UNIVERSITY OF STRATHCLYDE

DAVID LIVINGSTONE INSTITUTE
OF OVERSEAS DEVELOPMENT STUDIES

SEASONAL EMPLOYMENT AND TECHNOLOGICAL CHANGE ON SMALLHOLDINGS IN CHILALO, ETHIOPIA

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Ph.D. 1977

SUMMARY

Farm mechanisation in Chilalo has in the past caused severe labour displacement, but the 1975 land reform has altered the institutional basis of farming and provides an opportune moment for the evaluation of mechanisation policy. The present study uses, *inter alia*, data from interviews with Chilalo smallholders in order to arrive at an understanding of any problems arising from seasonality in employment, since this is an essential prerequisite for relevant policy formulation.

Examination of the availability of oxen and family labour in relation to the requirements imposed by typical crop mixes shows that during even a single cropping season periods of excess labour and/or oxen availability alternate with periods of sometimes acute shortage. Traditional methods do exist for easing 'bottleneck' periods, but the introduction of fertilizer and improved seed has upset such arrangements. In some cases, particularly during harvest, post-harvest operations and weeding, requirements have increased quite sharply. Smallholders have reacted by increased use of purchased inputs such as labour, herbicides and equipment, but the land reform proclamation has introduced new problems by prohibiting the hiring of labour by 'able bodied' farmers. The search for appropriate methods of relieving bottlenecks has thus assumed greater urgency.

SUMMARY (contd)

Evidence from various sources concerning crop yields indicates the magnitude of the losses which can result from both energy shortages and inefficient traditional techniques. Losses are particularly high in harvesting and threshing.

An evaluation, conducted in the light of the above findings, of the 'intermediate' technology presently available in Chilalo suggests new areas in which engineering research on improved implements might fruitfully be concentrated. Meanwhile a comparison of costs of available alternative technologies for various farm operations permits the identification of a 'least cost' mix of traditional, 'intermediate' and modern technologies. Finally it is possible to suggest a number of ways in which 'surplus' labour might usefully be employed in the slack season(s).

ACKNOWLEDGEMENTS

This study would not have been possible without the cooperation of a very large number of individuals - and very difficult to complete without the help of a great many more. It would be impossible to name all of these people individually, but a few deserve special mention and sincere thanks. Financial support came from the Social Science Grant to IDR from the Ford Foundation, and from the Planning and Evaluation Section of the Chilalo Agricultural Development Unit (CADU), and from the Inter-University Council (London). This assistance is most gratefully acknowledged, as is the enthusiastic encouragement received from Dr. Assefa Mehretu of I.D.R. Mr. T. E. Cobbald formerly of the CADU Agricultural Engineering Section gave indispensable assistance in formulating the Survey, as did Ato Teclemariam Gebre Medhim of the Addis Ababa University Agricultural Experiment Station. During the data collection phase of the Survey, invaluable help was provided by Ato Mahari Tesfaye and the staff of the CADU Planning and Evaluation Section. The main brunt of the work during this phase of the project was borne by the field enumerators: Dinku Abeba, Gedewon Makonnen, Kebede Berga, Olika Rundassa, Tesfaye Wegderesegn, and Hussein Hassan. Very useful practical assistance in supervision was also provided by my colleague at I.D.R., Ato Mathewos Woldu. For access to computer facilities and for practical help in using the machine, I am most grateful to Ato Behabtu Dagu and the staff of the Central Statistical Office Electronic Data Processing Section.

ACKNOWLEDGEMENTS (Contd.)

At Strathclyde I received much assistance and encouragement from my colleagues at the David Livingstone Institute. In particular I would like to acknowledge the invaluable advice and constructive criticism provided by Dr. James Keddie and by my supervisor Mr. James Pickett.

Most of all my sincere thanks and appreciation are due to the Chilalo farmers, without whose unfailing patience, hospitality, courtesy and consideration this study would have been quite literally impossible.

Final and complete responsibility for any errors of fact or interpretation, and for any culpable omission is, of course, entirely my own.

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EMPLOYMENT, SEASONALITY AND TECHNOLOGICAL CHANGE

1.1 THE EMPLOYMENT PROBLEM

The related questions of unemployment and income distribution have come increasingly to dominate thinking in development studies in recent years. The symptoms which have led to this domination are plainly visible in almost all developing countries. The steady drift of population from the countryside into the towns and cities has produced, often on a very large scale indeed, problems of very low standards of living with severe over-crowding, under very poor housing conditions. Even those in reasonably full-time employment - and this applies most especially to those workers with few or only traditional skills who are employed outside of the small modern manufacturing sector - usually find perpetual poverty to be their lot. At its worst, in many developing countries, the rapid rate of urban population growth has led to the appearance of sprawling crowded and insanitary shanty towns whose inhabitants live under perpetual conditions of squalor, ill-health and malnutrition, unable for the most part to obtain permanent productive employment and forced to exist on such a pittance as can be derived from occasional casual work, street trading, petty crime and minor service trades such as shoe-cleaning and car-minding. Where such urban conditions exist, they can generally be said to find their echo in, perhaps less crowded but almost equally squalid, conditions in the rural areas.

One basic underlying cause is of course the continued growth of population in such countries, but even if this could be brought under control the number of people requiring productive work would still be enormous. Professor Bunting (1974) has estimated that even if birth rates were to fall everywhere to replacement levels by the year 2000 - a sufficiently remote prospect in itself - it is unlikely that total human population would become stable until a hundred years from now, and that the figure would eventually stabilize at rather more than double the present total of approximately four billions.

Under such circumstances it has become painfully obvious that in the great majority of developing countries the urban sectors in general, and the modern manufacturing sector in particular, have been unable to provide adequate job opportunities even for those currently seeking them. The policy of import substitution in manufacturing which has been vigorously pursued by almost all such countries has led to the growth of a manufacturing sector which is capital intensive and labour displacing.

