up; Cereals - some late barnwork	24	4	1
July	Mid-Summer	Potatoes - spraying; C-s-R - Windrowed or combined etc.	24	8	1
August	Late Summer	Wheat - harvest; Barley - harvest; Oilseed Rape (O-r-S) - plough seedbed and drill	24	18	1
Sept	Late Summer		20	24	2
October	Early Autumn	Potatoes - haulm removal, harvest, clamped; Wheat, Barley - plough, prepare seedbed and sow; C-s-R - pre-emergent spray	17	47.5	3
November	Late Autumn	Ley - ploughing; cereal - barnwork; potatoes - riddling and bugging	14	19	2
December	Late Autumn		7	12	1
January	Winter	barnwork, potatoe bagging maintenance etc.	7	12	1
February	Winter		7	11	1

* lower labour requirement if potato planting mechanised.

[Source: Available days and S.M.D's taken from Nix. J (1971) "Farm Management Pocket Book" Wye College. MAFF (1969) "Labour and Machinery" Aids to Management Series No. 6 HMSO] be done, an extra one or two full-time workers could probably be employed on the Centre. At busy times it would probably be necessary to have more workers on the farm though it is possible that with mechanisation and sensible organisation of labour on the centre the need to employ casual workers would be small (this would certainly be so if contractor services were also used).

Over all the farm it is difficult to predict precisely what the total workforce would be but as the needs of each centre are roughly similar a total full-time workforce of twenty or so would seem to be adequate which is in fact a small workforce than that currently employed. This figure might be a little high but the precise number will depend on many factors, from the level of mechanisation adopted to the degree of flexibility in the daily work routine of any individual on the farm.

Labour needs can also be affected by post harvest operations. This is especially important for vegetable crops. The amount of post harvest work will depend on a number of factors, from the type of market to which the crop is going to the degree to which local farms co-operate . Produce for the fresh market has to be graded, sorted and packed in some way and these operations could be carried out on the farm. It is also possible that the farm could grow vegetables under contract for either the fresh or processing markets which might mean that the responsibility for post harvest handling is removed. Presumably, whether the operations are carried out on the farm, through some co-operative local venture or by some whole-saling or processing company, the probability is that the work would be done locally (or relatively locally if the latter alternative were the case). and this means there would be a need for local workers on a part-time, seasonal or full-time basis. It is very difficult to say whether a pool of suitable labour exists locally for this work. The farm is on a bus route from Bristol and other local centres which might provide labour but transport costs (particularly Bus fares) in the area are currently very high so wages would have to allow for this unless some alternative were available. In the immediate vicinity there are probably insufficient people willing to take up employment of this sort, especially as all farms locally would be producing some vegetables. The problems of adjustment to this new need for labour should not be underestimated in an area where there is little of this sort of farming at present.

The need for timeliness of operation is also going to demand some mechanisation even if contractors are used for certain jobs. For instance, in the spring, when seed beds are cultivated, each of the plots will require some cultivation and all this will have to be done at a time when the weather is suitable. There is unlikely to be time to stagger the use of machinery, so each plot will need at least one tractor. Total tractor numbers over the whole farm will, therefore, need to be at least eleven and the number of other pieces of machinery, such as harrows, may be just as high.

Another fixed cost for which there may be a different need under the novel system is buildings. The requirement will be different but many of the existing buildings will probably be suitable for converting to use under a cropping regime, although some purpose built buildings may become totally redundant, for instance, milking parlours. There is already a grain dryer on the farm but it is probably of insufficient capacity to cope with the greater quantity of grain and seed which would be produced.

3.36 Conclusions

In many ways this small study mirrors the country-wide plan for plant-based cropping in that on the purely physical and biological level there seems little reason to suppose that the system is not a feasible alternative. The conclusion in the single farm study is that this farm could shift to an all plant-based production after some readjustment in farm structure and in the deployment of resources. If this farm, which on the face of it appears to be unsuitable for cropping, can in fact be adapted to a cropping system the chances are that the overall area of the Plan could be increased comparitively easily. Despite the fact that cropping is a possibility on the farm it is obvious that it does not constitute a likely choice of business in the area, given the moderately high rainfall and, in some areas, the stony ground. Areas in which there are fewer restrictions on cultivation and in which weather and soil are more conducive to cropping will obviously have at least a biological edge on the area considered. The risks associated with shifting to plant-based agriculture on the study farm are fairly high, which is why a fairly broad range of crops has been suggested.

The intrinsic problems of cropping in the area mean that the level of management skill needed to make the business profitable will be high. The organisational changes proposed indicate possible measures to be taken, but they are presumably not the only possibilities. Decisions would also need to be made about such things as the size of the workforce, the level of mechanisation and the choice of market for farm production, all of which are variable. Not only will these decisions depend on the farm itself, they will also be conditioned by the local situation for each factor. It was noted before that the local labour market may not be able to provide labour for the seasonal and casual work nor even possibly for the part-time work load on the farm. The reasons for this are both the changing social mix in the area as it is in commuting distance from Bristol and the very high public transport fares. Neither of these two factors are unchangeable but change would not be straightforward. The situation with regard to labour tends to suggest that fairly high mechanisation and the hiring of contractor services will be the likely course. The calculated labour requirement for the farm under a totally plant-based regime, twenty, is not greatly different from the current full-time labour force of twenty-five but the requirements of farm house cheese making tend to make the current figure unrepresentatively high. Plant-based agriculture is likely to employ more people overall than animal-based farming. The power capacity on the farm is likely to be high per unit of land because of the need for fairly high mechanisation and because of the limited potential for creating very large areas for cultivation.

It is nearly impossible to compare the economic performance of the farm under the current system and under the novel system. A tentative attempt was made for the financial year 1976/77 but as this was the year of the drought the results were not at all conclusive. Gross margins per acre considerations indicate that cropping is slightly more profitable but this is again probably misleading given that the output level cannot be categorically assured and variable costs maybe very different from those which go towards estimating average standard gross margins. If a shift were contemplated country-wide it is likely that serious studies on the possibilities for arable farming in areas like the one in which the study farm is found, would be undertaken to establish the comparitive performances of the different types of farming more realistically. This could be done by setting up or changing the enterprises on experimental farms in appropriate areas. It would also be necessary at this stage to take into account the probable changes in the market for agricultural produce, the size of the industry, the demand for other forms of land-use and the local availability of labour.

CONCLUSION

The whole of this project has taken the form of a technology assessment to try and establish the consequences of plant-based agriculture in this country. The scheme proposed set out to provide nutritional self-sufficiency and a vegan type of diet. It has been assumed throughout that if we were all to adopt a vegan diet this would make the achievement of nutritional self-sufficiency very much easier. Chapter 24 which is concerned with the construction of an hypothetical system for British agriculture based on plants suitable for human consumption, leads to the conclusion that nutritional self-sufficiency is a possibility, with plant based foods only, if the present arable acreage is increased to its potential maximum by ploughing up some of the land which is currently under permanent pasture. The construction of the scheme was intentionally cautious and conservative. It is therefore reasonable to assume that no serious biological constraints to the realisation of the Plan would be encountered provided the standard of crop husbandry were good and every attempt was made to preserve soil structure and fertility.

The workability of a scheme does not however rest simply on whether or not it is biologically sound. The system investigated is fundamentally different from the one currently established; it embodies not only radical agricultural change but also, at the other end of the food production chain, enormous change in dietary habits. Change at the two poles of the system will also necessitate change in all the other aspects of food production and agriculture. In fact so great is the proposed change that its impacts are likely to be felt in almost every facet of life. Workability does, therefore, largely depend on the potential for a transition and this would undoubtedly be an extremely slow process because of the inherent inertia of something as large and as complex as the British food production system.

There is no realistic way of indicating how long transition would take if such a change in food production and diet were ever adopted as a long-term goal, especially as the reasons for wanting or needing to change are potentially very varied. However, it is possible to envisage a series of compromise situations which are stable in their own right and could be considered as stages in the transition to totally plant based agriculture. The incentives for and problems of adoption as well as the cost and benefits of the various stages will be discussed fairly briefly. The discussion will draw in many of the subjects and issues examined in the thesis and should provide a general conclusion to the work.

The three stages are defined by both agricultural and dietary changes. The agricultural changes and the dietary changes in the first two stages can be seen as specific steps in the progression towards the radical third alternative. The three stages are:-

1. The elimination of intensive meat production and of production exclusively devoted to meat though not necessarily on an intensive basis.
   A reduction in the amount of meat consumed in the diet.

2. The complete elimination of meat production, even that derived from dairy herds. This situation is that investigated in chapter 3.2 the 'Dairy Industry'.
   The adoption of an ovo-lacto-vegetarian diet.

3. The elimination of all animal-based farming. All farm production is to be in the form of plants suitable for human consumption.

   The adoption of a vegan type of diet.

Stage One

Stage One is a potentially stable system. It depends on the removal of types of livestock farming which are virtually exclusively devoted to meat production, particularly if this is on an intensive basis. Pigs, pure beef cattle and broiler chickens would disappear but egg laying hens and dairy cattle would be retained. Sheep farming will also remain to prevent severe problems in upland areas. Meat production from the dairy herd and sheep flock would continue at some level.

The accompanying dietary change is relatively mild. Meat supplies would fall substantially provided that there were no imports to counteract the change. It is likely that the diet could contain more home produced dairy produce and vegetable foodstuffs to compensate for the loss of meat.

The first stage is very similar to the plans for self-sufficiency in temperate food supplies noted in chapter 1.5. These plans do not just aim to cut back import demanding enterprises like intensive pig production, they also seek to maximise the potential supply of food of an acceptable type. The point being that change in food production is easier if the dietary change this creates is within the bounds of perceived acceptability. The rationale behind these sohemes was not a better diet but reduced dependence on imported food and feed. The incentives for moving towards this stage rest really on this import-saving, improved self-reliance argument. There may be an improvement in diet also but this is conditional on the pattern of supply which emerges when meat production is severely reduced. This can be briefly illustrated by examining one of the schemes for self-sufficiency noted in 1.5. Watkin William's ideas are based on the removal of lowland sheep, pigs and broiler poultry because of problems with the supply of feedingstuffs and the decline of the fishing industry. He proposes that, in the event of this removal of a significant proportion of our daily protein intake, the shortfall could be met by a number of different combinations: milk and eggs or protein rich grain crops, peas, beans etc., or a combination of both milk, eggs and vegetable protein. Each of these would result in a different diet with a varying ratio of animal protein (including meat) to vegetable protein. The 'healthiness' of these possible diets may vary. Some people would be very disturbed by policies which promoted extra dairy production and the consumption of dairy products, others would consider that diets in which meat was less important can only be an improvement on the current diet and it is likely that a number would welcome increased consumption of vegetable foodstuffs relative to animal foodstuffs*. It is difficult to comment further on the dietary significance of the change indicated by stage one simply because of the considerable potential for variation under this scheme, as can be seen in 1.5.

Another major incentive for moving towards a stage one situation is efficiency of resource use. Meat production is highly inefficient in terms of energy use when compared with milk, egg or plant protein production. The extravagance of energy use in meat production is not immediately obvious in terms, say, of direct oil-based inputs but is largely hidden by the indirect energy needs of feedingstuff production, much of which is not home produced anyway. Crop production under modern systems requires considerable amounts of non-renewable

* See 1.4

energy inputs to supplement the solar energy input. The energy output from crops is squandered by feeding the crops to animals as the efficiency with which they convert it to an edible end product is very poor*. Semi-intensive and intensive systems of meat production, which rely on feed being brought in, also hide another inefficiency in terms of land-use. Productivity per unit of land in intensive pig production for instance is superficially high, because most of the land-based inputs have to be derived from elsewhere. This means that although an intensive pig unit may occupy a relatively small area and pig population density might be high, the system cannot work if there is not a very large area of land somewhere else producing food for those pigs. A system therefore which maintains large animal populations under intensive methods can only be maintained in this country at least, by importing feedingstuffs grown elsewhere in the world. The sustainable livestock population in this country, if we are to feed ourselves and them, must be comparitively small compared with that which is currently supported.

Adopting stage one in some form or another as a system of agriculture in this country is likely to provide both costs and benefits. Costs of the change would be borne predominantly by farmers practising intensive or semi-intensive meat production, food processors dealing with meat, animal feedingstuff manufacturers and suppliers, specialist meat retailers, skin tanners and other people working with the by-products of meat production. In some cases the costs could be only short-term as there is still some flexibility of opportunity. For instance

* See 1.2

many farmers engaged in meat production will be able to alter their enterprise pattern under stage one with, relatively speaking, fairly minor disruptions. Other farmers who are constrained by land availability on their holding are likely to encounter considerable problems. The opportunities for changing from intensive broiler production to something else must be limited. The costs to farmers will be largely in terms of redundant capital, a situation which can be eased by slow change. There will also be some costs in terms of loss of livelihood and redundancy of expertise and skills. Costs resulting from loss of employment opportunities in some areas of farming are possible but are unlikely to compare with the costs of the loss of job opportunities in the meat, non-edible livestock products and animal feedingstuffs sectors. Chapter 13 conservatively estimates that the number of people employed in the meat and livestock industry was 500,000, the removal of a major proportion of current production is likely to create costs in terms of jobs lost. These are to an extent also ameliorated by the rate at which change occurs, if it is slow contraction in the meat industry can occur, at least in theory, without major problems developing. Large firms, not exclusively concerned with meat and/or livestock, should be able to change more easily, the greater problem is for those individuals who could not really alter their business in the event of such a shift, this includes those farmers already mentioned and people such as small retail butchers.

The benefits which may emerge also need to be considered. If there were no benefits there would be little incentive for change but this is not the case. Benefits are likely to be derived from reduced import bills, reduced energy-use (or at least more efficient energy use on farms), and possibly from improved diets. If some sector is expanded to compensate for the removal of part of the meat producing sector it will create a net benefit in terms of new employment in the expanded industry. There is also a potential benefit to be derived environmentally, stage one is likely to reduce the quantities of animal waste produced. The problem of waste production from intensive and semi-intensive livestock farming and from slaughtering and meat processing is quite considerable.

In many people's opinion the benefits of such a shift outweigh the costs. There seems little doubt that compared with the other two stages the shift to stage one could be achieved fairly easily and with fairly manageable consequences. It is possible that the new diet would meet with consumer resistance but if meat prices were to rise faster than the standard of living many may be eating a diet very similar to that derivable from stage one anyway. There does not seem to be any strong indication of change in the edible animal product purchasing pattern (although trends within this broad group are noted in 1.4) so in general one must assume that in terms of food buying and dietary aspirations meat and other animal products are still very important. If it proved necessary for a shift to occur, because of declining energy or feed supplies say, a sustainable system based on crops and animals would not only be the easiest to achieve agriculturally but probably the most acceptable to consumers. It would also be far less disruptive to other areas of society than stages two or three. Stage one does in fact, have much to recommend it.

The reason that no shift has occurred or seems likely to occur at the moment is probably not because there are any major practical problems connected with implementation over a number of years nor because no one perceives the potential benefits of a steady change, but is more concerned with political problems. The trading and other interrelationships, between Britain and her E.E.C. partners and the rest of the world, at present work against change. Also the meat lobby has considerable political power. One would also like to suppose that change is not encouraged because of insufficient evidence as to the health and social implications of change. Food and agricultural policies are largely sub-ordinate to broad economic and political policies and are expected to fit in with these. It is frustrating to realise that positive change, in an area so vital to mankind and so obviously in a state of extreme imbalance world-wide and here in Britain, is so dependent on factors which are determined solely by attitudes to power and money. However, it is probably naive to assume either that change is impossible or very easy, the truth is somewhere in between. Change forced on us by circumstances beyond our control is one extreme, steady change resulting from changing attitudes particularly those of consumers in a market orientated society is the other.

Stage Two

Stage two is envisaged as a system where meat production no longer exists but where dairying and egg production can still be maintained. In order to do this it would be essential to develop techniques of genetic and physiological manipulation like those described for dairy cows in 3.2. Alternatively one could accept that cows and chickens do produce surplus offspring of both sexes (though for chickens this problem is confined to male birds largely), and dispose of the surplus shortly after birth or hatching. The system is conditional on people adopting an ovo-lacto-vegetarian diet wholesale and if this were the case it is likely that both alternatives would offer moral problems, it would have to be decided which was the least abhorrent of the two. For argument's sake this discussion is confined to the alternative which rests on the development of induced lactation and the sex-determination of offspring prior to conception.

Pigs and broiler chickens have already been removed by Stage One but sheep were retained. Sheep pose a problem as they are virtually the only agricultural possibility for much of our uplands. They are, therefore, of immense importance to the economic continuance of communities in these regions. They also help to maintain upland landscapes in a condition which society values for amenity reasons. An acceptable aspect of sheep production, as far as Stage Two is concerned, would be wool production but as meat production is also of fundamental importance in the present sheep farming system some decision will have to be made about the future of sheep under Stage 2.

There are a number of possibilities, for upland areas unsuitable for little other than sheep, which spring to mind:-

(1) We could accept that sheep farming is the most practical use of these areas.

(2) We could maintain sheep in a feral state in order to preserve the landscape. This might present opportunities for wool cropping but would require some system of management to be developed.

(3) We could remove sheep altogether and leave upland areas to regenerate their natural flora and fauna.

(4) We could change the land-use of farmed upland areas by turning much of it over to forestry.