The most important linkage between the policy of import substitution and the observed capital intensity of the resultant manufacturing industries in the developing countries lies in the nature of the goods produced. 'Import substitution' has in such countries tended to be interpreted in the narrow sense of encouraging the domestic manufacture of goods which are, as near as is possible, exact replicas of those which were currently being imported. Hence the necessary technical expertise, processes, and capital equipment were found ready to hand in the industrialised countries and the technology ultimately installed has also tended to be an exact replica - of that found in the same industry in the industrialised world. Thus it has been shown that in Africa during the 1960's the proportion of the labour force employed in modern manufacturing actually declined.[1/]

This reality contrasts bleakly with the optimistic theories of the 1950's and 1960's when Lewis (1954) Rosenstein-Roden (1957) and their followers[2/] thought it necessary to construct models showing how an agricultural sector burdened with so many under-employed workers that the marginal product of labour was zero, could release this surplus for the development of manufacturing industry without loss of agricultural output. The question as to whether or not the agricultural sector could release labour thus painlessly almost immediately became, and has since remained, a matter for serious and sometimes heated debate, but from the viewpoint of employment policy it has become for most developing countries largely irrelevant. Agriculture is perforce no longer viewed as a reservoir of labour for industry, but rather as a potential source of employment which will halt or at least diminish the 'urban drift'. This change of outlook

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1/ For figures on various African countries see for example Frank (1968, p.254) Dissillusionment with the very poor progress achieved in manufacturing in many developing countries had by the late 1960's led to a marked shift in emphasis, in for example development plans, in favour of the previously neglected agricultural sector. An authorative account of this change in attitude towards agriculture is given by Little *et al* (1970).

2/ Of whom probably the best known and most controversial are Fei and Ranis (1964).

has reached such an extent that "the reduction of rural under-employment by agricultural development rather than by the development of manufacturing in urban centres has become a prime policy objective in most developing countries" (Blaug, 1974, p.117).

The question of employment has a number of dimensions, which have been grouped by Sen (1975, Ch. 1) under three headings. First there is what he calls 'the income aspect' of employment ("employment gives an income to the employed"). Two features of this aspect were outlined in an earlier ILO (1972) study of the Kenyan economy, the first being that unemployment usually entails low or poverty levels of income for the unemployed individual and his family, (as is indeed the case for many individuals in low-paid jobs), and the second that it is usually accompanied by very marked income inequalities between town and country, among regions and among individuals. Sen's second 'aspect', which he regards as being rather more complex than the first, he calls the 'production aspect' of employment ("employment yields an output"). Thus if a person is engaged on the family farm but the marginal productivity of his labour is zero, then he may be regarded as being in employment according to the 'income aspect' discussed above and possibly even according to the 'recognition aspect' discussed below, but from the 'production aspect' he is unemployed. Sen's 'recognition aspect' of employment ("employment gives a person the recognition of being engaged in something worth his while") is the most complex of the three, and concerns itself with such essentially non-quantifiable but nonetheless important factors as self-esteem, the esteem of others and the pervading sense of futility and frustration felt by unsuccessful job-seekers.[3/]

Sen's categorisation of aspects of employment provides a useful checklist against which it should be possible to judge the efficacy of development strategies aimed at reducing rural-urban migration through increased employment in agriculture. The creation on a large scale of new job opportunities which are at once remunerative, productive and recognized is a very large undertaking indeed and requires most careful planning; a mere vision of the 'ultimate goal' is not sufficient for this purpose. In the past rather more than at present this goal was often seen as the creation of a 'modern' high-technology agriculture, and it was left to a few agriculturalists inevitably with modern training and inclinations, to design the appropriate strategy. The result has in many countries been the creation of a dualistic farming structure with a small modern sub-sector under private or public ownership, very similar in many respects to its counterpart in domestic manufacturing, too alien to have any demonstration effect on the vast bulk of the farming population and

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3/ 'Disguised unemployment' in the sense that Joan Robinson originally used the expression, viz "the adoption of inferior occupations by dismissed workers" (Robinson, 1937, p.62) rather than simply in the sense of less than full-time employment ('underemployment') clearly relates to Sen's 'recognition' aspect as well as to the other two aspects.

too capital-intensive to make any significant impact on unemployment. Indeed such dualistic development has, as will be shown later, often worsened conditions in the traditional sub-sector and has thus actively contributed to net rural-urban migration.

If for example, a given country has 80 per cent of its population engaged in traditional smallholder farming and four percent in its modern agricultural sector, then in the event of the displacement of five percent of the former labour force, the latter would have to double its workforce in order to absorb all of this labour even without any net job creation. In addition, since the modern sub-sector is typified by relatively high capital-labour ratios, an increase in net investment would be required in order merely to prevent any growth in unemployment. Increased expenditure of other scarce resources such as skilled labour and foreign exchange would also be required for similar reasons.[4/] Thus the logic of the arithmetic alone, regardless of other considerations, suggests very strongly that improved employment opportunities would be more likely to be created if employment policy chose as its vehicle the development of the smallholder sub-sector rather than modern capital-intensive agriculture. This fact by itself of course constitutes no guarantee that this vehicle if chosen would necessarily prove suitable.

4/ The history of the block mechanization schemes in Tanzania gives an idea of the orders of magnitude involved (see Rutherberg 1964 and Newiger, 1968). It is not argued here however that it is impossible for the modern farming sub-sector to create jobs for the unskilled on any significant scale. For example, before the recent political unrest, the Setit-Humera region of Ethiopia was engaged in the highly commercialized production of sesame and sorghum. Tractors were used for land preparation, but weeding and harvesting were done by hand and occupied an estimated 100,000 seasonal workers for six months of the year. The circumstances which led to this were however very unusual and the employment was not achieved without the eviction of the traditional occupiers of the area. (see Blaug, 1974, p.162 and Gill 1977).

It would not be appropriate if, for example, peasant farmers in developing countries do not behave as 'economic men'[5/], but have evolved farming systems which are characterised by what Higgins (1959, p228) in a critique of Boeke's views described as "backward-sloping supply curves of effort and risk-taking".

This view of the traditional smallholder has by now, however, been widely discredited, and has largely been superseded by the opinion that "traditional patterns are maintained because peasant farmers are economic men... When faced with economic incentives(they will) respond in a manner predicted by economic theory" (Singh and Day, 1975, p.661)[6/].

If the time when it was fashionable to disregard almost with contempt the rationale behind traditional farming methods now belongs to the past, there is still, despite recent progress in this field, an alarming lack of specific information as to the agronomic and economic basis for much of traditional farm technology. This is particularly true of sub-Saharan Africa where empirical studies of such factors as labour supply and demand relationships within the traditional sector are very few and of quite recent origin[7/]. Of those which do exist, almost none

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5/. The best known and one of the least equivocal proponents of this view was probably Boeke (1953).

6/. Probably the earliest and certainly the best known of the works on this topic in an African setting was that by Jones (1960). Miracle and Fetter (1970) and Miracle (1976) have provided a critical examination of the earlier thesis in an historical African context.

7/. Two of the best available studies in this field are those by Collinson (1972) and Cleave (1974).

has set out to examine labour use under improved technologies (Spencer and Byerlee, 1976, p.874). The consequences of this information gap can be very serious. For example recommendations concerning new crops, husbandry practices and crop rotations are often put forward to farmers by extension services without adequate appreciation of the burdens which they will impose on farm resources[8/].

On the credit side, provided the above problem can be overcome the development of the traditional farm sector is potentially capable of achieving a great deal more than the mere absorption of labour and a reduction in 'urban drift'. First, almost by definition, total agricultural output will be increased, either through an expansion in output per unit area or by causing a larger area to be brought under cultivation or both. Second, provided output expands at a faster rate than population, and given the low initial levels of land and labour productivity especially in Africa this should not be too difficult initially, and provided the terms of trade do not change in favour of the non-agricultural sectors, per capita incomes in agriculture will also grow. Third, increasing prosperity together with increased use of purchased inputs will result in an increase in the degree of market-orientation among smallholders which will in turn provide a large-scale

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8/. Bell (1972, p.148) and Cleave (1974, Ch.5), especially the former, offer some illuminating examples of this type of practice and its consequences.

market for simple domestic manufactures as well as increased supplies of food and fibre for the export and domestic non-agricultural markets. Finally, a prosperous agricultural sector can generate an investible surplus for further agricultural and non-agricultural development.[9]

1.2 SEASONALITY

Surely the most fundamental distinction between the production process in agriculture and that in industry (other than processing industry) lies in the role played in the former case by the inter-related factors of climate and time. The process of industrial production is characterised by the simultaneous or the phased mechanical production of separate components for eventual assembly, a procedure which stands in sharp contrast to the intrinsically consecutive processes which govern the biological cycle of plant growth and which are very much less susceptible to human intervention. Variations in the tempo of this biological cycle are governed by the interaction of many variables including the availability of carbon dioxide, water and plant nutrients, the number of hours of sunlight, ambient temperature and variations thereof, and the condition of the soil, but since, particularly in the topics, these in turn correlate closely with changes in rainfall distribution, this latter variable can be used as a proxy for variations in the other factors.

9/. Unfortunately, however, agriculture has too often been regarded primarily as a source of surplus and has been bled for the benefit of other sectors. Griffin (1974, Ch.5) provides many examples of this.