Each of these alternatives will present problems but the whole issue of a future for upland areas under vegetarian schemes for agriculture, whether or not they contain milk and eggs, has to be faced at some point. If the dietary shift resulted from a moral reaction to meat eating then alternative (1) is unlikely to be acceptable and one of the other three or a composite alternative must be decided upon. Sensitive land-use policy for upland areas may include all the last three alternatives. This would give some scope for preserving parts of the upland landscape in a well-loved form and give some opportunity for employment with sheep even if not strictly speaking in farming. It would also allow for the expansion of forestry to start on a considerable scale and in some places natural upland vegetation could return for the fascination of ecologists, naturalists, botanists and others interested in nature. The important point is though that if agricultural production were to shift towards plant-based agriculture even in this interim stage it would be essential to develop a coherent and beneficial policy towards upland Britain. Some may consider that a policy for these areas is already long overdue but there is no doubt that shifts in agricultural production arising from dietary change would bring it very sharply into focus.

Stage Two is the genuine half-way stage between the present system and totally plant-based agriculture in as much as it provides the interim, ovo-lacto-vegetarian diet. Agriculturally it is likely to provide nutritional self-sufficiency and possibly self-sufficiency of temperate food supplies if the population were to go vegetarian. It can also be envisaged as occupying all the present agricultural area bar the most inhospitable and unproductive uplands. The removal of meat animals even those still permitted in Stage One might encourage an expansion of dairying in grassland areas and into upland areas where this is suitable. This expansion does depend however, on what demand pattern for food emerged. If dairying did not expand arable farming might encroach into grassland areas to provide greater self-sufficiency. If this were not the case attempts would have to be made to encourage production in lowland areas in order that the maximum amount of agricultural land was kept in agricultural use in Stage Two. The dislocation problems in upland areas encountered at this stage are such that it might be desirable to minimise the possibility of similar problems arising in lowland areas. Stage 3 would liberate so much land that these problems will arise in lowland areas anyway and it might be easier to go one step at a time, at least for discussion purposes.

It is important to determine whether there are any incentives for moving towards Stage 2. If people were to become vegetarian this would be a major incentive for agricultural change. They might actually do this if meat prices became exorbitant, thereby restricting the potential market. It is also possible that concern over what we eat and our state of health might grow, which could prompt radical dietary change. However, this seems some way off and it is difficult to see the sense in changing from a general mixed diet to a diet containing dairy produce, eggs and vegetable foodstuffs. The evidence presented in 2.3 suggests that there are no special health benefits derived from an ovo-lacto-vegetarian diet. The possibility that consumption of dairy produce and eggs might be used to make up for the loss of meat may in fact prove detrimental to health although this is a highly controversial issue and no one has provided evidence, generally regarded as proof, of the adverse health effects of these food items. If, on the other hand, dairying and egg production were retained to supplement a diet based largely on plant foodstuffs this might be fairly sensible as a largely plant-based diet can be made more interesting, of greater nutritional worth and easier to cope with in a culinary sense, by incorporating small amounts of egg and dairy produce. The difference between these two dietary situations, dairy produce as the basis of the diet and dairy produce as a supplement to a plant-based diet, might only be small in terms of actual quantity consumed but it represents a completely different attitude to this type of diet. If dairy produce is regarded merely as a supplement to a plant-based diet, the possibilities for changing to a diet without any animal products seem greater than if dairy produce were the basis of the diet.

A diet which was derived mainly from plant sources might be desirable if Britain aimed to become self-sufficient. The ease with which this could be achieved depends on the size of the population. It was noted in the Stage One discussion that a scheme of that sort could provide self-sufficiency in temperate foods now. Perhaps dairying and egg production is a way to self-sufficiency at a different level of population. The concept of self-sufficiency is however independent of the need to turn vegetarian so the biological techniques of induced lactation etc., might be unnecessary if the incentives for change were simply self-sufficiency. Vegetarianism is possibly only valid as an incentive for agricultural change if it results from a moral reaction to meat eating or a change in tastes and this would have to occur on a very large scale. A need for self-sufficiency may force us to near vegetarianism but would this stifle demand for meat or dairy produce? Unless the pressure on land became very great or for some reason livestock were wiped out there would always be somewhere to raise animals.

Stage Two will have its costs and benefits as did Stage One. Again the costs are largely those which result from the contraction of the meat and livestock industry but this time the greatest problem is in the uplands. The costs incurred there as a result of removing sheep will depend on the policy towards upland areas. There is no doubt that many people would lose their livelihood and that communities could go into a very steep decline, far worse than at present. The change over must be very steady, therefore, to allow communities to adjust healthily to a future where sheep are definitely secondary to trees and possibly tourists. It is impossible to state the costs with any accuracy as this is peripheral to the main study. Doubtless there would be an initial cost in amenity terms but this could be offset by sensitive organisation. People visit only a few specific places in upland areas in any great numbers so special care would be needed here. The journey to these places is also important but subtle change in a wide and distant landscape can probably be incorporated without much public reaction. The costs of reduced employment opportunities could be partially offset by new opportunities in an extended forestry industry and in the management of sheep for amenity reasons.

Benefits that may result include further possibilities for self-sufficiency and potentially improved diets. More subtle benefits may result from a realisation that food production is more humane if no unnecessary slaughtering is carried out and intensive systems disappear, but this depends on people's attitudes to the new techniques in dairy and poultry husbandry. Any moral reaction to meat eating might be extended to "unnatural" techniques used on livestock. Again there will be benefits from reducing energy use and animal waste production.

There are problems connected with achieving Stage Two. The biggest is probably the adoption of the vegetarian diet. The reasons for dietary change would have very variable effects on the type and rate of agricultural change. It is difficult to suggest how one might go about encouraging a steady change in diet, people are slow to react to health advice if it goes against ingrained habits and the agricultural rationale for vegetarianism is very weak. On the agricultural side the implementation of change to Stage Two could be fairly straight forward for most people other than sheep farmers. However, in order to achieve Stage Two the techniques of induced lactation, sex determination etc., would have to be much more fully developed although this might not take long (see 3.2). It would be important to keep a careful check on the effects of the techniques on the quality of milk and eggs as foodstuffs. The upland area policy would need careful appraisal and the impacts of implementation would have to be assessed. The important aspects are, at least, viewing the issue from the present, the maintenance of healthy rural communities in the areas, which means encouraging the provision of jobs and services and preserving both some of the visual character and the natural life of the areas while allowing for public accessibility.

Stage Three

Stage Three is the scheme investigated in this thesis, totally plant-based agriculture in England and Wales to provide nutritional self-sufficiency. It depends on the removal of all livestock from the agricultural system and the production of plant foods for human consumption. There is no reason to suppose that a system without animals is not sustainable on already proven arable land and the construction of this novel Plan was confined to this area. In fact if there were worries about organic matter levels, soil fertility and structure, this could be countered by the use of sewage and re-cycled plant material. The use of sewage on a large scale would require some reorganisation of sewerage systems. Chapter 2.4 shows that nutritional self-sufficiency is also possible if the present arable area is expanded to include some land considered suitable for crop production but at present under permanent grass. The two conditions can be met but there are, of course, other factors which must be taken into account.

Stage Three is completely different from either of the previous stages, the agricultural and dietary changes examined are radical and it is likely that this change would be far more difficult to accomplish than either Stage One or Two. This stage is, like Stage Two, dependent on a dietary change but in this instance it is not from one sort of omnivorous diet to another slightly more restricted one. It is a change to herbivorousness. The vegan type of diet is probably only consciously practised by a relatively small number of people world wide even though many people exist nearly entirely on plant based foods because of their extreme poverty. Their diet must, however, still tend to be opportunist, for instance, if animal foods are offered or chanced upon they are unlikely to be rejected. Veganism must arise nearly exclusively from two ideas, one that it is wrong to exploit animals for food and two that the consumption of animal-based foods is unhealthy, unclean or not sufficiently ascetic. It is not impossible that these reasons could bring about dietary change to veganism but it is certainly improbable. There is an extreme possibility that veganism may be forced on us because of some catastrophe befalling food animals. Veganism might be more healthy than other diets but evidence is scant and the comparisons that have been made by nutritional and clinical researchers do not include the sort of diet likely to emerge from plant based agriculture in England and Wales, although most of the factors which are considered an advantage in the "normal" vegan diet would be present. A diet of cereals, potatoes, root and green vegetables, some legumes and dessert fruit only partially resembles the sort of diet likely to be eaten by a vegan in this country today, whose diet normally contains significant proportions of pulses and nuts which are difficult to produce here in sufficient quantities. The goal for the Plan was nutritional self-sufficiency not necessarily self-sufficiency for total food supplies so it is possible that the Plan derived diet could be added to with more exotic imports. The all plant diet derived from the Plan is potentially adequate if efforts are made to supplement it with calcium, possibly iron and those micronutrients not present in plants (see 2.3 and 2.4).

The main drawback to the whole population adopting the diet even if there was a commitment to it, is the problem of variety and menu planning. The constituent foods are fairly limited when compared with the current potential selection. Balancing meals would be very important particularly if they are to provide the correct amino acid profile. There appears to be more than enough protein produced by the Plan but much of this could be wasted if attention is not paid to complementing the proteins from the various sources. Cereals and beans are the classic combination. The success of the diet is, therefore, conditional on culinary and nutritional commitment to providing a healthy, interesting diet.

The food industry is in a good position to help with the success of a scheme like this. One might even say its contribution would be vital. It will have to provide new ranges of balanced vegan products and to develop new foods from rather unexciting raw materials. The Plan produces barley in excess of amounts needed by the brewing industry and some use of this surplus as food must be found. It is not currently a major cereal in British diets but the success of the Plan would depend on its inclusion as a dietary item. The production of many vegetables still tends to be seasonal and although methods have been devised for preserving some so that they are available all the year round there may be a need to provide even greater variety over the whole year if a vegan diet is to be acceptable.

Biologically there is no reason why agriculture could not be solely devoted to crop production but the change would not be easy. Stage Two removed the uplands from agricultural use but Stage Three goes further and releases a lot of lowland England and Wales too. Even if use was made of every piece of land suitable for crop production there would still be areas too wet, too cold, too steep or too unproductive in other ways to include in the food production system. Land availability in this country is fairly restricted and there is considerable pressure from other forms of land-use on agricultural land even at present. It is of paramount importance to the Plan that crop producing land is protected from other primary uses. The Plan does generate spare land and in theory this should provide great opportunity for satisfying all individual land-use needs. It is very likely, though, that available land will not be where it is needed. The problem of conflicting land use needs and the generation of "spare" land is going to need careful resolution. A coherent land use policy which builds on the one for uplands suggested in Stage Two will be essential. The issue is not just one of sorting out what can be done where, but also of protecting rural communities, preserving the food production potential, providing amenities, providing timber etc. The loss of agriculture as a way of life in many rural areas, an undoubted effect of such a change, is likely to result over a fairly long period of time in such changes in the countryside that there is little hope of preserving its characteristic appearance, particularly in pastoral areas. In terms of current values regarding rural England and Wales the change is probably unacceptable. It is now perhaps as well to examine what incentives there are, if any, for a shift to Stage Three.

Incentives for agricultural change can arise as the result of a variety of considerations. Chapters 1.1 and 1.2 help to identify some of the historical incentives for change these can be strategic; economic, usually in terms of the extent of reliance on imported food supplies and agricultural input needs or the Exchequer costs of the industry; consumer demand changes, social considerations which may be concerned with the preservation of livelihood, policy towards marginal areas and the countryside in general; public health considerations though these do not seem to have had any marked effect in recent years, and finally technological changes. Some of these reasons or incentives for change may also provide reasons for a move to plant-based agriculture.

Historically speaking strategic and import level considerations have at times prompted action to encourage self-sufficiency or, at least, a greater degree of import saving in food supplies. It is not unrealistic to suggest that demands for increased self-reliance or even total self-sufficiency will occur again, given the fluctuating world food and energy supply situation and the chronic balance of payments problems of the British Economy. The Plan is capable of providing nutritional self-sufficiency for a population of about 49 million, but only if the current arable area is expanded by ploughing up land with lower crop producing potential. Land is a critical limitation to the achievement of self-sufficiency in this country under virtually any production system, especially if the population level rises much above current levels. It is unlikely that plant-based agriculture could provide basic nutritional needs for a population very much bigger than 49 million unless the range of crops grown were severely reduced. The Plan set out to provide a wide range of food crops to improve the acceptability of the diet and to make it easier to overcome the problems of balancing the diet. Unfortunately variety can only be achieved at the expense of energy output. In a plant based system the problem would always be one of balancing the fundamental need for energy with the provision of all other nutrients and a range of foods to provide acceptable variety. The concept of self-sufficiency often tends to embody another idea, the maximisation of food producing potential. Food plants offer the most sensible approach to maximising food production on certain types of land, output is greater per unit of land and per unit of input energy than for animals. Not all land, however, is ideally suited for crop production so in the Plan only that land with potential for commercial production is included and this is only some fifty percent of the current total agricultural area. If maximum food producing potential is to be achieved, there is no reason not to use the remaining land for food production but this is unlikely to be plant-based food, it is far more likely to be easily and sensibly exploited by animals. In time technology and science may provide an alternative of course but as long as animal products are acceptable in the diet scenarios for self-sufficiency will, in this effort to maximise food producing potential, include animals. Another possibility is that two major demands for land, food and timber production, may both aim towards self-sufficiency. This situation would have to lead to a compromise whereby food production largely from plants would occupy the better land and timber production, land of poorer quality. Even in this situation there is still the possibility that animals would have an agricultural role. Self-sufficiency as an objective seems to constitute a rather dubious basis for a change to totally plant-based agriculture, although it is interesting to note that if for some reason we did adopt a plant-based system one of the outcomes would be greater self-sufficiency.

The shortages of energy supplies may act as an incentive for agricultural change. If we wished to minimise the amount of non-renewable energy use in agriculture and to maximise the potential output of food, this would encourage a significant shift towards food crops at the expense of livestock. There is no doubt that crops, by and large, make more efficient use of energy inputs to production than animals. Any shift resulting from a desire to limit energy usage is unlikely, however, to warrant the complete removal of livestock. The reduction of support energy inputs to production under the current agricultural system would have dramatic effects on the production potential of British agriculture.

Non-renewable sources of energy are becoming increasingly scarce and new sources are being looked for. Fuel crops are a possibility. In this country the likely technique for producing a fuel from crops would be fermentation. The most likely crops would be those which could be harvested regularly, thus in most cases fuel crops would be indirect competition with food crops. The Plan potentially leaves grassland untouched and certainly unusable, under current technology for food production. Grass would, therefore, be the one plentiful and harvestable crop for fuel production. It is difficult to determine whether the effort to harvest the grass for fuel would be worthwhile. Blaxter* states that if all the crop and grass land in the U.K. were cropped for biological fermentation this would only produce 8% of the country's primary fuel supply. The potential fuel production from redundant grassland even if some other fuel crop could be grown instead of grass is unlikely to be very significant. Nevertheless this use of grassland does offer an alternative under the Plan. Unfortunately, the merits of this use compared

* Blaxter, K.L. (1978 "Energy Use in Farming and its Cost" 32nd Oxford Farming Conference. p28-38.

with other uses has not been assessed in the thesis, this is partially because of the lack of technological development in the area which prevents a reliable picture of this use for grassland being drawn up.

Another incentive suggested is that the burden of state support for the industry becomes too high and that this might prompt change. In the past this incentive has only brought about minor changes and few of these have noticeably reduced the Exchequer bill. However, it is one of the considerations which cause governments to review their policies and attitudes towards agriculture. Unfortunately the monetary costs of a change to plant-based agriculture even over a long time period are likely to be high because of the dislocation in rural areas, the creation of new marginal areas and the necessity to ensure carefully that the right quantities of food are reaching each individual as the diet is far more difficult to balance than an omnivorous one. If we wish to preserve certain amenity areas like the National Parks this too will cost money as they will have to be entirely stage managed, the economic processes which preserve their present appearance having been removed. All these costs could be discounted, if government were not overly concerned with social issues but just with changing agriculture to a plant-based production system, but this would hardly be desirable or, it is to be hoped, likely.

The major incentive for a change to stage three would have to be a change in the population's eating habits. If everyone were to become vegan, agriculture would have no choice but to become plant-based. It is possible that this dietary change might be actively encouraged if a totally plant-based diet were considered more health or humane than an omnivorous diet with or without meat. However, on the basis of available information, there is no evidence to suggest that this is so, nor really that it is not. A change in moral attitudes to animal-based food or a change in people's tastes is also possible, if not probable.

Technological innovations can provide incentives for agricultural change e.g. the development of intensive systems of livestock husbandry. Changes in technology are, however, rather like the chicken and the egg as it is often difficult to see whether change in agriculture or another area induced the innovation in technology or vice versa. The scheme set out for plant-based agriculture assumed no change in agricultural technology (except in the study on the Dairy Industry which looked at induced lactation etc., see 3.2) but this would obviously not be the case over the long period of transition envisaged. There is no apparent technical reason why Stage Three could not be achieved agriculturally. However, new technologies would be needed in other areas if the system is to work. New foods would have to be developed particularly from those food crops not currently part of the diet to any great extent. An abundance of plant waste is produced under the Plan, new technology or the further development of existing technology would be needed to utilise this. Straw has many uses which could be developed and other plant material could be composted or fermented to provide useful products. The assumptions governing the Plan also take no account of possible changes outside agriculture, such as substantially reduced energy supplies, which might significantly affect the realisation of Stage Three and would definitely require technological readjustment and new developments. It is difficult to see what technological change might prompt a shift to plant-based agriculture but it is likely to come from outside agriculture altogether. If meat-like products made from vegetable protein became more acceptable and could be made economically from home grown plant protein this might encourage dietary change which in turn would provide incentives for a shift towards a plant-based system. The Plan would only be achieved if there were a change in attitudes (unless it had to be implemented in some emergency) and the direction taken by technological developments is closely linked with the attitudes of the prevailing system. This was illustrated by the Delphi study. The developments required in the dairy industry to achieve Stage Two are already in existence, if not totally developed, but the reasons for and the direction these developments take now would be substantially different from that required under a Stage Two scenario because the goals are different.