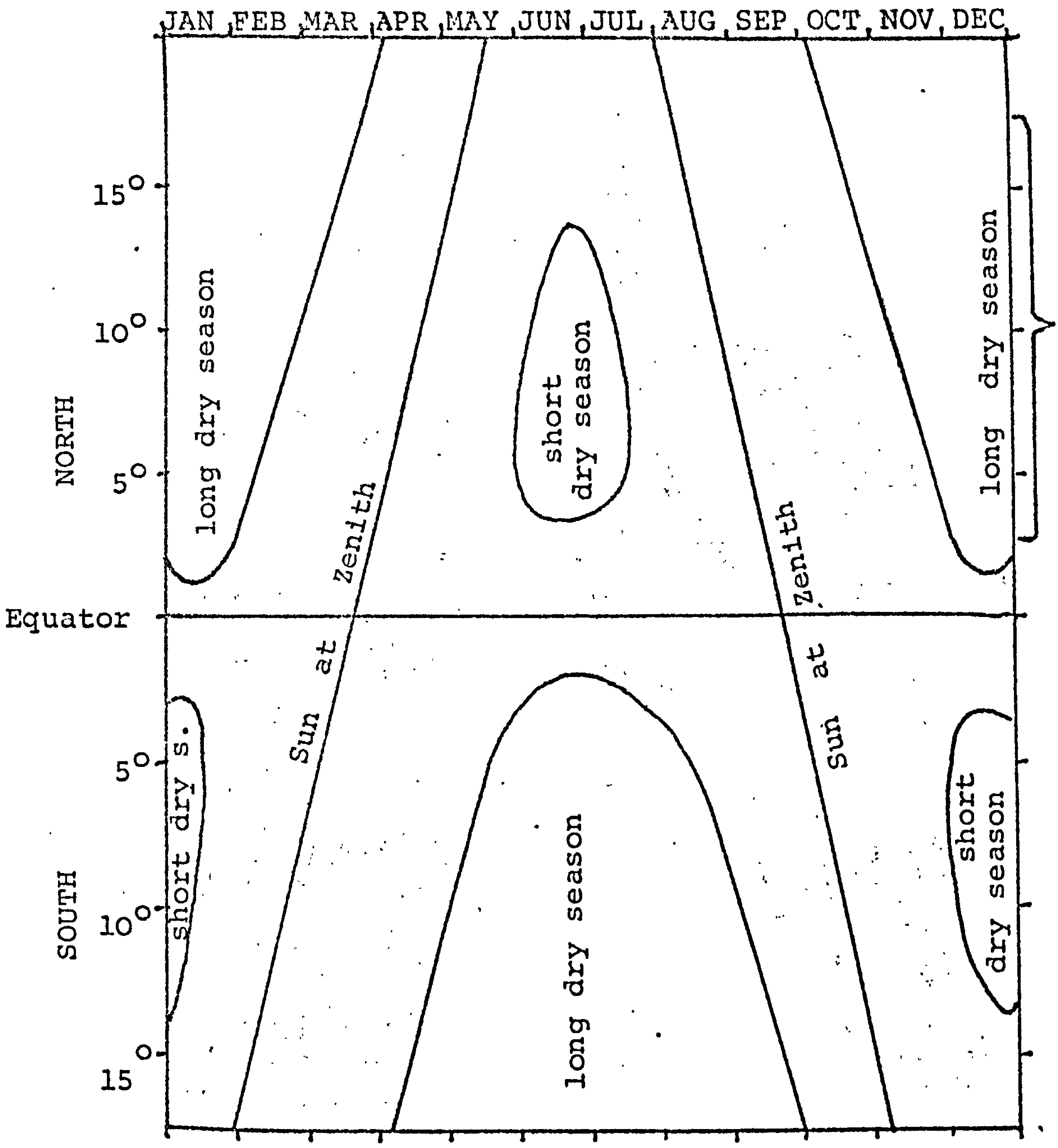

FIGURE 1.1: DISTRIBUTION OF WET AND DRY SEASONS IN THE TROPICS IN RELATION TO LATITUDE (SCHEMATIC REPRESENTATION)

Source: Richards (1952,p.139).

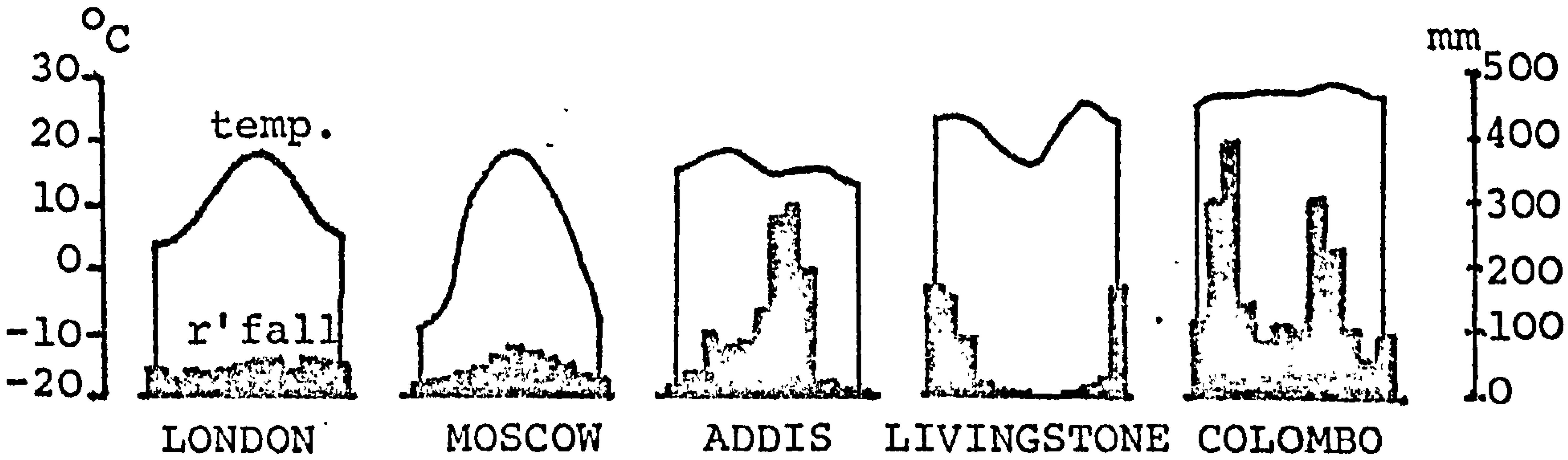

FIGURE 1.2: MONTHLY TEMPERATURE AND RAINFALL VARIATIONS IN FIVE LOCATIONS

Source: The Times Atlas(1975,pp xxiv-xxv)

Figure 1.1 shows in schematic form the general relationships which exists in the tropics between latitude and the seasonal distribution of rainfall. Not only are there very distinct separate seasons but, as can be seen from Figure 1.2, the seasonal differences in rainfall can be very marked indeed. The relatively greater seasonality of rainfall in the tropics can also be gauged from Figure 1.2 which illustrates how in the non-tropical zones it is temperature rather than rainfall which accounts for the seasonal pattern. It is worth noting, moreover, that the tropical examples shown in this diagram are by no means atypical and that seasonality of rainfall can be very much more marked than has been shown here. One extreme case is that of Cherrapunji in India where average rainfall ranges from 10 mm in December to over 2500 mm in June. Elevation is another factor which helps influence rainfall and in highland areas, such as the East African plateau where Chilalo is situated, both the level of annual precipitation and the length of the rainy season(s) are for a given latitude positively related to altitude.

In the absence of irrigation, and this is certainly the norm almost everywhere in sub-Saharan Africa, peaks and troughs in annual rainfall govern to a marked extent the stages of crop growth and therefore the input of energy required for crop production. De Wilde has observed, on the basis of a wide-ranging study of diverse African farming systems that:

"Seasonal labour peaks tend to be particularly high in Savanna[10/] areas where climatic factors, particularly rainfall, severely limit the cropping season and put a premium on the timeliness of agricultural operations. The fluctuation in labour requirements may be much less great where rainfall is more evenly distributed and both climate and soils are such as to permit greater flexibility in the timing of agricultural operations or a greater choice of crops and combination of crops and livestock. Such conditions, however, are not found in many areas of tropical Africa" (1967, p.83).

Thus for example, the onset of the first rains usually signals the start of a period of intense agricultural activity as farmers prepare land which was previously too hard for cultivation, in order to be able to sow their crops as quickly as possible. The harvest period for some crops, particularly small grains, imposes another such peak, since the crop must be gathered in after it has ripened but before it falls to the ground or is spoilt by bad weather or other forces.

The degree of variation in energy requirements which is imposed by seasonality (not only energy supplied from human labour but also in that supplied in the form of the services of draft animals and farm machinery where this is available) can be very pronounced. Even China with its enormous population

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10/. Of which Chilalo is one.

suffers from shortages of agricultural labour during busy seasons, especially the harvest, so that workers have to be brought from urban areas in order to get the crop in on time (Kuo, 1972, Ch.12). Government estimates in Thailand put labour shortages at 30 percent during land preparation and at 15 percent during the rice harvest in some parts of the country (Inukai, 1970). In Africa it would appear that the single most important call on labour supply in the farming year is for weeding. Cleave's synthesis of studies of labour use in African agriculture revealed that this was true "to a remarkable extent" in the areas surveyed (1974, p.129) and that the potential returns to weeding could be very significant indeed. Using data from a study by Margaret Haswell in the Gambia for instance, he found that the marginal return to weeding groundnut (unshelled) could be as high as 1.75 lbs per hour (1974, p.63).

The degree of variation in labour demand across the year can also be very marked. Typically the peak periods of seedbed preparation, sowing, weeding, harvesting and threshing, are interspersed with periods of low or even zero energy requirement. Again turning to Cleave's study, it appears to be very common for slack season labour requirements to be twenty percent or less of peak period demand (1974, Chs. 3-5). A study in Chilalo in which farmers were actually timed, found that they were working up to nine hours a day (which is an extremely long working day by traditional African standards) in order to thresh a crop of wheat on time (CADU, 1969, pp.25-28). In contrast to this in the slackest season in Chilalo there is often no work at all to be done in direct connection with crop production.

1.3 SEASONALITY AND EMPLOYMENT

Winkelman (1972, p.6) has observed that one element which was quickly settled in the discussion initiated by Lewis as to the existence or otherwise of surplus labour in traditional agriculture, was the fact that "there is a good bit of seasonal unemployment in all agriculture"[11/]. This having been agreed,

"the discussion centred on whether it is labor, measured in terms of time worked, or workers measured in terms of man-years of farmers, which has zero marginal product . That is, will a reduction in number of hours worked give rise to a reduction in production or is the significant act a reduction for the entire year in the number of farmers?"

The importance of this distinction must be seen in terms of the seasonality of employment in agriculture. The latter versions of the argument is usually interpreted as meaning that labour could be withdrawn from agriculture even in the busiest season without reducing output and without requiring any increase in the input of other factors, although it is possible that some reorganisation of the remaining labour

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11/. It is still possible, however to encounter discussions of labour utilization in agriculture which make no explicit mention of seasonality. See Humphrey (1974) for example.

force would be necessary.[12/]. The alternative interpretation implies that the marginal product of labour may be zero in the slack season but positive in the busy season, so that only in the former period could it be expected that an increase in the number of hours worked would not increase output. Empirical weight has been given to this latter version of the theory by Nath, who noted that in India one set of studies had found the marginal product of labour to be zero while others had found it to be positive and that at least in part the explanation for these apparently contradictory results lay in the fact that "when it comes to estimating the marginal product of labour it has invariably been the practice to ignore seasonal differences" (1974, p.375, italics added). Nath's own research confirmed the existence of positive and zero marginal products of labour in the busy and slack seasons respectively.

If the 'surplus labourers' version of the theory holds true at all in practice[13/], it must surely be much more likely to occur in the densely populated countries of, for example, the Far East[14/], than in Africa where the land-labour ratio is typically much more favourable and where therefore availability

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12/. This condition forms the basis of Sen's (1966, p.423) definition of surplus labour.

13/. Viner (1957, p.18) has argued most persuasively that he found it "impossible to conceive of" any farm on which it was not possible in some seasons at least to increase output by increased labour input.

14/. The evidence cited earlier suggests that it does not hold true even in China.

of other factors including labour are more likely than land to constrain the expansion of output.

The traditional farmer in Africa and elsewhere in the developing world must not be thought of as simply the passive victim of seasonality in the demands placed on farm energy resources by the needs of crop production. Cleave (1974, p.131) noted that "perhaps the most impressive and consistent features" of the forty-five surveys covering eleven African countries on which he based his own work, were "the extent to which farming systems are modified in response to labour conflicts and the flexibility that can be achieved in operations". These modifications are of two types: changes in "the timing, intensity and nature of farm operations" and "changes in the cropping pattern".

The range of options open to, and in fact used by, the traditional farmer in modifying the sharpness of peak energy requirements has not yet achieved full recognition in the literature on the subject. For instance it is widely recognised in this literature that labour supplied at different points in the crop year is often complementary, so that, for example, increased effort in land preparation which brings a larger area under cultivation will for that same reason also call for greater effort in weeding, harvesting and post-harvest operations. What is not so widely appreciated is the fact that labour supplied at different periods can also be to some extent mutually substitutable[15/]. Thus, a farmer who

15/. Stiglitz (1969, p.11) and Sen (1975, pp.74-75) touch briefly and tantalizingly on the topic from a theoretical viewpoint in the course of some mutual criticism, but neither provides any concrete example. A further example of this type of substitution is given below (Ch.2, Section 2.3).

faces a severe problem of weed infestation of his fields might begin to select and clean his seed very carefully so as to eliminate any weed seeds which contaminate it. He would also succeed in reducing such infestation by supplying extra labour at the time of land preparation, either to permit earlier sowing, which will give the crop a good start on the weeds, or through very thorough cultivation aimed at eliminating weeds from the seedbed.

Nevertheless the opportunities which such farmers enjoy for smoothing out the peaks and troughs in energy requirements are rather limited when they have to rely on purely traditional technology. Nor is modern technology as such necessarily of help in this respect: it may even be a hindrance, since, as will be shown later, the introduction of chemical fertilizer and new high-yielding varieties of seed which has taken place in many developing countries as a result of smallholder development programmes, often actually calls for additional energy input during busy periods.

If in such a situation the smallholder sub-sector is expected to absorb sufficient labour on a permanent basis to eliminate bottlenecks with traditional techniques at whatever happens to be the busiest season in a particular locality with a particular cropping system, then the prospect of such labour being employed in a remunerative, productive and recognised way during the remainder of the year would be very remote indeed. Fortunately, as was noted earlier, in Africa at least the land-labour ratio is relatively favourable so that additional agricultural employment can be generated by such measures as land clearance, resettlement, irrigation and land reform without the need to overburden the traditional sector in this way. On the other hand, if traditional farmers cannot obtain assistance in overcoming energy bottlenecks during the period(s) of peak demand they may find that they cannot adhere to 'optimum' timing and cultivation practices with the result that the productive potential of the new chemical-biological technology will not be realised in full.