The incentives for a change to totally plant-based agriculture are not very apparent and therefore the benefits of the change are difficult to estimate. Agriculturally there seems to be few benefits, as the industry is substantially reduced in size, the constraints on the choice of enterprise and the level of risk involved in some agricultural areas would be increased, from a wider perspective there may be benefits derived in the long term from the release of land from agriculture, especially as this does not, under a plant-based system, so severely affect our food producing potential. The demand for alternative uses of land and multiple uses of land is sure to grow if the current levels of affluence persist or increase and if we wish to improve our timber producing potential.

It must be remembered though, that these benefits are not without very substantial costs, incurred not only in the transition but also once the final scheme is achieved. Plant-based agriculture would, looking at it from this point in time, be a very contrived goal and would therefore have to be virtually entirely state managed. The only hope for a natural shift lies in a change in consumer demand for food. The benefits of the resulting diet are also difficult to see. It is important to realise that to advocate this sort of diet for all the population is, on the basis of current information, foolhardy and likely to result in severe public health problems. These would probably emerge as a result of deficiency rather than excess as seems often to be the case at present.

The Plan did not insist on total self-sufficiency so it is possible that the diet could be substantially improved in terms of variety by importing certain foods, particularly pulses, nuts, fruit and vegetable oils. It is difficult to estimate what quantities would be needed as this depends on the pattern of demand which emerges.

There are a number of problems connected with a shift to plant-based agriculture resulting from the limitations on the possible range of crops. The Plan cannot produce sufficient fat or oil for one thing. There is considerable research going on to find oilseed crops suitable for temperate climates. These were not included in the Plan but will be included in a revised Plan being compiled in the Unit. Oilseeds tend to compete with other much needed crops for land, so in improving the fat situation we may reduce the potential for other crops. It has yet to be determined whether in the effort to increase dietary fat content we can still provide nutritional self-sufficiency. Oilseeds do yield protein rich residues after the fat has been extracted and these are a potential substrate for texturised vegetable protein or protein isolate production. The Plan incorporates substantial areas of grass and lucerne for rotation purposes, which would currently constitute a net loss in food producing potential for the system. Green leaf protein is a potential food use for production from these areas. This potential will also be investigated in the revised Plan. There is considerable development still needed to create varieties of plants suitable for our climate, and to make acceptable food products from or containing these novel protein sources. Cereals will be very important in the Plan derived diet and the wheat produced will largely have to be used for bread making. Wheats grown in this country tend to be soft wheats for use as feed or biscuit flour. Harder wheats, better for bread making, are being developed but it seems likely that under the Plan the type of bread eaten would have to be of a wholewheat type. This is a good thing from the dietary point of view.

The main agricultural problems connected with a move to Stage Three are the creation of a new type of marginal farm, greater risk in production and the loss of livelihood for a considerable number of farmers. Much of this is discussed in chapters 2.5 and 3.1 but it is worth recapitulating briefly. One of the biggest problems encountered when constructing the Plan was visualising, with any degree of accuracy, where farming could continue under the novel scheme. Arable land is not always found in handy areas suitable for farming as a unit, This problem is likely to be greater in the western part of the country, but is by no means confined to this area. Many farmers would be unable to shift to arable or horticultural production at all, others might be able to crop parts but not all of their land. This last group may be able to extend cropping to rather unsuitable land in order to stay in business, others may not have this option and would have to go out of business, although this might mean abandoning potential crop producing land. In any case the shift is likely to produce a new group of marginal farmers in need of state support to continue but whose contribution is vital to the achievement of nutritional self-sufficiency.

It is possible that the extent of this problem is overstated. Chapter 3.3 discusses the possibilities for a large holding on what many might consider marginal land for crop production. The conclusion of the farmer was that food crops could be produced on at least 75 per cent of the holding which would enable it to stay in business. However, the level of expertise needed to make a business work on this land under a plant-based system would be considerable. The climate and the stoniness of the land all conspire against crop production in the area. The infrastructure for crop production does not exist to a sufficient extent either but this could be built up over the transition period. Crop production as an enterprise in the area would be a high risk choice and there is no doubt that other areas would be more favoured than the study farm area. The limitations the shift brings with it in terms of choice of enterprise are likely to reduce the flexibility within the agricultural system and increase the level of risk associated with farming.

Land in more marginal areas is likely to be capable of supporting fewer crops and this means that unbalanced production of certain products might occur. The economics of the new system have not been investigated because the market is such an unknown quantity and this makes any attempt at producing a realistic economic scenario, very difficult, if not impossible. However, imbalance in production is likely to make the problems of farmers in new marginal areas even worse unless strict measures are enforced to prevent imbalance occurring. This is notoriously difficult to do. Quotas are one method used for some crops but are considered unfair by many people as they restrict cropping options still further.

The novel system puts many farmers out of business altogether in lowland England and Wales. The problems here are much the same as those discussed under Stage Two. It must be remembered that the removal of agriculture as a way of life has repercussions, in areas where this occurs on a large scale, which extend beyond the farming community. Most rural communities are still dependent on agriculture for economic life and their viability is dependent on economic activity. There are no long term benefits from allowing rural communities to become simply exclusive dormitories for former urban dwellers. Considerable effort will be required to provide new employment opportunities in rural areas if agriculture disappears, if the problems are considered great now they would be worse under plant-based agriculture. Loss of livelihood is one thing but loss of opportunity for using skills is another and one which it would be difficult to cost. The time it would take to affect the transition would allow skills connected with livestock farming to disappear slowly and naturally, but we may be poorer, in some sense, for their disappearance.

There are problems outside the agricultural and dietary areas which are difficult to cover fully. Some of these more peripheral areas of impact are shown in the relevance tree, Chapter 2.1. The relevance tree extended its branches from the node of agricultural change. If it had been constructed from another starting point, say the required dietary change, the areas of impact may have been subtly different with extra weight being given to such matters as the organisation of health services, changes in the food industry and the need for new approaches to nutrition and home economics education. The perspective from which a problem is viewed, however broad will substantially alter both the method employed for tackling it and the outcome. There is no doubt that the question of a change to plant-based agriculture could be approached from a variety of angles.

This study is not without precendent. A couple of schemes for vegan agriculture have been constructed*. The obvious difference between this study and those is that they base the change on a vision of what they would like agriculture to be and what they would like it to provide. The approach in this project has been to view the potential for change within the context of today and as such the conclusions are somewhat gloomy. The goals of the novel system reflect current goals in British agriculture and perhaps this is not entirely fair to the concept of plant-based agriculture. There are no attempts to suggest alterations in farm structure in terms of farm size or ownership. The technological base was assumed to be unchanged

* a) H. Valentine-Davis, 1950, "Farming Without Animals: A Scheme of Agricultural Development and Social Reconstruction".
b) Vegetarian Society UK, "Green Plan", Synopsis released to press 1976; main work unpublished.

and this meant farmers would continue to substitute capital for labour, use fertilisers and pesticides and, one imagines, aim for good returns.

However, even in the absence of these goals and attitudes the case for plant-based agriculture may not be very strong. If there was a desire to change to a system which was more ecologically sound, consumed hardly any non-renewable energy, involved more labour, and did not necessarily pursue financial goals, this would result in moves to greater reliance on crop production on smaller more labour intensive units which would allow for the extension of arable production into areas currently used for livestock. These units would be partly self-supporting, but as it is unlikely that all could "return to the land" there would have to be excess production to supply urban areas. Crops would be likely to provide the major food output and there would be many units which could be sustained and flourish exclusively on crop production. Areas of poor land and the production of plant wastes provide opportunities for livestock farming. This would probably prove to be the most economic use of these two resources although alternatives exist. The product is as important as the economic use of resources and some small amount of animal-based food does act as a useful dietary addition. Totally plant-based agriculture would therefore, even under this alternative, require the dietary change to veganism before it provided a realistic scenario. In order to achieve this sort of system the change would have to come not only in agriculture or even through dietary change but at a much more fundamental level through the changing of society's attitudes to the way we currently live, or possibly as the result of a major change in resource availability. There are those who already feel we should move to a more sustainable way of life making the most economic use of all our resources. It is impossible to do full justice here to the question of plant-based agriculture assuming a different technological and economic base. It is as well to be aware, though,that the whole issue is open to a variety of interpretations depending on your point of view (or brief) and the extent of available data.

APPENDIX I

Geographical Variations in household consumption of the main food groups 1970-75

Source: adapted from: MAFF "Household Food Consumption and Expenditure: 1975" HMSO Tbl 18.

Regions	More than 10% above the national average for the period 1970-75		More than 10% below the National average for the period 1970-75	
Wales	Butter	+31	Preserves	-13
	Cooking Fat	+21	Margarine	-20
	Uncooked bacon and ham	+17	Coffee	-27
	Sugar	+10		
	Bread	+10		
North	Flour	+50	'Other' fats	-10
	'other' meat	+24	Coffee	-10
	Margarine	+22	Liquid milk	-12
	Fish	+21	Pork	-12
	Processed Veg. (incl. frozen)	+19	'other' fruit	-14
	Uncooked bacon and ham	+18	Fresh fruit	-18
	Eggs	+14	Poultry, uncooked	-19
	Cakes and biscuits	+14	Fresh Green Veg	-21
	Potatoes	+13	Cheese	-22
	Cooking fat	+12	Mutton and lamb	-23
	Preserves	+12		
Yorkshire and Humberside	Cooking fat	+42	'Other' fruit	-10
	Flour	+42	Poultry uncooked	-11
	Fish	+28	Fresh fruit	-11
	Margarine	+27	Cheese	-14
	Preserves	+15	'Other' fats	-17
	Processed Veg. (incl frozen)	+13	Mutton and lamb	-19
	Uncooked bacon and ham	+11		
	Pork	+10		
North West	Margarine	+29	'Other' fats	-12
	Mutton and fat	+21	Flour	-16
	Uncooked bacon and ham	+16	Fresh greeen Veg	-28
			Pork	-29
East Midlands	Flour	+38	Poultry, uncooked	-12
	cooking fat	+31	Beef and veal	-15
	Fresh green veg.	+18	Mutton and lamb	-17
	Margarine	+11		
	Cheese	+10		
	Sugar	+10		
West Midlands	Pork	+31	Beef and veal	-10
	Uncooked bacon and ham	+21	Cakes & biscuits	-11
	Mutton and lamb	+14	Preserves	-15
	Sugar	+14	'Other' fats	-16
	Cooking fat	+12		
	Fresh green veg.	+12		
	Cheese	+11		
	Bread	+11		
South West	Fresh green veg.	+23	Uncooked ham and bacon	-11
	Pork	+19	Margarine	-14
	Flour	+13	fish	-14
	Coffee	+13		
	'other' fruit	+11		
South East/East Anglia	Fresh green veg.	+21	Cooking fat	-11
	'Other' fats	+19	Uncooked ham and bacon	-11
	Fresh fruit	+19		
	Mutton and lamb	+19	Bread	-12
	'other' fruit	+17	Potatoes	-12
	Pork	+17	Margarine	-21
	Poultry, uncooked	+17		
	Coffee	+11		

APPENDIX II

Example Of Regional Crop Pattern Alteration

The method used involved setting out the pattern for 1973 then shifting acreages devoted to crops not to be included in the Plan to crops that were acceptable. Three alternatives for each region were worked out. The table below shows the formation of one alternative for the West Midlands*

Present Pattern				Alternative Pattern		
Crop	Acreage	as % Arable	Instruction	Reallocation of acreage	New acreage	as % Arable
Wheat	220,099	15.2	I		245,784	17
Barley	442,416	30.6	D	to wheat oats beans	410,000	28
oats	66,109	4.6	I		81,592	5.6
Mixed corn	14,753	1.0	R	to oats	-	-
Rye	316	v. small	I		3,593	0.2
Maize	74	v. small	L		74	v. small
Silage maize	823	v. small	R	to rye	-	-
Early potatoes	7,897	0.5	L		7,897	0.5
M/C Potatoes	40,608	2.8	I		45,972	3.2
Field beans	6,042	0.4	I		14,042	0.9
Turnips etc.	13,364	0.9	C	to main crop potatoes	10,000	0.7
Mangolds	2,004	0.1	R	to sugarbeet	-	-
Rape for feed	2,545	0.1	R	to sugarbeet	-	-
Kale for feed	11,245	0.7	R	to cabbage, beans oilseed rape	-	-
Cabbage for feed	463	v. small	C		4,708	0.3
Mustard	226	v. small	L		226	v. small
Other feed	2,083	0.1	R	to other crops	-	-
Oilseed Rape	734	v. small	I		5,734	0.4
Sugarbeet	39,730	2.7	I		44,279	3.0
Hops	5,807	0.4	L		5,807	0.4
Orchards	24,460	1.7	I		26,460	1.8
Small fruit	6,914	0.5	L		6,914	0.5
Vegetables	19,877	1.4	I		22,877	-
Glasshouses	399	v. small	L		399	v. small
Flowers	2,662	0.2	L		2,662	0.2
Other crops	675	v. small	I		2,758	0.2
Lucerne	1,763	0.1	I		2,763	0.2
Rotation grass	495,434	34.3	D	to most other crops needing Incr.	485,000	33.5
Bare fallow	16,259	1.1	L		16,259	1.1
TOTAL	1,445,799				1,445,799	

The Instructions sometimes varied i.e., orchards might not always have been increased in area.

* units of area used in this table are acres as they were in 1973 statistics.

APPENDIX II

Key to abbreviations used in the table.

I = Increase

D = Decrease

R = Remove

L = Leave as at present

C = change to cultivar suitable for human food

APPENDIX III

Energy and Protein Maximisation Calculations:

The maximisation of energy and protein output was attempted using a very simple iterative linear programming technique.

The objective function was of the form:-

Maximise, $Z = a_1x_1 + a_2x_2 + a_3x_3 \ldots\ldots + a_nx_n$ (1)

Where 'x' was equivalent to the acreage of a particular crop and 'a' was the coefficient relevant to the maximisation i.e.for energy calculation it corresponded to the energy output per hectare for a crop and for the protein calculation it corresponded to both the quantity and quality of protein output per hectare for a crop. The total number of crops considered was 38. Thus 'x' ranged from x_1 ___ x_{38}.

The objective function (1) was constrained by a number of other functions. Equation (2) relates to the maximum amount of land available for crops. Equation (3) constrains all crops with 'special' land requirement.

$$\sum_{x_{38}}^{x_1} Z(x_n) \leq 5,641,098 \text{ hectares} \quad (2)$$

Also,

$$x_1 + x_8 + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} + x_{18} + x_{19} + x_{2\cdot} + x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + x_{27} + x_{31} + x_{32} + x_{34} \leq 1,917,973 \quad (3)$$

All 'x' had to be present in the maximised objective function, for soil structure and fertility reasons and for pleasure in the case of flowers, even though some have no edible energy or protein output. These crops were therefore given fixed acreages.

Fixed Acreage Crops

x_{26}	mustard	6410 ha	(for green manure)
x_{28}	Hops	6900 ha	(for flavouring beer)
x_{31}	Watercress	470 ha	(special crop not actually grown on arable land)
x_{32}	other vegetables	10300 ha	(unspecified so area fixed)
x_{33}	glass house crops	2000 ha	(not always fixed in calculations - regarded as being "tomatoes")
x_{34}	flowers, bulbs, etc	15118 ha	(for pleasure)
x_{35}	other crops	11750 ha	(unspecified so area fixed)
x_{36}	lucerne	29000 ha	(these can really be lumped together as breaks in crop rotations. Lucerne is given separate consideration as it may one day prove useful for leaf protein production)
x_{37}	temporary grass	1300000 ha	
x_{38}	fallow	57000 ha	

Thus a further condition binding the objective function is that,

$$x_{26} + x_{28} + x_{31} + x_{32} + x_{33} + x_{34} + x_{35} + x_{36} + x_{37} + x_{38} = 1,438,948 \text{ ha} \qquad \text{------- (4)}$$

Energy Maximisation

All crops bar those in (4) were subjected to the iteration steps although those in (4) still appear in the objective function (1).

The coefficients for the objective function had to be identified. For the energy maximisation this just entailed the energy output per hectare of the crop. To simplify the process by avoiding unwieldy numbers the energy outputs were indexed on a scale of 1 - 10. The index only serves to facilitate a more straightforward choice of crop in the iterative process, the index values are not used in the final calculation of maximum output.