An important related factor which is not always fully appreciated is the extremely arduous nature of many farm operations during the peak season - as anyone who has undertaken sustained periods of ridging with a hoe, hand-weeding, or reaping with a sickle will readily attest. This type of drudgery can do nothing to diminish the relative unattractiveness of farm life for the teenagers who form such a large proportion of the 'urban drift' in developing countries.

The connection between the employment problem and seasonality in agriculture under these circumstances resolves itself into a question of whether seasonality can be modified sufficiently in order to increase the relative attractiveness of farming as a means of earning one's livelihood. This would in turn require an increase in remuneration from farm employment (Sen's income aspect) and a reduction in both the arduousness of peak period work and the tedium of slack period enforced idleness (both of which certainly form part of the recognition aspect of farm employment). Increased remuneration could materialise not only from an easing of peak period energy supply limitations which presently limit productive potential, but also from the provision of employment opportunities in the slack season. A positive contribution to the income aspect of employment would under these circumstances be matched by a similar contribution to the production aspect[16/].

1.4 THE IMPACT OF TECHNOLOGICAL CHANGE

The development of agriculture in the temperate zones has since the agrarian revolution of the eighteenth centrure involved, at the level of the individual farm, investment of four types. These are: (a) short-term investment in highly divisible inputs such as improved seeds, fertilizer and other chemicals (b) medium-term investment in farm machinery and improved livestock, (c) long-term investment in farm improvement (building, field leveling, drainage, fencing, irrigation, etc.) and (d) the all-important catalytic factor, investment in human capital in the form of new knowledge and skills. Outside of the individual farm, changes such as the improvement of transportation links, the development of crop processing facilities, the growth of domestic manufacturing and related employment opportunities

16/. In the event that increased farm output was matched by a deterioration in the barter terms of trade between agriculture and the other sectors of the economy, an improvement in the productive aspect of employment might not be matched by a similar improvement in the income aspect. This situation has indeed materialised in certain Asian countries and will be discussed below.

and an increasing degree of urbanisation provided both the material inputs for the above investment and the market opportunities for its economic justification.

The industries which were developed to supply capital goods to agriculture under these circumstances were naturally geared to the needs of farming in the temperate zones and in most cases to those of particular agricultural systems within these zones. In the case of early farm machinery, very specific local conditions could be taken into account since equipment was often made, or at least adapted, by small-scale blacksmiths familar with peculiar local needs and conditions[17/]. This basic relevance did not, however, always remain a characteristic of such agricultural technology when it was later exported to areas outside of the temperate zones.

Rattan and Hayami (1971, Ch.9) have listed three stages in the process of technological transfer between countries. These are, in increasing order of sophistication on the part of the recipient country, (a) 'material transfer' (i.e. the simple transfer of materials and machinery), (b) 'design transfer', which includes, for example, drawings, plans and blue-prints and (c) 'capacity transfer', which entails the transference of scientific and engineering knowledge. Only

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17/. Examples of the factors which have historically affected the rate of diffusion of new agricultural equipment are provided by David (1966) and MacDonald (1975) who discuss respectively the spread of reaping and threshing machinery in the nineteenth ecentury.

whén thethird of these three levels has been reached can a locally adapted modern technology emerge.

The diffusion of modern high yielding agricultural inputs in the developing world has come to be known as the 'green revolution'. This has comprised essentially the introduction of high-yielding varieties of cereals together with fertilizer and other agro-chemicals and in some cases irrigation facilities[18/]. Thus, apart from the irrigation, it corresponds to the first of the four categories of investment listed earlier. Of these inputs only the first, improved seed, has been systematically developed with tropical conditions specifically in view[19/]. When farm mechanization, for example, has been introduced, the level of transfer has been mainly material[20/].

Much the same can be said of investment in human capital. First, at the level of national and international research, considerable advances have been made since World War 11 most especially in plant breeding, but more recently in the cases of farm equipment and buildings also,[21/] but an enormous amount

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18/. Cepede (1972) equates it essentially with a shift from extensive to intensive farming.

19/. Evenson (1974) argues convincingly that even research on the two main 'green revolution'crops, wheat and rice, has been insufficiently adapted to meet the needs of specific limited regions.

20/. In fairness, though, it should be added that owing to the increasing scale of production of agricultural machinery, even farmers in the industrialized countries are finding that their choice of equipment is becoming increasingly restricted (Donaldson and McInerney, 1973).

21/. See, for example, Khan (1976).

of work remains to be done particularly at the level of adaptive research on producing suitable recommendations as to for example new crop rotations, cultural practices and machinery suited both to limited geographical areas and to particular countries' relative resource endowment. Second it must be recognized that the ability of the typical smallholder in developing countries to absorb information is greatly hampered by the fact that he is generally illiterate[22/], although the development of local radio systems can be of great assistance in overcoming this particular problem. Shortage of qualified extension workers is another factor limiting the spread of new farming knowledge and skills[23/]. Finally it is worth repeating that the acquisition of knowledge is a two-way process and that it is essential that the raison d'etre for traditional farming practices be fully understood before any attempt is made to improve upon them.

In any development as far-reaching as a 'green revolution' problems of implementation are certain to arise. In this

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22/. Nulty (1972, Ch.3) has observed that even among relatively sophisticated farmers in the Third World, such as those of the Pakistani Punjab, the most efficient way of using modern inputs like fertilizer is not known.

23. In Ethiopia, for example, there were in 1970 an estimated 27,000 farm families for each extension worker (United Nations, 1971), which is a high figure even by African standards. The target even in Chilalo, where relatively intensive effort is taking place, is one extension worker per 1800 farmers (Goering, 1971). This compares with the figure of one graduate- or diplomate- level agricultural advisor per 200 farmers in the U.K. (Collinson, 1974), a country whose farmers obviously have a relatively high standard of professional education and where good 'backup' facilities and transportation links made the advisor's work more effective than it would be in the Third World.

particular case the initial hopes raised by early successes in producing high yielding grain varieties adapted to tropical and sub-tropical conditions and in inducing farmers to adopt them were very great indeed. It was once actually possible, for example, for one writer to observe that:

"It is difficult to remember that only a few years ago there seemed to be a very serious prospect of starvation in the poorer world, particularly in Asia"[24/]. The optimism of the early days has by now changed to a more sober, often downright sceptical, view. A host of problems, all of which tend to impede the full realization of the potential of the new seed-fertilizer technology in developing countries, has now been identified. Among the most important of those arising from the very great increase in marketed output have been marketing difficulties, and bottlenecks arising from inadequate transportation, storage and processing facilities[25/] - in fact inadequacies in those very facilities whose improvement in the temperate zones accompanied the growth in agricultural productivity during and after the agrarian revolution.