TABLE III A

Crop Energy Indices

Range of Output ($MJ \times 10^2$)	Index Value	Crops
100-900 ($\times 10^2$)	10	Main crop potatoes, sugar beet
899-800	9	---
799-700	8	---
699-600 .	7	Oats, Maize
599-500	6	Wheat, barley, Early potatoes
499-400	5	Rye, Parsnips
399-300	4	Field beans, oilseed rape, carrots, beetroot, dried peas, onions.
299-200	3	Turnips, cabbage, broad beans, leeks
199-100	2	Brussels sprouts, celery, cauliflower, Runner bean, green peas, top fruit
99- 0	1	French beans, lettuce, small fruit

Sources

Yields: from MAFF (1975) "Agricultural Statistics: UK 1973" HMSO

Nix, J. (1976) "Farm Management Handbook"

MAFF "Basic Horticultural Statistics UK 1967/68 - 1976/77

Energy Values: Paul, A. A. and Southgate D. A. T. (1978) McCance and Widdowson's "The Composition of Foods" HMSO

There were few defined limits on the area of individual crops except for those with fixed area or those constrained by the special grade land limitation. The fear was that any crop not limited in some way would, if its energy output was high, capture all the remaining land not bound by contraints. To avoid this upper and lower limits were set for all crops other than those with fixed acreages. The lower limit ensured that all crops appeared in the maximisation. A condition which was necessary if maximum variety of crops, and thus food, was to be guaranteed. The upper and lower limits were chosen by examining the Initial Cropping Plan and the 1973 cropping pattern. Lower limits were set at some feasible value below that in the Initial Plan or at the 1973 level. Upper limits were set at a level above that in the Initial Plan but within practical bounds.

Table IIIB gives the initial feasible solution for the objective function, which is based on the lower limits and the optimum solution which is obtained by redistributing the difference between the initial solution area and the total area. It was important to remember that 1,490,091 ha. of the total area was taken up with fixed crops. The area for redistribution was therefore only 1,435,078 ha. Redistribution was done iteratively, crops with the highest index being increased in area first up to their upper limit. This process continued until no land remained for redistribution. It was also important to remember the constraint on certain crops limiting them to Grade 1 and 2 land, but in this example the area of Grade 1 and 2 land was not exceeded by the special crops in the normal course of the iteration.

When an optimum solution for the objective function had been found the energy output was calculated. This ammounted to 241.2 MGJ , not an enormous percentage increase on the energy output from the Initial Plan.

TABLE IIIB ENERGY MAXIMISATION

Crop	Index	Initial Feasible Solution		Optimum Solution: Hectares	Optimum Solution: Energy Yield(GJ)
Wheat *	6	1,103,063	x_1	1,400,000	76,860,000
Barley	6	700,000	x_2	1,000,000	54,900,000
Oats	7	193,176	x_3	900,000	57,150,000
Rye	5	7,078	x_4	42,000	17,136,000
Maize	7	2,802	x_5	4,000	277,600
Early Potatoes	6	23,000	x_6	25,000	1,490,000
M/C Potatoes	10	152,000	x_7	130,000	19,080,000
Field Beans *	4	60,837	x_8	90,000	2,709,000
Turnips	3	20,000	x_9	20,000	568,000
Cabbage	3	4,010	x_{10}	4,010	99,849
Oilseed Rape	4	15,234	x_{11}	36,715	1,193,238
Brussel Sprouts *	2	17,108	x_{12}	17,108	248,066
Celery *	2	3,549	x_{13}	3,549	46,491
Cauliflower *	2	10,217	x_{14}	10,217	114,430
Carrots *	4	14,870	x_{15}	14,870	547,216
Beetroot *	4	4,764	x_{16}	4,764	172,933
Parsnips *	5	4,000	x_{17}	8,000	376,000
Broad Beans *	3	6,024	x_{18}	6,024	126,504
Runner Beans *	2	5,781	x_{19}	5,781	68,216
French Beans *	1	9,718	x_{20}	9,718	48,590
Green Peas *	2	56,196	x_{21}	56,196	955,332
Dried Peas *	4	23,118	x_{22}	23,118	903,914
Onions *	4	8,154	x_{23}	8,154	282,944
Lettuce *	1	6,402	x_{24}	6,402	64,020
Leeks *	3	2,715	x_{25}	2,715	79,550
Sugarbeet *	10	193,646	x_{27}	205,000	20,295,000
Top Fruit	2	55,666	x_{29}	55,666	745,924
Small Fruit	1	12,000	x_{30}	12,000	72,000
		2,715,928		4,151,007	241,200,000
				+ 1,490,091 (fixed crops)	
Remainder for redistribution:		1,435,078		Total 5,641,098	Energy total = 241.2 MGJ

* 'special land' crop.

Protein Maximisation

The protein maximisation was very similar to the energy example except fewer crops were included and the indices were different. The indices were based not simply on the protein output of the crops per hectare but also on the quality of the protein in the crop. Chemical scores were used as the basis of quality. The chemical scores used were those derived by the Mitchell and Block method which relates the proportion of the limiting amino acid in a protein to the proportion of that same amino acid in egg protein. The indices are shown below in Table IIIC and are the product of the protein output per hectare and an index for chemical score. Table IIID gives optimum solution for protein maximisation.

TABLE IIIC Crop Protein Indices

	Crop	Index		Crop	Index
x_1	Wheat	2.5	x_{14}	Cauliflower	2.5
x_2	Barley	2.4	x_{15}	Carrots	1.2
x_3	Oats	3.0	x_{16}	Beetroot	2.4
x_4	Rye	1.5	x_{17}	Parsnips	1.2
x_5	Maize	2.0	x_{18}	Broad Beans	1.8
x_6	Early Potatoes	1.99	x_{19}	Runner Beans	0.8
x_7	M/C Potatoes	2.0	x_{20}	French Beans	0.8
x_8	Field Beans	1.8	x_{21}	Green Peas	1.8
x_9	Turnips	o.9	x_{22}	Dried Peas	3.6
x_{10}	Cabbage	1.6	x_{23}	Onions	1.2
x_{11}	Oilseed Rape	1.6	x_{24}	Lettuce	1.2
x_{12}	Brussels Sprouts	1.5	x_{25}	Leeks	1.2
x_{13}	Celery	1.6			

Source: Chem.Scores from; FAO (1970)"Amino acid content of foods and biological data on proteins" FAO Rome.

TABLE IIID — OPTIMUM SOLUTION FOR PROTEIN MAXIMISATION

	Crop	Index	Area (hectares)	Protein Production (tonnes)
x_1	Wheat	2.5	1,378,500	689,250
x_2	Barley	2.4	1,000,000	400,000
x_3	Oats	3.0	900,000	450,000
x_4	Rye	1.5	42,000	12,600
x_5	Maize	2.0	4,000	1,600
x_6	Early Potatoes	1.99	25,000	12,500
x_7	M/C Potatoes	2.0	180,000	90,000
x_8	Field Beans	1.8	83,000	49,800
x_9	Turnips	0.9	20,000	6,000
x_{10}	Cabbage	1.6	23,000	9,200
x_{11}	Oilseed Rape	1.6	43,000	14,400
x_{12}	Brussel Sprouts	1.5	25,000	12,500
x_{13}	Celery	1.6	6,500	2,600
x_{14}	Cauliflower	2.5	17,000	8,500
x_{15}	Carrots	1.2	20,058	6,017.4
x_{16}	Beetroot	2.4	3,000	4,800
x_{17}	Parsnips	1.2	4,000	1,200
x_{18}	Broad Beans	1.8	10,000	4,000
x_{19}	Runner Beans	0.8	5,781	1,156.2
x_{20}	French Beans	0.8	9,718	1,943.6
x_{21}	Green Peas	1.8	79,000	39,500
x_{22}	Dried Peas	3.6	35,000	31,500
x_{23}	Onions	1.2	8,154	2,446.2
x_{24}	Lettuce	1.2	6,402	1,230.4
x_{25}	Leeks	1.2	2,715	541
			TOTAL PROTEIN OUTPUT	1,853,235

[Notes: Protein Data in this example is all from FAO (1970) "Amino Acid Content of Foods and Biological Data on Proteins." Nutrition Studies No.24 FAO Rome. The upper limits for crop acrea es were slightly different from energy example as priority given to protein crops.]

APPENDIX IV

An Introduction To The Delphi Method

Technological Forecasting has grown up as an area of study over recent years because in a rapidly changing world with new technologies being regularly introduced it seems important to review what future developments there might be and their possible impact. It is hoped that information derived from forecasts can prove beneficial to decision makers in whose hands, to a large extent, the pattern of development lies. A number of techniques for technological forecasting now exist

Forecasting the future is of course a very hit and miss affair, but to know what the future holds has been an eternal preoccupation of man. The study of the future can only be attempted in relation to the historical and current situation(1). The trends observed in the past and present have to be extended into the future, rather as when betting on a horse the experienced gambler takes account of its form. A drawback to this extrapolation is of course that it is unlikely that a forecast of any particular future can take into account all those past and present factors which will impinge on the final outcome (2). Any forecast will also incorporate a substantial amount of subjective opinion however much the forecaster may wish to eliminate this. It is a moot point whether this is to the detriment or the improvement of the forecast (1). In any case the future must be coloured by the values of present society, the accuracy of the forecast must therefore depend on how in touch the forecaster is with the pervading trends in societys' values. Some writers feel that more forecasting attention should be placed on the mores of society and how these relate to long-term goals (1, 3, 4). It was inevitable therefore that techniques developed for forecasting technological developments, and their impact in the future, should now be extended to other fields of crucial importance both in the long and short term (5, 6, 7).

The Delphi technique is one method available for forecasting. Its use has now extended outside technological forecasting; but discussion here will be limited to its original role. Like many modern research techniques the Delphi evolved from military research. The first Delphi was started in the late 1950's by Dalkey and Helmer for the Rand Corporation under sponsorship from the United States Air Force (5). The problem under investigation was to select, from the point of view of a Soviet strategic planner, an optimal United States industrial target system and to make an estimate of the number of atomic bombs that would be needed to reduce munitions output by a prescribed amount. The approach of the researchers was to canvas opinion from a group of experts all putting themselves in the role of a Soviet strategic planner. This work was secret and a later Delphi published in 1964 brought outside attention to the method. This Delphi by Gordon and Helmer assessed the direction of long range trends in Science and Technology and their probable effects on society and the world. Again a systematic use of expert opinion was used to achieve the forecasts. The study was not without its critics. Overbury (3) rather damningly states that the results were immature and goes on to stress his case with the following statement; "for instance ... the apparent confidence of respondents in an infinite world abundance of food, energy and raw materials ... (plus) a rather barren pre-occupation with far out weaponry and landing on Mars first". His attitude to forecasting is rather different to that implied in the original Delphi anyway in that he feels that broadly speaking nothing will happen in the future that is not now conceivable; consequently more effort should be put into defining the right kinds of objectives for the future rather than passively assessing future possibilities. This more active role of identifying problems and pinpointing aspects of these which can be solved in an attempt to reach a certain desired objective is possibly the way the Delphi technique will develop in Technological forecasting. The extension of Delphi in this way is advocated by a number of writers, Hetman (4) suggests that relating technological developments with their possible consequences in society may also be broadened to generate possible political actions to be taken if desirable effects are to be maximised and undesirable effects minimised. He does however realise how imperfect the art of forecasting is and goes on to state that the probability of occurrence, as predicted, is restricted by a variety of unknowns and inherent faults in methodology.

The Delphi method is described by some as a method of applying intuitive creative thinking to the forecasting of future developments (8). Intuitive thinking by its very nature relies on imaginative leaps in the dark or hunches and as such it incorporates a lot of superfluous ideas. The Delphi method seeks to eliminate these by using iterative rounds to damp out what Jantsch[8] describes as "background" noise.

Before going on to describe the details of the Delphi technique it is worth supplying a definition of the method. The one given by Linstone and Turoff (5) is broad but clear and relates well to the current state of the Delphi method.

"A Delphi maybe characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem".
Earlier descriptions and definitions of the method tended to be far more precise about the method used and it is interesting that this definition is more concerned with Delphi as a structured communications exercise rather than as a stepwise approach to forecasting.

In general the method used for Delphi is to canvas the opinions of a panel of experts, in the field under examination, by postal questionnaire (9). The opinions of experts can be expected to vary considerably so over proceeding rounds an attempt is made to bring the panel members to a consensus opinion on the forecast for each issue. There are a number of ways used for generating the questions in the initial questionnaire. One method involves the researcher compiling it from his own knowledge from the very beginning. Another method is to send out a probe questionnaire to generate the questions from the experts for the first round questionnaire. The object of the first round questionnaire proper is to yield estimates for various developments occurring as either most likely date of occurrence or probability of occurrence by a certain date, to name two possible forms of answer. The 'answers' should, in any case, be mathematically processable. Space is also provided on the questionnaire for the respondent's reason for giving a particular answer and any general comments. The researcher on receipt of the first round replies usually processes them to give the range of estimates and the median for each question. A second questionnaire is then sent out giving the results of the first round and showing the reasons given for predicting the extremes of the range and the median. The respondents are invited to reconsider their initial response, in the light of opinion expressed by the other panel members, and then to estimate again. The same process is repeated again in the hope that rough consensus will be reached. If of course everyone agrees in the first round there is little point in continuing for further rounds. There is no direct contact between panellists and in fact they are usually not named to preserve anonymity. The forecasts are usually expressed as a range of estimates and the median value rather than as a single "most likely" value.

There is a rationale behind the method. Firstly, it seeks to utilize the expert, who because of his special knowledge of a particular field may have insight into its potential development in the future and its potential impacts (1, 2, 5). On the other hand he may be restricted by the boundaries of his particular subject, so the method seeks to involve a wide range of experts whose interests relate to the question under examination from a variety of angles. Another method of dealing with the problem would be to bring all the experts together for the purpose of thrashing out an answer. However, there are inherent difficulties with this committee approach. The second aim of the Delphi is to overcome these difficulties. One of the main problems of the committee approach, especially if the researcher wishes to bring a large number of experts together, is actually getting them physically in the same place at the same time. Communication by post is therefore an advantage in that it allows communication with all panellists wherever they might be. Committees are also subject to many psychological giving the results of the first round and showing the reasons given for predicting the extremes of the range and the median. The respondents are invited to reconsider their initial response, in the light of opinion expressed by the other panel members, and then to estimate again. The same process is repeated again in the hope that rough consensus will be reached. If of course everyone agrees in the first round there is little point in continuing for further rounds. There is no direct contact between panellists and in fact they are usually not named to preserve anonymity. The forecasts are usually expressed as a range of estimates and the median value rather than as a single "most likely" value.

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1. New specialists from a wide range of disciplines may add further parameters to the discussion which inhibit progress in any direction.
2. The status of committee members may be reluctant to expose themselves to ridicule or criticism by their peers or their superiors.
3. Committees may be prone to what is called the "bandwagon" effect. This is the influence put on a group by glib fast-talking members.

Anonymity is preserved by the Delphi but free discussion is encouraged, so it is felt that the Delphi exploits the benefits of the committee approach and to an extent overcomes the difficulties. Despite this there are numerous critics of the Delphi rationale.

Can it really be assumed that consensus is not forced by pressure on those who do not agree with the majority opinion even in the absence of face to face confrontation [2]? Those whose opinions are at variance with the majority are asked to review their judgement in the light of the case formed by the majority. It takes a stubborn individual to stick to his or her own reasoning in such a situation. It is also slightly suspect to assume that the consensus is necessarily the correct forecast of future events (9). An inability to reach consensus may provide equally valuable information in some cases. However it has always been the object of the Delphi to provide concise statements about the future rather than a review of variation in expert thinking on the matter. These statements are, as a result, more helpful in the formulation of plans and policies, as a single conclusion has been reached which eliminates the need for the decision-maker to sift through opinion and reach his own conclusions: but are these statements more accurate?

Secondly, can the views of all panel members be counted of equal value(2)? A multidisciplinary panel of experts approaching a particular problem is going to have a variety of strengths and weaknesses. The Delphi method has been adapted to overcome this problem by asking panellists to self-rate their expertise in answering each question. The estimates are then given suitable weighting during the processing of the results. Some writers have indicated that they feel this self-rating is contrary to the spirit of Delphi(1). Self-ratings tend to reflect the personality of the respondent as well as the quality of his or her answers. Women it seems consistently mark their expertise lower than men (5). This sort of factor must detract from any effort to remove bias from Delphi.

Delphi is still a technique in its infancy and as yet cannot be viewed as a scientific pursuit. One of the criteria for a scientific method is held to be reproducibility of results. There is some evidence to suggest that some consistency exists in the results of Delphis on the same subject(5,7), but not sufficient, many authorities feel, to categorise the method as scientific. The lack of reliability seems to stem from variations in procedure. There are as yet no hard and fast rules governing the execution of a Delphi other than rather woolly descriptions of the general steps to be taken. Many factors can act to threaten the reliability of the exercise.

In the first place questionnaires are often poorly designed and can introduce bias and distortion in responses (5, 7). The design of questionnaires has always been tricky; it is never easy to construct an objective question which contains no ambiguities. Added to this are the differing degrees of perception and understanding shown by respondents when confronted with a questionnaire.

Another factor connected with questionnaires that affects the whole exercise is the construction of the first round(7). It has already been mentioned that two methods for compiling the first round questionnaire are in general use. One polls the experts to generate the first round questions, by asking them to make predictions of major developments in areas which specially concern them. There is no doubt that this approach produces a plethora of material which the researcher then has to edit and amalgamate to submit as the first round questionnaire, and that this is very time consuming. Consequently, the other method is often adopted as it cuts out the probing round. In this instance the researcher compiles the questionnaire from his own knowledge or on particular topics he wishes to cover and sends this out for the forecasts on dates of occurrence. The second method saves time but may go against the original intent of Delphi which some would argue was to allow experts to suggest important future developments in their particular field and to predict the likely dates of occurrence. The likelihood of bias being introduced by the researcher is also far higher if the second method is used.