All of the above problems are in a sense extraneous to agriculture and are at least capable of solution provided that

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24/. Sir Arthur Gaitskell in the foreword to Nulty (1972); similarly optimistic views have been expressed by others, of whom one of the better known is Lester Brown (1970).

25/. A very great deal has been written on this topic. Among the most enlightening are Falcon (1970), Yudelman et al (1971) and Griffin (1974). Cleaver (1972) provides a rather extreme but very challenging view of the problems that have arisen.

governments are able and willing to devote enough of their scarce resources to them. Meanwhile, however, another and very disturbing trend has emerged, partly as a result of the above factors. Local marketing, storage and transportation bottlenecks have in many areas combined to keep crop prices low in primary markets and high in terminal markets, Large-scale farmers can bypass congested local markets and take advantage of high city prices - prices which are often maintained at high levels by inappropriate government support policies - while smallholders' incomes are squeezed simultaneously by low farm gate crop prices on the one side and the need to market at least sufficient produce to pay for purchased inputs on the other. Developing country 'agribusiness' has therefore, become both able and willing to expand by absorbing neighbouring smallholdings and tenant farms.

Accompanying this trend towards an increasing scale of operation has been a tendency towards growing mechanization of farm operations, a tendency which has been encouraged, deliberately or otherwise, by government policies producing in addition to high support prices for grain, an over-valued currency, liberal tariff policies and relatively cheap credit[26/]. Modern engine-powered machinery naturally commends itself to farmers everywhere because it is effort-saving. In many cases it also does a better job of work than traditional implements[27/].

26/. Such policies as they have been applied in a number of different countries are discussed in some detail by Barker et al (1972).

27/. Ahmed (1976) for example glosses over this fact; see also Gill (1977).

Where multiple cropping has been introduced as a result of the new seed-fertilizer technology, mechanization has been encouraged by the need for timeliness of operation, a need which becomes more difficult to meet with traditional methods as seasonal peaks become sharper.

A further consideration, very important although impossible to quantify, is the prestige factor. Historians have documented many instances in which an economically or even technically inferior new technology has replaced a superior traditional one simply because the former conferred more prestige[28/]. In Ethiopia, as in other developing countries, the status of being a 'modern' commercialised farmer with one or more tractors and perhaps a combine harvester came increasingly to outshine that of being a semi-feudal overlord of a large number of traditional sharecroppers[29/]. This consideration can operate on a national level also and there is no reason to believe that the abolition of landlordism and the expropriation of large private farms, which occurred in Ethiopia under the 1975 land reform proclamation, will do anything to diminish the prestige of modern engine-powered farm equipment in the eyes of the decision-makers.

28/. Many very illuminating examples have been provided by White (1974).

29/. See for example Ellis (1972, Ch.V1).

The scale of operations by itself, however, has provided one of the most compelling reasons for mechanization. While improved seed and fertilizer are essentially neutral to scale, increasing returns to scale obtain in the case of farm machinery. This is obviously the case where a very large estate using large numbers of machines enjoys the usual advantages deriving from bult buying of machines, fuel, lubricants and spares and the provision of specialist 'back-up' facilities, but even farms with only one or two machines enjoy advantages of scale for at least two reasons. The first is that it is uneconomic to use heavy machinery on small fields. Kline et al (1969) suggest that a standard utility type four-wheel tractor of 50-65 horsepower cannot be operated economically on plots of less than two hectares. This is larger than the total area farmed by the typical peasant in a developing country. Peasant farms, are, moreover, usually fragmented, so that field sizes are normally smaller than total farm sizes. Scale economies also apply as machine capacity is increased. Thus as a general rule both fixed and operating costs per unit of horsepower decline with increasing machine capacity. Scale of operation must, however also increase if this potential is to be realised. For example, again according to calculations by Kline et al, in African conditions a 110 h.p. crawler tractor requires for economic operation fields of at least twenty hectares. The same general arguments apply to other large machines such as combine harvesters.

The second scale advantage of farm mechanization concerns economies in supervisory costs, since the problems of organising and supervising a workforce tend to increase in proportion to its size. Thus those with larger holdings find it much easier effectively to control the activities of a few tractor and combine operators than those of a large number of labourers less elaborately equipped. This factor is for many large scale farmers the most crucial one in determining whether or not to use heavy agricultural machinery. In fact it is arguable that it was the development of suitable machinery that led to the creation of large scale arable farming rather than the reverse[30/].

Croon (1974 pp.28-29) in a survey of Chilalo which was conducted shorly before the recent land reform procolamation, reported finding that large-scale farms (360 to 1700 hectares) in his sample had capital-labour ratios approaching those found in the U.S.A. The owners of these farms were unanimous in their agreement that even if it would have been 'cheaper' to employ more labour and less capital they would not have been prepared to do so because of the organizational difficulties involved.

In view of the practical importance of this point insofar as it affects the motivation for farm machinzation and therefore labour displacement, and in view of the fact that is is not nearly as widely recognized as might be expected[31/], it will be worth

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30/. This argument is put convincingly by Donaldson and McInerney (1973).

31/. Ahmed (1976), for example, produces a list of reasons for farm mechanization without even mentioning this point.

exploring the argument a little further by examining its theoretical basis. David (1966, pp.9-20) has provided an analytical approach which can be adapted to suit the needs of this discussion.