This brings up the issue of how to use experts in a Delphi. The first problem here arises in choosing the panel (5, 7). In this situation how does one define expertness and select experts? Most researchers will select experts on a subjective basis from fields that they feel are relevant to the subject. This obviously introduces some bias and consequently makes it difficult to be sure that the panel members represent all relevant areas. Some work has been done to determine the difference between experts and non-experts in a Delphi situation. The evidence is inconclusive some studies indicate that the predictions of each group are indistinguishable; some that the experts are consistently more accurate (5, 7). However, it is a criticism of the Delphi that it utilizes the knowledge of only a small body of persons out of a multitude of involved individuals, experts and non-experts. In the main though it is probably desirable from the point of view of the method to stick to the original rationale for using experts.

The other factor which brings the predictions generated by most Delphis into doubt, and has bearing on the panel, is the drop out rate during rounds. In the final analysis this means that the eventual consensus is based on the opinions of a smaller panel than was originally intended. Drop out rates of 50 per cent and over are regularly reported (5, 7). There are many reasons suggested for this. One is that the whole process of the conventional Delphi is so lengthy, round after round, that participants become bored (5). Another suggestion is that many experts feel underutilized by the exercise, all the ideas are spoon fed to them (7). This must be especially true if there has been no initial probe round which allows them opportunity for creative thinking about their subject area. Participants may also drop out if they feel the researcher is not giving sufficient attention to their point of view in the review of opinions submitted in the second and third round (7). This can be particularly true for those who have views which strongly diverge from the majority opinion and where the researcher is attempting to get consensus. These view points can very easily be interpreted as extreme in the process of trying to reach consensus and maybe unwittingly prejudiced against.

This is hardly encouraging for a participant. For whatever reason a panellist may drop out, the effect on the validity of the eventual consensus must be great.

Many of the problems associated with Delphi are a result of the researcher not realising the very demanding nature of the exercise (5). Not only has he or she got to choose experts and send out questionnaires that have been carefully formulated. He or she has also to act as chairman for the ensuing discussion, making sure everyone gets a fair hearing and not attempting to force the panel into consensus. Every attempt should be made to ensure that the experts are treated like human beings, proper remuneration should be made available to them for the time and consultancy effort they are putting into the exercise (5, 7, 10). It may also be valuable not to restrict communication to the Delphi rounds in all situations but this presumably depends on individual approach as some might argue that extra communication between researcher and panel members detracts from the original concept (5).

Despite the many drawbacks to Delphi outlined above, many might believe that if the forecasts are accurate then the drawbacks do not matter. This rather depends on what is meant by accuracy in this context. For one thing not all forecasts are attempts to predict inevitable truths, other motives are sometimes involved (5). It is hoped that carefully conducted forecasts will become another input to decision making (3, 5, 9). In this situation forecasts may act as a warning or as an incentive on which to act to avoid or to move towards a predicted outcome. Then if they succeed in producing a movement in a desirable direction, they have served their purpose but may not be accurate in the sense that the predictions came to pass at the appointed time.

In other cases forecasts are made to predict precise developments for which there is little present basis. Whether some of these potential developments will appear at the predicted time, or at all, is yet to be ascertained. The method has not been used for long enough to indicate whether forecasts of long-term developments are materialising at the predicted time (5, 9). What evidence does exist seems to show that long-term forecasts tend to be pessimistic and short-term forecasts optimistic regarding development times. In 1969 another Delphi study on scientific and technological developments was done and then compared with the Gordon and Helmer study of 1964 (5). All items originally predicted to occur before 1980 in the original study were shifted further into the future in the later study while two thirds of the developments predicted to occur after 1980 in the original study were estimated as occuring at an earlier date in 1969. Other studies too have shown that this "pessimistic - optimistic" theory is generally true although not in all cases. From all this it is difficult to say just how accurate the Delphi method really is, but in some cases the results may prove helpful in decision making.

The general opinion surrounding the method would indicate that it has survived because in Futures research there are few enough methods available anyway and Delphi for all its failings has helped to legitimize the whole exercise of seeing into the future (5, 9). Most writers consider that much work needs to be done to improve the theoretical base and to evaluate the Delphi thoroughly as a method of research (1, 2, 3, 4, 5, 10). In some ways, this can only help to strengthen the position of the method even if it eventually moves from being a tool for forecasting time scales to becoming a sophisticated structured communication exercise. There seems little doubt that a committee can reach more appropriate conclusions and provide fuller undertanding of the future than an individual. Many sophistications are already being incorporated into Delphi, e.g., cross-impact matrices (5, 9), computer analyses (5), expert sub-groups (5) and parallel questionnaires (10), all of which have yet to be fully examined, but may well be to the advantage of the method. The picture is of a healthy pioneering technique which has not yet quite made it to full acceptability.

APPENDIX V

Questionnaire and covering letters for the Delphi Study.

Dear Sir,

In view of your special knowledge of agriculture and milk production, I am writing to ask for your help on certain aspects of my research work, which I hope will lead to a Ph.D. degree.

I work within the Technology Policy Unit here at Aston University. This Unit is concerned with studying the interactions between technology and society in the hope that this may generate ideas for the better utilization of technology. We feel that food production is an important area of technology and of fundamental importance to mankind.

The emphasis in British agriculture is on the production of food from animal sources. It may be that this approach is not the most beneficial in terms of land utilization, energy and nutrition. My project is concerned with assessing the potential for and implications of a shift from the present system to one in which there is increased emphasis on the production of food from plant sources. The impacts are obviously many and far reaching.

My part of the study is primarily concerned with the impacts of the shift on the farming sector. One of the areas that will be affected is the Dairy Industry. In view of its particular importance in agriculture and for the national diet, I believe it is worthy of special attention. I have postulated a series of developments that might make the preservation of dairying in a plant-based system a possibility. It is on these that I would like your comments.

Another of my difficulties has been to determine the time scale over which such developments would become technically feasible, if they should be deemed desirable. I feel it might be useful to try and obtain an answer to these questions by conducting a Delphi Study. This involves consulting a panel of experts and obtaining, if necessary over a few rounds of questionnaires, a 'concensus' of opinion on the technical possibilities and their timing. I would be very pleased if you would agree to be one of my panel in this study. I promise that the questionnaires will be short!

Enclosed with this letter is a copy of the initial questionnaire should you wish to participate. Please feel free to comment on it or on any aspect of my research programme. If you do not wish to be included in the study or offer any other comments, perhaps you would be kind enough to suggest someone else who might be interested.

I look forward to hearing your views on the study. Thank you.

Yours sincerely,

Susan Thompson.

DELPHI QUESTIONNAIRE

Indicate in appropriate column the probable time-scale of development for the following:-

	Within 10 years from now	From 11-30 years	More than 30 years	Comments
(1) Viable techniques of induced lactation in cows to enable milk to be produced without necessarily having calves.				
(2) Sex-determination in fertilised ova transplantation in cattle, insuring a majority of female offspring.				
(3) Milk-like substitutes made from plant sources which exhibit not only nutritional equivalence or superiority to cow's milk but also high organoleptic standards and versatility of use.				

(4) General comments.

Dear

First of all I would like to thank you for completing the first questionnaire of my Delphi study: on possible futures for milk production in a plant-based food production system. Many of the comments were most helpful and informative. I have summarised both the comments and the results. These are enclosed with this letter.

I have also included the second round questionnaire and your first round answer. The Delphi method of forecasting attempts to reach a concensus of opinion, by asking contributors to reappraise their original estimates, in the light of comments from other contributors, if they so wish. Unfortunately in this study there is a roughly even split in estimate (especially for questions one and two). One result of this is that it is unlikely that concensus would be achieved. I have, therefore, altered the questionnaire "development time" periods to see if in fact there is a more definite peak in opinion than was evident from the results of questionnaire No. 1. I have also added another question relating to sperm selection techniques for sex-determination as opposed to fertilised ova techniques.

Once again I thank you for your kind participation and help and I look forward to hearing from you.

Yours sincerely,

Susan Thompson,
Technology Policy Unit.

DELPHI QUESTIONNAIRE NO. 2

Indicate in appropriate column the probable time-scale of development for the following:-

		0-5 yrs	6-10 yrs	11-15 yrs	16-20 yrs	More than 20 yrs
(1)	Viable techniques of induced lactation in cows to enable milk to be produced without necessarily having calves.					
(2)	Sex-determination in fertilised ova transplantation in cattle ensuring a majority of female offspring.					
(3)	Sex-determination by sperm selection and AI techniques.					
(4)	Milk-like substitute made from plant sources which exhibit not only nutritional equivalence or superiority to cow's milk but also high organoleptic standards and versatility of use.					
(5)	Comments.					

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11. Prof. B. Weitz, Director, NIRD, Shinfield Rd., Reading.

12. Mr R.E. Williams, Chief Economist, Milk Marketing Board.

APPENDIX VI

Maps of the Centres in the Single Farm Study.

The four maps overleaf show the four farm centres A,B,C and D. The maps are to scale and are taken from the 6" to the mile Ordnance Survey map of the area. The detail given is intentionally sparse so they serve more as diagrams than maps.

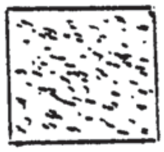
The purpose of adding these maps into the appendices is to illustrate a couple of points. First they show the complexities of farm layout and the variations in this which can exist in a small geographical area. Second they point out where the theoretical divisions into plots might be made. As far as possible existing boundaries such as roads were used to facilitate the division (see 3.3). Also shown on the maps are the areas of land which,though farmed at present,are inherently unsuitable for cropping in a plant-based agricultural system. The current field pattern is not shown as this,it was decided, would need to be changed.

The actual management approach to farming these centres under a plant-based system might well differ from that suggested in 3.3. It is possible that the changes envisaged would not gain approval from bodies concerned with the appearance of the landscape for one thing. The conversion of mixed farms like these with substantial livestock interests to plant-based agriculture would not be easy. The maps show, for instance, that the cultivable land is not always in easy to manage areas. Although in theory the study shows that change on farms such as these is possible, an actual shift on these farms,if a move to plant-based agriculture was positively encouraged, would depend on many considerations. For example it might depend on whether or not the country aimed for the maximum possible amount of land in cultivation.

Notes For Appendix VI

Notes relating to maps, A., B., C. and D. overleaf

Key to maps

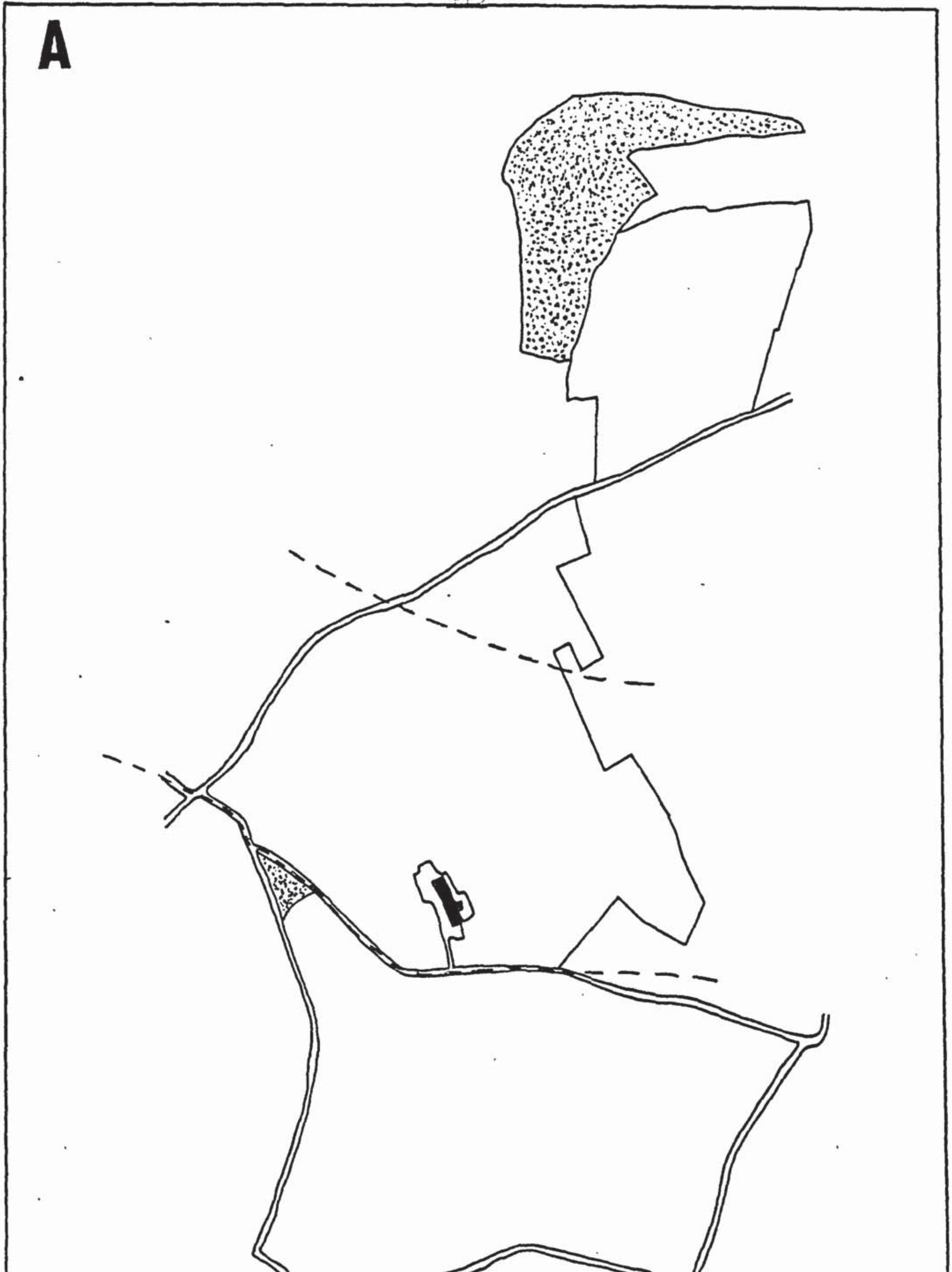
Land unsuitable for cropping
in plant-based scheme .. .. 

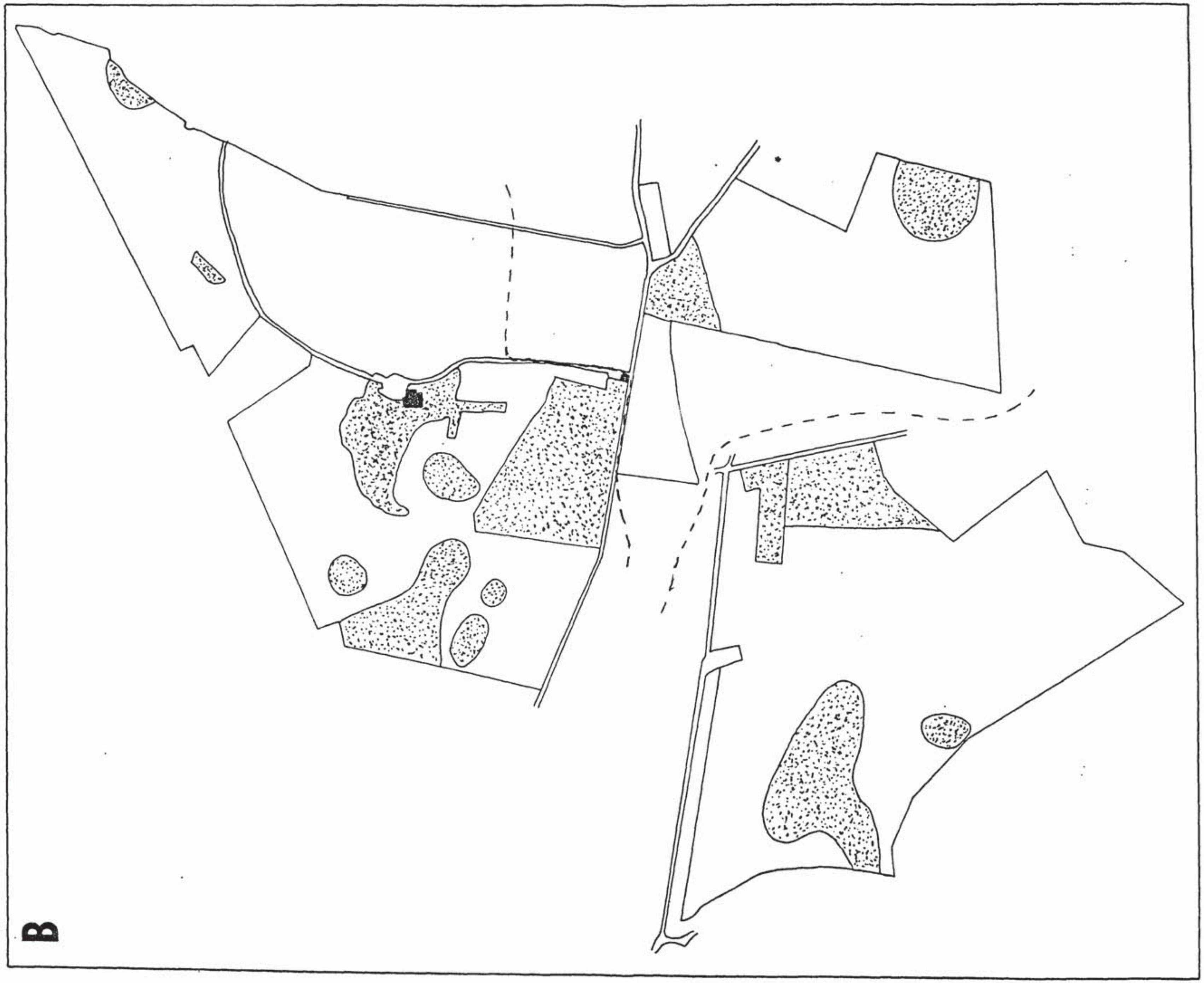
Farm Buildings . .. . 

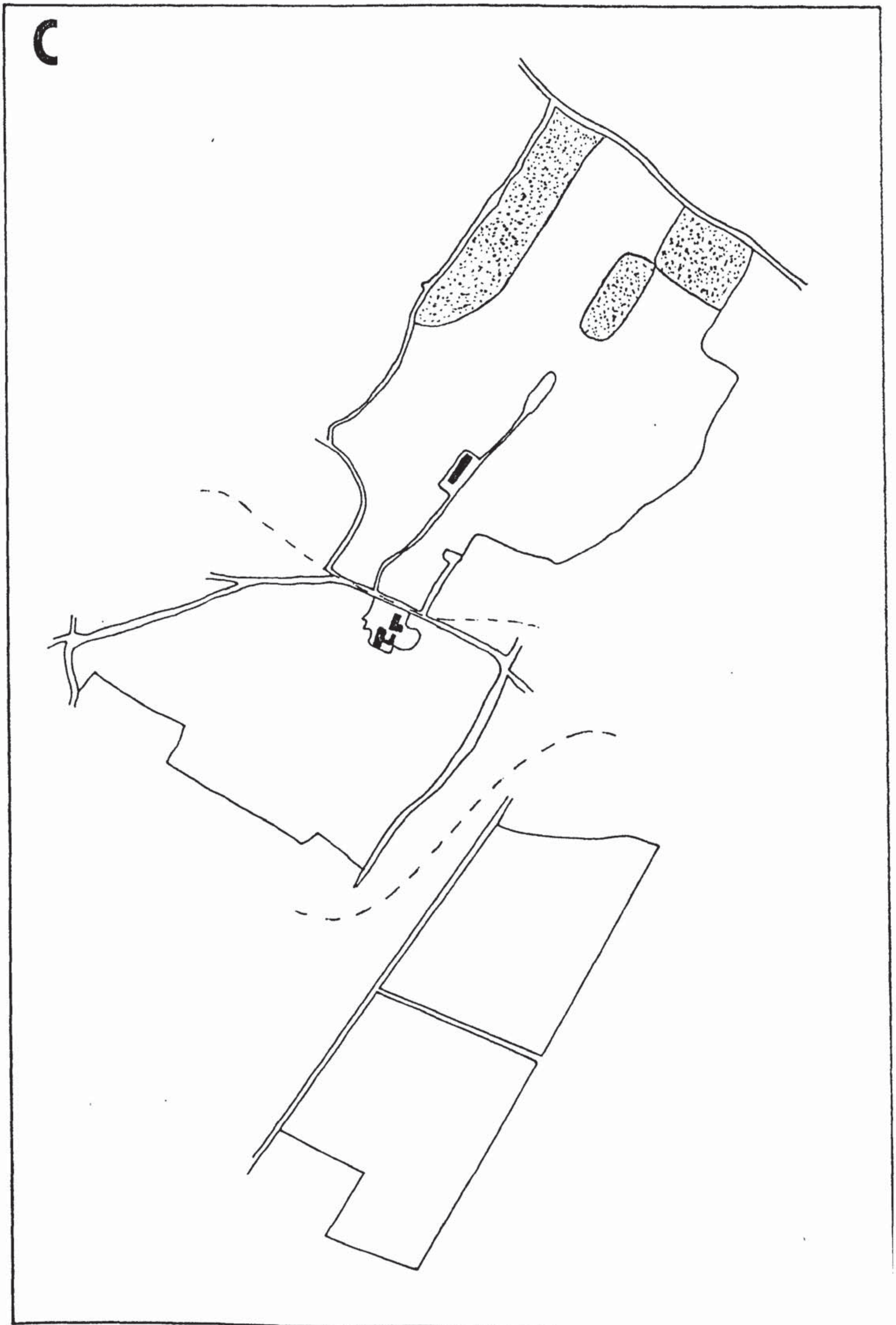
Division into theoretical
management plots denoted by .. .. 

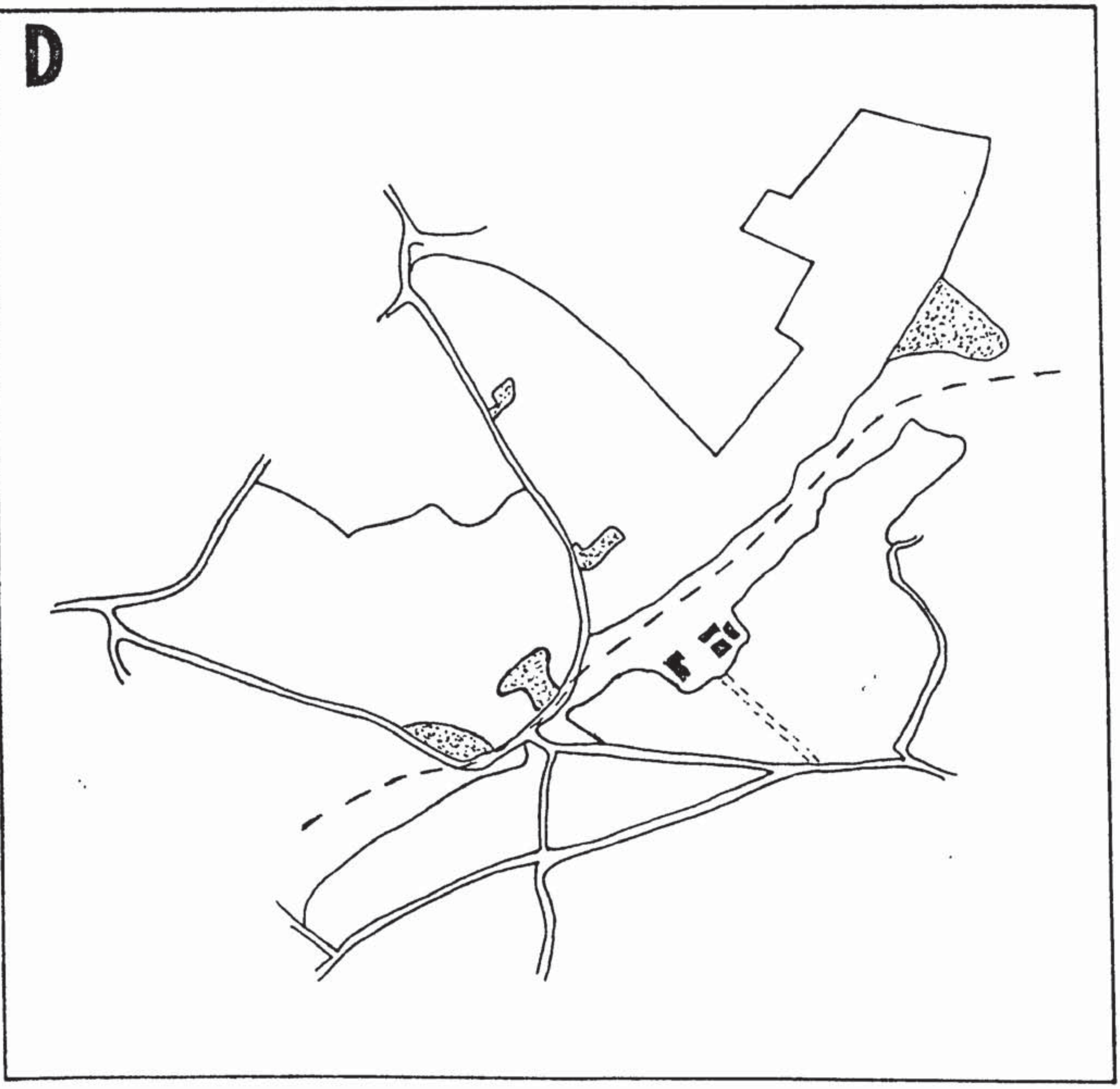
Additional Information

Centres B and C both have a "Plot" detached from the centre at a distance of approximately 1 mile and 1.5 miles respectively. These Plots are shown on the maps with respect to the main part of the centres.


A


B


C


D

REFERENCES

Part One

The Current Agricultural System And Present Day Diets In Britain

Section 1.1

Historical Development Of Agriculture In This Century

1. Wardle, C. (1977) "Changing food habits in the UK" Earth Resources Research. p. 36.

2. Ibid, p. 47.

3. Self, P. and Storing H. J. (1971) "The State and the Farmer" George Allen and Unwin p. 17.

4. MAFF (1975) "Agricultural statistics for the United Kingdom" HMSO

5. C.S.O. "Annual Abstract of Statistics 1977" HMSO

6. MAFF (1968) "A Century of Agricultural Statistics Great Britain 1866 - 1966" HMSO

7. Agriculture EDC (1977) "Agriculture into the 1980's: Animal Feedingstuffs" NEDC

8. Cmnd 6020 (1975) "Food from our own resources" HMSO

9. MAFF (1978) "UK Food and Farming in Figures" MAFF

10. Cmnd 7058 (1978) "Annual Review of Agriculture 1978" HMSO

11. MAFF (1976) "Farm Classification in England and Wales 1975" HMSO

12. Self, P. and Storing, H. J. (1971) op cit p. 28.

13. Hammond, R. J. (1955) "Food: The Growth of Policy" in series "History of the Second World War" Longmans and MHSO

14. Self, P. and Storing, H. J. (1971) op cit p. 21.

15. Selly, C. (1972) "Ill fares the land: Food, Farming and the Countryside" Andre Deutsch p. 39.

16. Jones, A. S. (1977) "The Principles of green crop fractionation" in "Green Crop Fractionation". Editor, R. J. Wilkins. Occasional Symposium No. 9. Brit.Grassland Soc.

17. Donaldson, J. G. S., Donaldson, F. and Barber, D. (1972) "Farming in Britain Today" Pelican p. 186.

18. CSO (1974) "Facts in Focus" Second Edition. Penguin

Section 1.1 continued

19. Agriculture EDC (1977) "Agriculture into the 1980's: Manpower" NEDC

20. Metcalf, D. (1970) "The Economics of agriculture" Penguin Modern Economics p. 50.

21. Leach, G. (1975) "Energy and Food Production" International Institute for Environment and Development p. 16.

22. Ibid (1975) p. 24.

23. Ibid (1975) p. 27.

24. Blaxter, K. L. (1978) "Energy Use in Farming and its Cost" in Report and Proceedings of the 32nd Oxford Farming Conference. 3rd - 5th January 1978.

25. Anon (1977) "The Agricultural Common Market: Beyond Transition" Barclays Bank Ltd, P. 6.

26. Ojala, E. M. (1973) "The Common Agricultural Policy and Britain" Eds., S. J. Rogers and B. H. Davey Lexington Books

27. Marsh, J. S. (1977) "UK Agricultural Policy within the European Community" Centre for Agricultural Strategy Paper One.

28. Anon (1977) op cit p. 17.

29. Agriculture EDC (1977) "Agriculture in the 1980's: Resources and Strategy" NEDO

30. Agriculture EDC (1977) "The Impact of Taxation" NEDO

31. Agriculture EDC (1977) "Finance" NEDO

32. Agriculture EDC (1977) "Land-use" NEDO

<u>Bibliography for historical and EEC sections not quoted above</u>

33. Davey, B., Josling, T. E. and McFarquhar, A. (1976) "Agriculture and the State" Macmillan

34. Beresford, T. (1975) "We plough the Fields: British Farming Today" Pelican

35. Higgs, J. (1964) "The Land" Studio vista

36. Agriculture EDC (1973) "UK Farming and the Common Market" a series of reports. NEDC

37. Green, D. (1975) "The Politics of Food" Gordon Cremonesi

Section 1.2

Present Day Farming

1. MAFF (1975) "Agricultural Statistics for England and Wales 1973" HMSO

2. Agriculture EDC (1977) "Agriculture into the 1980's Land-use" NEDC

3. Centre for Agricultural Strategy (1976) "Land for Agriculture" CAS Report No. One. p. 48.

4. Donaldson, J. G. S., Donaldson, F. and Barber, D. (1972) "Farming in Britain Today" Pelican p. 105.

5. Jarrett, G. (1978) "The Battle of Exmoor" Esso Farmer 30 (1) pp. 15 - 20.

6. Coppock, J. T. (1964) "an Agricultural Atlas of England and Wales" Faber p. 120.

7. Ibid p. 168 - 179

8. MAFF (1972) "Type of Farm maps" HMSO

9. Beresford, T. (1975) "We plough the fields: British Farming Today" Pelican

10. MAFF (1977) "Output and Utilisation of Farm Produce in the UK 1969/70 to 1975/76" HMSO

11. Cmnd 6020 (1975) "Food from our own resources" HMSO

12. Ulbricht, T. L. V. (1977) "Cereals, the world food problem and UK self-sufficiency" Proc. Nutr. Soc <u>36</u> p. 121.

13. Yudkin, J. (1972) "Pure, White and Deadly" Davis-Poynter

14. Shaper, A. G. and Marr, J. W. (1977) "Dietary recommendations for the community towards the postponement of CHD" Brit.Med Journal <u>1</u> pp 867 - 871.

15. Centre for Agricultural Strategy (1978) "Strategy for the UK Dairy Industry" CAS

16. Parkes, C. (1978) "Dairy Industry proposals cause anger" Financial Times 7th August

17. Cmnd 7058 (1978) "Annual Review of Agriculture 1978" HMSO

18. Agriculture EDC (1977) "Agriculture into the 1980's: Resources and Strategy" NEDO

19. Leach, G. (1975) "Energy and Food Production" International Institute for Environment and Development. p. 10.

Section 1.2 continued

20. Donaldson, J. G. S. and Donaldson, F. and Barber, D. (1972) op cit p. 150 - 157.

21. Fairbrother, N. (1970) "New Lives, New Landscapes" Pelican p. 81 - 82.

22. Selly, C. (1972) "Ill fares the Land" Andre Deutsch p. 113.

23. Blaxter, K. L. (1975) "Can Britain Feed Herself?" New Scientist 20th March pp 697 - 702.

24. ICI (1975) "ICI Recorded Farms 1974 Crop Year" Farm Advisory Service Report 8, ICI Farm Service

25. MAFF (1976) "Farm classification in England and Wales 1975" HMSO

Section 1.3

A Review of the Meat and Livestock Industry

1. Anon (1978) "Good in Parts " Big Farm Weekly 24th August

2. Agriculture EDC (1977) "Agriculture into the 1980's: Animal feedingstuffs" NEDO

3. Tudge, C. (1977) "The Famine Business" Faber

4. Blaxter, K. L. (1975) "Can Britain Feed Herself?" New Scientist March 20th pp. 697 - 702

5. Cmnd 6020 (1975) "Food From Our Own Resources" HMSO

6. Coppock, J. T. (1964) "An Agricultural Atlas of England and Wales" Faber

7. Anon (1978) "Finance for farmers and growers 1978/79" Barclays Bank Ltd.,

8. Agriculture EDC (1973) "UK Farming and the Common Market Beef" NEDO

9. Dept, of Industry (1973) "Report on census of production" Business Monitor pp 214 HMSO

10. Anon (1976) "UK Food Industries Review 1975-1976" Gower Economic Publications.

11. Anon (1976("Financial Times Survey 'Meat and Poultry'" Financial Times 6th December

12. MAFF (1975) "Household food consumption and expenditure: Annual Report of the National Food Survey 1975" HMSO

13. Greenfield, J. N. (1974) "Effects of price changes on the demand for meat" Monthly bulletin of agric. economics and statistics 23 (12) pp 1 - 7.

14. Government Statistical Service, MAFF (1978) "UK Food and Farming Figures" HMSO

15. Cmnd 7058 (1978) "Annual Review Of Agriculture 1978" HMSO

16. Dept. of Trade "Overseas Trade Statistics 1975" HMSO

17. MAFF (1977) "Output and Utilisation of Farm Produce in the UK 1969/70 to 1975/76" HMSO

18. United Nations Economic Committee for Europe, Food and Agriculture Organisation (1977) "Prices of agricultural products and selected inputs in Europe and North America 1975/76" United Nations, New York.

Section 1.3 continued

19. C.S.O. "Animal Abstract of Statistics 1977" HMSO

20. Agriculture EDC (1973) "UK Farming and the Common Market: Pigs and Pigmeat" NEDO p. 17.

Section 1.4

The Present Dietary Pattern In England And Wales

1. Truswell, A. S. (1977) "Some micronutrients that may be critical" in "People and Food Tomorrow" Second British Nutrition Foundation Conference April 1976. Applied Science Publication p. 61.

2. Darke, S. (1977) "Monitoring the nutritional status of the UK population" Proc. Nutr. Soc. 36 p. 235.

3. Buss, D. H. (1977) "Food habits in Britain" Proc. Nutr. Soc. 36

4. Slater, J. M. (1969) "Regional consumer expenditure studies using National Food Survey Data" J. Agric. Economics 20 pp. 197 - 216.

5. Yudkin, J. (1978) "Physiological determinants of food choice" in "Diet of man: needs and wants" Editor, J. Yudkin Applied Science Publication p. 243 - 260.

6. Le Gros Clark, F. (1967) "Human food habits as determining the basic patterns of economic and social life" Seventh International Congress on Nutrition, Hamburg 1966

7. Wardle, C. (1977) "Changing food habits in the UK" Earth Resources Research

8. Shack, W. A. (1978) "Anthropology and the diet of man" in "Diet of Man: needs and wants" Editor J. Yudkin, Applied Science Publication pp. 261 - 280.

9. Tannahill, R. (1975) "Food in History" Paladin

10. Hollingsworth, D. (1974) "Changing pattern of food consumption in Britain" British Nutrition Foundation Bulletin 12 p. 31.

11. Barker, T. C. (1978) "Changing pattern of food consumption in the United Kingdom" in "Diet of Man: needs and wants" Editor J. Yudkin Applied Science Publication

12. Shack, D. N. (1978) "Social and cultural determinants of food preferences" in Diet of Man: needs and wants" Editor J. Yudkin Applied Science Publication

13. Ward, A. G. (1977) "Potential for change in the Food Industry" Proc. Nutr. Soc. 36

14. Edwards, A. M. and Wibberley, G. P. (1971) "An Agricultural Land Budget for Britain 1965 - 2000"

15. Tudge, C. (1974) "Food for the unthinking" World Medicine June 5th p. 17.

Section 1.4 continued

16. McKenzie, J. C. (1977) "Potential for change in food habits in the UK population" Proc Nutr Soc 36

17. Green, D, (1975) "The Politics of Food" Gordon Cremonesi

18. Miller, S. A. (1978) "The kinetics of nutritional status" in "Diet of Man: needs and wants" Editor J. Yudkin Applied Science Publication pp. 187 - 203

19. Baines, A. H. J. (1977) "Food supplies in the United Kingdom" Proc Nutr Soc 36

20. MAFF (1977) "Household food consumption and expenditure 1975, Annual Report of the National Food Survey Committee" HMSO Table 7. Appendix B p. 224.

21. Béhar, M. (1976) "European diets Vs. traditional foods" Food Policy 1 (5) pp. 432 - 435.

22. MAFF (1977) "Annual Report of the National Food Survey Committee 1975" HMSO p. 13.

23. Ibid p. 20. paragraph 28.

24. Trenchard, (1978) "The inter-relationship of marketing and nutrition" in Diet of Man: needs and wants" Editor J. Yudkin Applied Science Publication

25. Ciba Foundation Symposium (1972) "Lipids, Malnutrition and the Developing Brain" Applied Science Publication

26. Payne, P. R. (1976) "Nutrition Planning and Food Policy" Food Policy 1 February

27. Mašek, J. (1976) "Recommended Nutrient Allowances" World Rev. Nutrition and Dietetics 25 pp 1 - 107.

28. ARC/MRC (1974) Joint Report on "Food and Nutrition Research" HMSO

29. Elton, G. A. H. (1978) "European diets in relation to standards of need" in "Diets of Man: needs and wants" Editor J. Yudkin Applied Science Publication

30. Anon (1978) "Birds Eye Annual Review" Birds Eye Co Ltd

31. Wardle, C. (1977) op cit pp. 24 - 26

32. Ibid pp. 31 - 35.

33. Ibid pp 36.

34. Ibid pp 73.

35. Breckon, W. (1976) "You and what you eat" BBC Publication p. 84.

Section 1.5

Criticisms Of British Agriculture And Diet

1. Ojala, E. M. (1975) "The Importance of agriculture to humanity" Monthly Bulletin of Agric. Economics and Statistics 24 (1) pp. 1 - 11.

2. Jansen, A. J. (1975) "Constructing Tomorrow's Agriculture" Report on a cross-national research into alternative futures for European Agriculture. Bulletin 38. Department for Sociology and sociography, Agricultural University, Wageningen pp. 16 - 17.

3. Houston, G. (1976) "Problems of interdependence - is food a special case?" in "People and Food Tomorrow" Applied Science Publication pp. 149 - 155.

4. Tudge, C. (1977) "The Famine Business" p. 2, 3, 25 - 39 Faber

5. Marei, S. A. (1976) "The World Food Crisis" Longman

6. Ulbricht, T. L. V. (1977) "Cereals, the world food problem and UK self-sufficiency" Proc. Nutr. Soc. 36 pp 121 - 126.

7. George, S. (1976) "How the other half dies" Pelican

8. Allaby, M. (1977) "World Food Resources" Chap. 1. Applied Science Publication

9. Norton-Taylor, R. (1977) "The rich shall inherit the earth" Guardian =4th January

10. Dexter, K. (1976) "Food in Britain - Prospects and Problems" Brit. Assoc. Adv. Sci. Annual Meeting September 1976

11. Ritson, C. (1975) "Should Britain Feed Itself?" Synopsis of paper present at conference "Alternative Food Policy Strategies for the UK - Policy Options and the Public Interest" Conservation Soc. and U.K.I.S.A. at University of Reading.

12. Cmnd 6020 (1975) "Food from our own resources" HMSO

13. Marsh, J. S. (1977) "United Kingdom Agricultural Policy within the European Community" CAS Paper 1. p 39 & 58.

14. Mellanby, K. (1975) "Can Britain Feed Itself?" Merlin Press

15. Anon (1975) "Food for thought" Guardian 2nd May

16. Blaxter, K. L. (1975) "Can Britain Feed herself?" New Scientist 20th March pp 697 - 702.

Section 1.5 continued

17. Williams, W. (1977) "UK Food Production: Resources and Alternatives" New Scientist 8th December pp 626-628

18. MAFF (1975) "Agricultural statistics 1973" HMSO

19. Centre for Agricultural Strategy (1976) "Land for Agriculture" CAS Report No. 1. p. 9 - 15.

20. Agriculture EDC (1977) "Agriculture into the 1980's: Manpower" NEDO

21. Selly, C. (1972) "Ill Fares the Land: food, farming and the countryside" Andre Deutsch

22. Agriculture EDC (1978) "Agriculture into the 1980's; Finance" NEDO

23. Stabler, M. J. (1975) "Agricultural Economics and Rural Land-use" Macmillan studies in Economics.

24. Blaxter, K. L. (1978) "Energy use in farming and its cost" in Report and Proceedings 32nd Oxford Farming Conference Editor M. M. R. Soper pp. 28 - 38.

25. Leach, G. (1975) "Energy and Food Production" (pp. 29, 30, 32, 122, 10) International Institute for Environment and Development.

26. Dwyer, M. J. and Matthews, J. (1976) "Efficient Use of Field Machinery" in "Energy Use and British Agriculture" Eds. D. M. Bather and H. J. Day. Reading University Agricultural Club pp 5 - 9.

27. Wilson, P. N. (1976) "Introductory Address" in as above pp 1 - 3.

28. Cooke, G. W. (1976) "The roles of organic manures and legumes in crop production" as above pp 15 - 18

29. Blaxter, K. L. (1975) "The Energetics of British Agriculture" Jnl. of Science of Food & Agriculture, 26, 8.

30. Cooper, J. P. (1976) "Biological limits to agricultural production" BAAS Annual Meeting September 2nd

31. Snaydon, R. W. and Elston, J. (1976) "Flows, cycles and yields in agricultural ecosystems" in "Food Production and Consumption" Eds. Duckham, Jones, Roberts. N. Holland

32. Nature Conservancy Council (1977) "Nature Conservation and Agriculture" p. 6 and 7.

33. Patmore, J. A. (1972) "Land and Leisure" Pelican p. 36.

Section 1.5 continued

34. Countryside Commission (1977) "New Agricultural Landscapes: issues, objectives and action" Countryside Commission Press. p 2 and 3.

35. Mellanby, K. (1976) "Pesticides, the Environment and the balance of nature" in "Pesticides and human welfare" Editors, D. L. Gunn and J. G. R. Stevens. Ox Univ Press.

36. Anon (1972) "Pollution: Nuisance or Nemesis?" A report on the control of pollution HMSO p. 15.

37. Braun, E and Collingridge, D. (1975) "Science and Survival" p. 17. Siscon

38. Beresford, T. (1975) "We plough the fields" Chapter 15. Pelican

39. Donaldson, J. G. S., Donaldson, F. and Barber, D. (1972) "Farming in Britain today" Chapter 20 Pelican

40. Dawkins, M. (1978) "Battery hens vote with their feet" New Scientist 12th October pp 118 - 119

41. McLaren, D. (1976) "Nutrition and its Disorders" 2nd Edition Livingstone Medical Text pp 164 - 170 and 174 - 182

42. Breckon, W. (1976) "You are what you eat" BBC publications

43. ARC/MRC Joint Report (1974) "Food and Nutrition Research" HMSO

44. C.A.S. (1978) "Food, health and farming; reports of panels on the implication for UK agriculture " Editor; C. J. Robbins CAS Paper 7 pp 27 - 73

45. Ibid (1978) pp 101 - 119

46. CAS (1978) "Strategy for the United Kingdom Dairy Industry" Cas Report 4 p. 68.

47. Shaper, A. G. and Marr, J. W. (1977) "Dietary recommendations for the community towards the postponement of CHD" British Medical Journal 1 pp 867 - 871

48. Leveille, G. A. (1976) "Dierary fibre" Cereals Foods World 21 pp 255 - 258.

49. Burkitt, D. P. and Trowell, H. C. (1975) "Refined Carbohydrate foods and disease" Aca Press.

50. Centre for Agricultural Stategy (1978) "Food health and farming" CAS Paper 7 pp 77 - 97.

51. Mead, J. F. and Fulco, A. J. (1976) "The unsaturated and Polyunsaturated fats in health and disease" Charles C Thomas

REFERENCES

Part Two

Section 2.2

Agricultural Goals And Constraints

1. Frank H. Garner (Editor) (1972) "Modern British Farming Systems: an introduction" Chapter 1. Paul Elek (Scientific Books Ltd)

2. Cooper, J. P. (1976) "Biological limits to agricultural production" BAAS Annual Meeting September 1976

3. Bland, B. F. (1971) "Crop production: cereals and legumes" Aca Press.

4. MAFF (1970) "Modern Farming and the Soil" HMSO

5. Bartholomew, J. C. (1977) "World Atlas" 11th edition Bartholomew and Son, Edinburgh

6. Page, J. B. (1976) (personal communication)

7. Boddington, M. A. B. (1978) "The classification of Agricultural land in England and Wales: A critique" Rural Planning Services Publication No. 4.

8. MAFF (1974) "Agricultural land classification of England and Wales" Land Service Ministry of Agriculture

9. MAFF (1976) "Agricultural land classification of England and Wales" ADAS Ministry Technical Report 11/1

10. Bibby, J. S. and Mackney, D. (1969) "Land use capability classification" Rothamsted, soil survey of England and Wales

section 2.3

Dietary Goals And Constraints

1. Department of Health and Social Security (1978) "Eating for health" HMSO

2. Davidson, S., Passmore, R. and Brock, J. F. (1972) "Human Nutrition And Dietetics" 5th Edition, chapter on recommended intakes of nutrients. Churchill Livingstone

3. Truswell, A. S. (1977) "Minimal estimates of needs and recommended intakes of nutrients" in "Diet of Man: needs and wants" Editor J. Yudkin. Applied Science Publishers pp 5 - 24.

4. Ellis, F. R. and Montegriffo, V. M. E. (1971) "The health of vegans" Plant foods in human nutrition 2 pp 93 - 103

5. Mašek, J. (1976) "Recommended Nutrient Allowances" World Rev. Nutr. Diet 25 pp 1 - 107

6. Payne, P. R. (1976) "Nutritional Planning and Food Policy" Food Policy 1 February

7. Truswell, A. S. (1977) "The need for change in food habits from a medical viewpoint" Proc. Nutr. Soc. 36 (3) pp 7 - 15.

8. See Chapter 1.4

9. McLaren, D. (1976) "Nutrition and its Disorders" Churchill Livingstone

10. National Academy of Sciences (1974) "Recommended Dietary Allowances" 8th Edition National Academy of Sciences.

11. Barkus, J. (1975) "The Vegetable Passion" Routledge and Kegan Paul

12. Jenkins, P. R. (1975) "Health Implications of the Vegetarian Diet". J. Am. Coll. Health 24 (2) pp. 68 - 71.

13. Committee on Nutritional Misinformation, Food and Nutrition Board, Research Council National Academy of Sciences (1974) "Vegetarian diets" J. A . Diet. Assoc 65 pp. 121 - 122

14. Ibid (1975) "Can a vegetarian be well nourished?" J.A.M.A. 233 p 898

15. Register, V. D. and Sonnenberg, L. M. (1973) "The Vegetarian Diet" J. Am Diet. Assoc. 62 pp. 253 - 261.

16. Erhard, D. (1973) "The new vegetarians; part 1: - vegetarianism and its medical consequences" Nutrition Today, November - December pp. 4 - 12.

section 2.3 continued

17. Hawkes, N. (1979) "Macrobiotic babies who suffer" Observer 4th February

18. Brown, P. T. and Bergen, J. G. (1975) "The dietary status of 'new' vegetarians" J. AM. Diet Assoc. 67 pp 455 - 459

19. Guggenheim, K., Weiss, Y., and Fostick.M. (1962) "Composition and nutritive value of diets consumed by strict vegetarians" Brit.J. Nutr 16 pp. 467 - 474.

20. Hardinge, M. G. and Stare, F. J. (1954) "Nutritional studies of vegetarians" J. Clin. Nutr. 2 pp. 73 - 82

21. Miller, D. S. and Mumford, P. (1972) "The nutritive value of western vegan and vegetarian diets" Pl. Fds. Hum. Nutr. 2 pp. 201 - 213.

22. Lee, K. T., Kim, D. N., Han, Y. S. and Goodale, F. (1962) "The effect of a strict vegetarian diet on serum lipids and E.C.G. patterns" Arch. Envir. Hlth. 4 pp 4 - 10.

23. Ellis, F. R. and Mumford, P. (1967) "The nutritional status of vegans and vegetarians" Proc. Nutr. Soc (2) p 205

24. Centre for Agricultural Strategy—(1978) "Food, Health and Farming: reports of panels on the implications for UK agriculture". CAS Paper No. 7. Editor C. J. Robbins p. 55. CAS

25. Borgstrom, G. (1173) "World food resources" Intertext books p. 157

26. Hardinge, M. G., Crooks, H. and Stare, F. J. (1966) "Nutritional studies of vegetarians: proteins and essential amino acids" J. Am. Diet. Assoc. 48 pp. 25 - 28

27. Hughes, B. P. (1959) Brit. J. Nutr. 13 pp. 330 - 337

28. Mumford, P. report Queen Elizabeth College, University of London.

29. American Academy of Pediatrics, Committee on Nutrition (1977) "Nutritional aspects of vegetarianism, Health foods and fad diets". Nutrition Reviews 35 (6) p. 153

30. Taylor, R. J. (1972) "Micro-nutrients" Unilever Educational Booklet p. 7.

31. Badenoch, J. (1954) "The Use of labelled vitamin B_{12} and gastric biopsy in the investigation of anaemia" Proc. Roy. Soc. Med. 47 pp. 426 - 427.

section 2.3 continued

32. Ellis, F. R., West, E. D. and Sander, T. A. B. (1976) "The health of vegans compared with omnivores assessment by health questionnaire". Pl. fds. for Man 2 pp. 43 - 52.

33. Cotes, J. E., Dabbs, J. M. et al (1970) "Possible effects of a vegan diet upon lung function and the cardio respiratory response to sub-maximal exercise in healthy women". J. Physiol. 209 p. 30

34. Sanders, T. A. B., Ellis, F. R. and Dickerson, J. W. T. (1976 "Serum cholesterol and triglycerides concentrations in vegans". Proc. Nutr. Soc. 36 p. 45A.

35. (1977) "Plant foods and atherosclerosis" Nutrition Reviews 35 (6) p. 148

36. Ellis, F. R. and Sanders, T. A. B. (1976) "Angina and the vegan diet" Unpublished work.

37. Aries, V. C., Crowther, J. S., Drasar, B. S., Hill, M. J. and Ellis, F. R. (1971) "The effect of a strict vegetarian diet on the faecal flora and faecal steroids" J. Pathol 103 (1) pp. 54 - 56

38. Hepner, G. W. (1975) "Altered bile acid metabolism in vegetarians" Am. J. Dig. Dis. 20 p. 935

39. Underwood, E. J. (1977) "Trace Elements in Human Nutrition" 4th Edition. Aca Press.

40. Davidson, S., Passmore, R. and Brock, J. F. (1972) op cit p. 105. and section on Trace Elements p111

41. MAFF (1970) 'Manual of Nutrition' HMSO

42. World Health Organisation (1970) Technical Report Series No. 452. "Requirements for Vitamin C, Vitamin D, Vitamin B_{12}, folate and Iron". WHO

43. Layrisse, M., Martinez-Torres, C., and Roche, M. (1968) "Effect of interaction of various foods on iron absorption" Am. J. Clin. Nutr. 21 p. 1175.

44. Jacobs, A. (1774) "Erythropoesis and Iron Deficiency Anaemia" in 'Iron in Biochemistry and Medicine. Editors. Jacobs, A., and Worwood, M. Aca Press

45. Beaton, G. H. (1974) "Epidemiology of Iron Deficiency" in "Iron in Biochemistry and Medicine" Editor. Worwood and Jacobs. Aca Press

46. Davidson, L. S. P., Donaldson, G. M. M., Dyar, M. S., Lindsay, S. T., and McSorley, J. G. (1942) "Nutritional Iron deficiency Anaemia in wartime: the haemoglobin levels of 831 infants and children" Brit. Med. J. 2 pp. 505 - 507.

section 2.3 continued

47. Elwood, P. C. (1973) "Evaluation of the clinical importance of anaemia" Am. J. Clin. Nutr. 26 pp. 958 - 964.

48. Truswell, A. S. (1977) "Some micronutrients that may be critical" pp. 57 - 70 in 2nd British Nutrition Foundation Conference. April 1976. "People and Food tomorrow" Applied Science Publication

49. Underwood, E. J. (1977) op cit. Chapter on 'Iron'

50. Turnbull, A. (1974) "Iron absorption" in "Iron in Biochemistry and Medicine" Editors. Jacobs, A. and Worwood, M. Aca Press

51. Bowering, J. and Sanchez, A. M. (1976) "A conspectus of Research on Iron requirements of Man". J. of nutrition. 106 (?) pp 985 - 1074.

52. Jacobs, A. and Greenman, D. A. (1969) "Availability of food Iron" Brit. Med. Journal 1 pp. 673 - 676.

53. Reinhold, J. G., Faramarz, I. B., and Bahrain, F. (1975) "Fibre Vs. Phytate as determinant of the availability of calcium, zinc and iron of breadstuffs". Nutr Repts. Int. 12 (2) pp. 75 - 85.

54. Disler, P. B., Lynch, S. R., Charlton, R. W., Torrance, J. D., Bothwell, T. H., Walker, R. B. and Mayet, F. (1975) "The effect of tea on iron absorption" Gut 16 pp. 193 - 200

55. Dobbs, R. J. and Baird, I. M. (1977) "Effect of wholemeal and white bread on iron absorption in normal people" B.M.J. 1 pp. 1641 - 1642.

56. Widdowson, E. M. and McCance, R. A. (1942) "Iron exchanges of adults on white and brown bread diets" Lancet 1 pp. 588 - 590

57. Elwood, P. C., Newton, D., Eakins, J. D., and Brown, D. A. (1968) "Absorption of Iron from bread" Am. J. Clin. Nutr. 21 pp. 1162 - 1169.

58. Callender, J. T. and Warner, G. T. (1970) "Iron absorption from brown bread" Lancet 1 pp. 546 - 547

59. (1974) "Bread: an assessment of the bread industry in Britain" p. 34. The TACC Report. Intermediate Publishing.

60. Hussain, R., Walker, R. B., Layrisse, M., Clark, P. and Finch, C. A. (1965) "Nutritive Value of Food Iron" Am. J. Clin. Nutr. 16 pp. 464 - 471.

61. Ministry of Agriculture, Fisheries and Food (1970) op cit p. 20.

section 2.3 continued

62. Irwin, M. I. and Kienholz, E. W. (1973) "A conspectus of research on calcium requirements of Man" J of Nutr. 103 pp. 1019 - 1095.

63. Ajayi, O. A. (1977) "Plant protein and calcium balance" Qualitas Plantarum 27 pp. 161 - 169.

64. Halstead, J. A., Smith, J. C. Jnr., Irwin, M. I. (1974) "A conspectus of research on zinc requirements of Man" J. of Nutrition 104 pp. 345 - 378.

65. Underwood, E. J. (1977) op cit. chapter on 'zinc'

66. World Health Organisation (1974) "Handbook on Human Nutritional Requirements" Mongraph series No. 61. WHO Geneva.

67. Department of Health and Social Security (1969) "Recommended intakes of Nutrients for the United Kingdom" Reports on Public Health and Medical Subjects No. 120. HMSO

68. MAFF (1977) "Household Food Consumption and Expenditure: 1975" Table 29. HMSO

Section 2.4

An Alternative Cropping Plan For Agriculture In England and Wales

1. MAFF (1975) "Agricultural Statistics for England and Wales 1973" HMSO

2. Murray, K. A. H. (1956) "Agriculture in History of the Second World War" HMSO and Longmans

3. Hammond, R. J. (1916) "Food, The Growth of Policy" in History of the Second World War HMSO and Longmans

4. MAFF (1967) "A Century of Agricultural Statistics 1866 - 1966" HMSO

5. Page, J. B. Personnal communication.

6. Blaxter, K. L. (1975) "Can Britain Feed Herself?" New Scientist 20th March

7. MAFF (1977) "Output and Utilisation of Farm Produce in the UK 1969/70 to 1975/76" HMSO

8. C.S.O. (1974) "Annual Abstract of Statistics 1973" HMSO

9. World Health Organisation (1974) "Handbook on Human Nutritional Requirements" Monograph Series No. 61. WHO Geneva.

10. WHO (1970) "Requirements for vitamin C., vitamin D., vitamin B_{12} folate and Iron" Tech. Report Series No. 452, WHO Geneva

11. Stanley, R. P. (1978) "Oilseeds Assessed" Esso farmer

12. Beaton, G. H. and Swiss, L. (1974) "Evaluation of the nutritional quality of food supplies: prediction of 'desirable' or 'safe' protein calorie ratios" Am. J. Clinical Nutrition. 27 pp. 485 - 504.

13. Garza, C., Scrimshaw, N. S. and Young, V. R. (1977) "Human protein requirements: the effects of variation in energy intake within the maintenance range" Am. J. Clin. Nutr. 29 p 280

14. Paul, A. A. and Southgate, D. A. T. (1978) "McCance and Widdowson's 'The Composition of Foods'". HMSO

Section 2.5

A Comparison Between The Present System And The Novel Cropping Plan

1. Agriculture EDC (1974) "UK Farming and the Common Market: Grass products" p. 38. NEDO

2. Cmnd 6392 (1976) "Annual Review of Agriculture 1976" HMSO

3. ICI Farm Advisory Service (1975) "ICI recorded farms 1974 Crop Year" Report 8. p. 17.

4. Agriculture EDC (1977) "Agriculture into the 1980's: Man power" NEDO p. 3.

5. MAFF (1969) "The Farm as a business: Labour and machinery" 2nd Edition, Aids to management series, No. 6. HMSO

6. MAFF Economics Division (1977) "Agricultural Labour in England and Wales 1976" HMSO

7. Association of District Councils (1978) "Rural Recovery - Strategy for survival"

8. Newby, H. (1979) "Urbanisation and the rural class structure; reflections on a case study" paper presented to the Centre for Environmental studies conf., on "Urban Change and Conflict" Univ. Nottingham January 1979.

9. Leach, G. (1976) "Energy and Food Production" IPC science and Technology Press p. 8.

10. Blaxter, K. L. (1978) "Energy Use in Farming and its cost" in Report and proceedings of the 32nd Oxford Farming Conference 3rd - 5th January 1978. pp. 28 - 38.

11. Dean, T. W. R. (1976) "Straw as a potential fibre source for paper making" in MAFF/ADAS 'Report on straw Utilisation conference' Oxford January 23rd.

12. Hayes, W. A. (1977) "Mushrooms for Every Home" paper presented at 139th Annual Meeting of BAAS 31st August to 7th September.

Section 3.1

Potential Uses For Agricultural Land Not Involved In The Plan For Food Production

1. (1974) "British Forestry" Editor, D. B. Rocke. Forestry Commisson.

2. The British Paper and Board Makers' Association (1974) "Reference Tables for 1972" p. 7. (The above association is now The British Paper and Board Industry Federation).

3. Roche, L. (1977) "Forestry and the Community" Paper presented at 139th Meeting of BAAS

4. Miles, R. (1967) "Forestry in the English Landscape" Faber chapters 3 and 4.

5. H. M. Treasury (1972) "Forestry in Great Britain: an Interdepartmental Cos/benefit study" HMSO

6. Association of District Councils (1978) "Rural Recovery: Strategy for Survival"

7. Patmore, J. A. (1972) "Land for Leisure" Pelican Chapters 1, 2, 4 and 6.

8. Countryside Commission (1978) Introductory pamphlet on the Commission HMSO

9. Long, A. (1977) "Green Plan (synopsis)" The Vegetarian Society (UK) Ltd. Press Release.

10. Donaldson, J. G. S., Donaldson, F. and Barber. D. (1972) "Farming in Britain Today" Chapter 22 Pelican

11. Fairbrother, N. (1970) "New Lives, New Landscapes" Pelican

12. Nature Conservancy Council (1977) "Nature Conservation and Agriculture" NCC

Section 3.2

The Dairy Industry - Introduction

1. Donaldson, J. G. S. & F., Barber, D. Farming in Britain Today" Pelican 1972

2. MAFF Annual Review of Agriculture 1978 Cmd. 7058 HMSO

3. M.M.B. "Dairy Farming in Transition: Structural Development in England and Wales; 1963/64 - 1968/69"

4. Agriculture EDC (1973) "Milk and Milk Products" in series "UK farming in the Common Market" NEDC

5. Williams, R. E. (1971) "The problem of the size of the Milk Industry in the United Kingdom" J. Agric. Econ. 22 p. 1 - 11.

6. Yudkin, J. (1976) "The changing role of milk and milk products in diets in the UK" J. of Soc. of Dairy Tech 29 (2) p. 108.

7. McLaren, D. S. (1976) "Nutrition and its Disorders" 2nd edition Churchill Livingstone.

8. Burnett, J. (1966) "Plenty and Want" Nelson

9. Cmd. 2175 (1904) Interdepartmental Committee Report on Physical Deterioration. HMSO

10. Evans, J. (1974) "Catering in Schools and Colleges" Barrie and Jenkins London

11. Smith, C. "Britain's food supply" A Survey prepared for the Fabian Society Routledge (1940)

12. Hammond, R. J. "Food: the growth of policy" HMSO and Longmans

Induced Lactation

13. (1971) "Hammond's Farm Animals" 4th Edition Arnold

14. Meites, J. (1961) in Kon, S. K. and Cowie, A. T. "MILK: the mammary gland and its secretion" Vol 1. p. 321. Aca Press.

15. Erb, R. E. (1976) "Hormonal control of mamimogenesis and onset of lactation in cows - a review" J. Dairy Sci. 60 (2) pp. 155 - 169

16. Smith, K. L and Schanbacker, F. L. (1973) "Hormone induced lactation in the bovine. Lactational performance following injections of 17β - estradiol and progesterone". J. Dairy Sci. 56 (6) pp. 738 - 743.

section 3.2 continued

17. Erb, R. E., Monk, E. L., Mollett, T. A., Malven, P. V. and Callahan, C. J. (1976) "Estrogen, Progesterone, prolactin and other changes associated with bovine lactation induced with Estradiol - 17β and progesterone" J. Animal Sci. 42 (3) pp. 644 - 654.

18. Navendran, R., Hacher, R. R., Batra, T. R. and Burnside, E. B (1974) "Hormonal induction of lactation in the bovine. Mammary gland histology and milk composition" J. Dairy. Sci. 57 p. 1334.

19. Willet, L. B., Smith, K. L., Schanbacher, F. L., Erb, R. E. and Malven, P. V. (1976) "Hormone induced lactation in the bovine. III Dynamics of injected and endogenous hormones" J. Dairy. Sci. 59 pp. 504 - 514

Ova transplantation

20. Church, R. B. and Shea, B. F. (1977) "The role of embryo transfer in cattle improvement programs" Canadian J. Animal Sci. 55 pp. 33 - 45.

21. Newcomb, R. (1976) "Fundamental aspects of ovum transfer in cattle" Vet. Rec. 99 pp. 40 - 44.

22. Alexander, A. M. and Markus, A. N. (1977) "A modified technique for the transplantation of embryos into recipient cows" Vet. Rec. 100 pp. 73 - 74.

23. Cox, S. (1976) "Costs limit scope for ova transplants" Farmers Weekly November 26th p. 85 - 87.

24. Watson, J. D. (1970) "Molecular Biology of the Gene" 2nd Edition. W. A. Benjamin-Inc.

25. (1978) "Sexed Semen for sale now" Livestock Farming November

Simulated Dairy Products

26. Winkelmann, F. (1975) "Imitation milk and imitation milk products" World Animal Review 14 pp. 31 - 36.

27. Wokes, F. (1960) "Wanderlac - a brief account of its origin and development during 1945 to 1959" Unpublished account from Vegetarian Soc. UK.

28. Spensley, P. C., Halliday, D., and Orr, E. (1972) "The prospects for non-conventional protein resources" Tropical science 14 pp. 203

29. Kosikowski, F. V. (1969) "Role of imitation milk in the feeding of tomorrow's population" J. Dairy Sci. 52 pp. 756 - 760.

section 3.2 continued

30. Jones, J. J. (1975) "Impact of Vegetable proteins on Dairy Products" J. Milk and Food Tech. 38 p. 39

31. Miller, W. (1944) "The story of milk from the soya bean" published by International Nutrition Lab., Mount Vernon, Ohio.

32. Tiling, W., Ehring, A. M. and Stewart, C. P. (1961) "The use of soya-based foods in infant feeding" Nutritio et Dieta 3 pp. 89 - 104.

33. Swaminathan, M. and Parpia, H. A. B. (1967) "Milk substitutes based on oilseeds and nuts" World Review of Nutrition and Diet. 8 pp. 184 - 206.

34. Bourne, M. C. (1970) "Recent advances in soybean milk processing technology" Protein Advisory Group Bulletin 10 pp. 14 - 21.

35. Shurpalekar, S. R., Chandrasekhara, M. R., Lahiry, N. L., Swaminathan, M., Sreenivasan, A., and Subrahmanyan, V. (1963) "Preparation and nutritive value of spray-dried milk substitutes from blends of goundnut, soybean and sesame" J. Oil Tech. Association India 2 (18)

36. Shurpalekar, S. R., Lahiry, N. L., Chandrasekhara, M. R, Swaminathan, M., Indiramma, K., and Subrahmanyan, V. (1959) "Studies on milk substitutes of vegetable origin. Part 1. The nutritive value of milk substitutes prepared from soyabean and groundnut". Annals of Biochem and Experimental Medicine. 19 (1)

37. Shurpalekar, S. R., Chandrasekhara, M. R., Lahiry, N. L., Indiramma, K., Swaminathan, N., Sreenivasan, A., and Subrahmanyan, V. (1962) "Studies on milk substitutes of vegetable origin: Part 4. , the supplementary value of spray-dried vegetable milk powder obtained from a blend of soyabean and groundnut milks to a poor rice diet" Annal. Biochem. and Experimental Medicine 22 (3)

38. Hagenmaier, R., Mattil, K. F. and Cater, C. M. (1974) "Dehydrated coconut skim milk as a food product: composition and functionality". J. Food. Sci. 39 p. 196

39. Puertollano, C. L., Bourne, M. C., Banzon, J. and Melgar, J. C. (1970) "Effects of change in the formulatiom of soymilk on its acceptability to Filipino children". Philippine Agriculturist 54 pp. 227 - 240.

40. Ashworth, V. S. (1972) "The protein content of milks, imitation milks and dairy products" American Dairy Review 34 pp. 24, 26, 54.

section 3.2 continued

41. Filer, J. Jnr. (1972) "Filled milks, imitation milks, coffee whiteners" Pediatrics USA 49 pp. 770 - 775.

42. Call, D. L. (1970) "Fluid milk substitutes - current status and expected trends" paper presented at Symposium on "The challenge of synthetic and substitute foods" Gottlieb Duttweiler Instit. Zurich

43. Mann, E. J. (1974) "Imitation milks and milk products" Dairy Industries 39 pp. 165 - 166

44. Horn, H. E. and Godzicki, M. M. (1972) "What now, brown cow?". Cereal Science Today 17 pp. 135 - 137.

45. Shurpalekar, S. R., Lahiry, N. L. et al (1961) "Studies on milk substitutes of vegetable origin Part 3: The nutritive value of spray-dried soya bean milk fortified with DL-methionine and spray-dried powder from a 2:1 blend of soyabean milk and sesame milk" Annal of Biochem and Exptl. Medicine 21 (6)

46. 1974 "Infant protein needs provided by a soy-based formula" Nutrition Reviews 32 (2) pp. 42 - 43.

47. Wills, G., Wilson, R., Manning, N. and Hildebrandt, R. (1972) "Technological Forecasting" Pelican

Section 3.3

1. (1977) "Farm Management Handbook 1976" Universities of Bristol and Exeter.

2. Stanley, R. (1978) "Oilseeds Assessed" Esso Farmer

REFERENCES

Appendix IV

Delphi

1. Encel, S., Marstrand, P. K., and Page, W. (1975) "The Art of Anticipation: values and methods in forecasting" Martin Robertson

2. Wills, G., Wilson, R., Manning, N. and Hildebrandt, R. (1972) "Technological Forecasting" Pelican

3. Overbury, R. E. (1969) "Technological Forecasting - A Criticism of the Delphi Technique" Long Range Planning 1 pp. 76 - 77.

4. Hetman, F. (1973) "Society and the Assessment of Technology" OECD

5. Linstone, H. A. and Turoff, M. (Editors) (1975) "The Delphi Method: Techniques and Applications" Addison-Wesley Publ. Co.

6. Stander, A. and Rickards, T. (1975) "The Oracle that failed" Long Range Planning 8 (5) pp. 13 - 17.

7. Wilson, L. S. (1977) "A Unique Event and Delphi" Long Range Planning 10 p. 79

8. Jantsch, E. (1967) "Technological forecasting in perspective" OECD

9. Hill, J. Q., and Fowles, J. (1975) "The methodological worth of the Delphi forecasting technique". Technological forecasting and social change 7 pp. 179 - 192.

10. Kendal, J. W. (1977) "Variations of Delphi" Technological forecasting and social change 11 pp. 75 - 85.