Consider the case of a farmer who has a given size of holding and has to choose between two alternative ways of performing a certain farm operation, one using a relatively high input of hired labour with simple equipment, the other a mechanized technique using relatively more capital and less labour. Figure 1.3 shows a comparison of hypothetical cost curves for the labour-intensive method (Cl-Cl) and the mechanized method (Cm-Cm)[32]. Both methods include some element of fixed costs, so that initially cost per unit area declines with increasing acreage. Fixed costs are of course higher with the machine method, so that average costs with this method are the higher initially but continue to decline after Cl-Cl has begun to rise. The reason that unit costs begin to rise is the limitation on the farmer's capacity to organize and supervise labour, a constraint which will obviously begin to be felt at a lower acreage with the more labour-intensive method. Thus there is a 'threshold' size of farm (St in Fig. 1.3) below which the labour-intensive method is least-cost but above which this is replaced by the mechanized technique. In this diagram each method is shown as incurring the same average cost per unit area at its particular low (Sl and Sm respectively)

32/. It is assumed for the moment that output per unit area is the same for both techniques. Later it will be shown that in fact yields tend to correlate negatively with farm size, at least in developing countries.

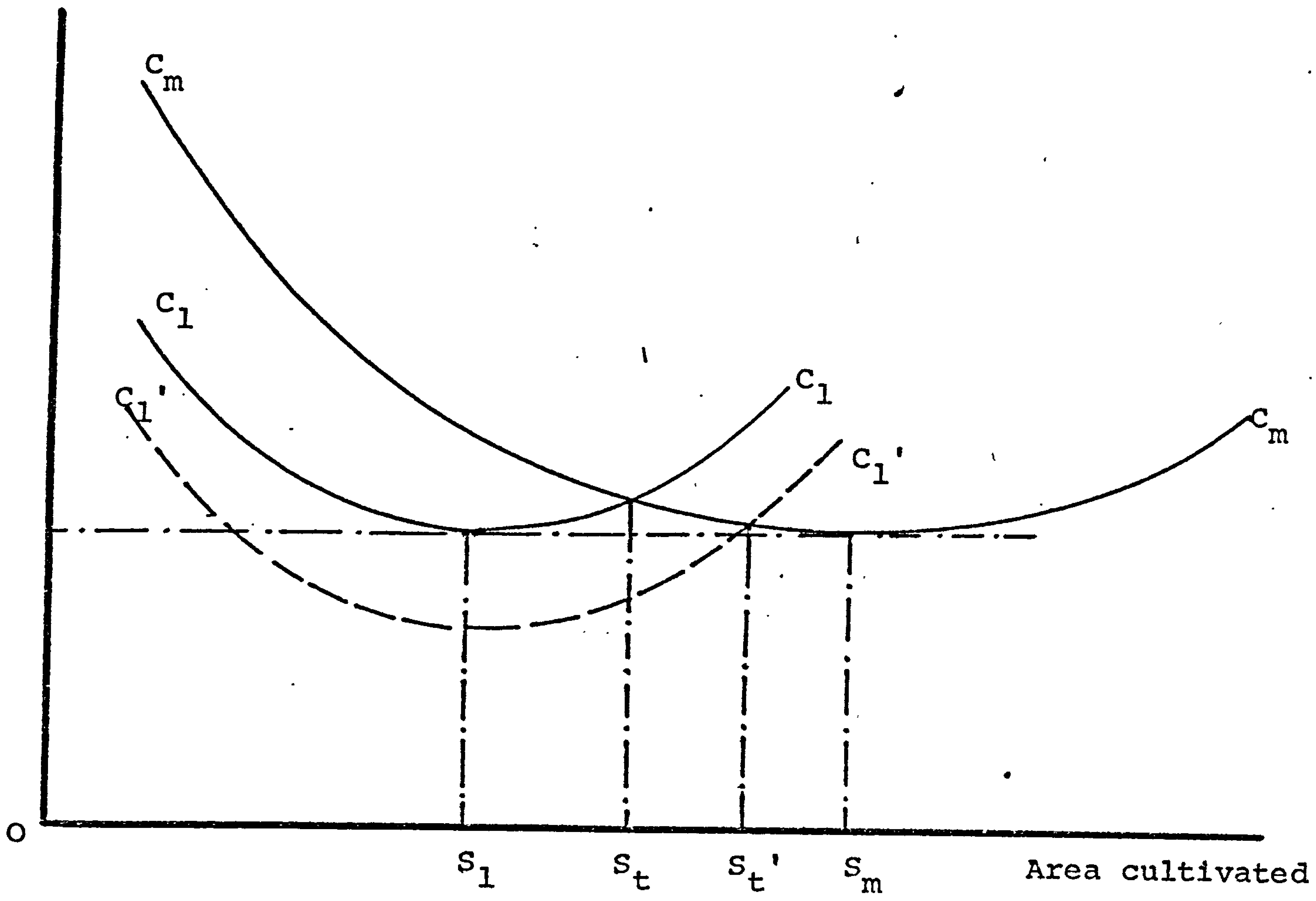

FIGURE 1.3: HYPOTHETICAL LONG-RUN AVERAGE COST CURVES

but there is of course no reason, why this need be so. It is at least theoretically possible that there could exist a labour-intensive technique (with cost curve Cl'-Cl') whose lowest point was below that of the machine method without altering the fact that the large scale farmer with limited supervisory capacity would find the machine method the least-cost technique.

The above discussion implies that farm mechanization maximises returns to management skills and of course other labour. There is no clear empirical evidence that mechanization as such maximises returns to other factors of production. In fact the available evidence from many developing countries suggests that where there is equal application per unit area of factors which are neutral to scale, the smaller, unmechanized (or less mechanized) farming system tends to yield higher returns per unit input of such scarce resources as capital, foreign exchange and, perhaps surprisingly, land[33/]. The main reasons for the higher yield per unit area appears to be the higher level of labour input on family farms and the fact that family labour is largely 'self supervised'. In addition many of the theoretical advantages, in terms of cultivation standards and potential to increase yields, of farm machinery are lost in practice in developing countries because of the

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33/. This is obviously not always the case, but there is an impressive array of evidence to show both that mechanisation as such does not increase yields and that in developing countries, at least in Asia, yields tend to be higher on smaller farms. See among others Sen (1962, Appendix A), Clayton (1972), Spencer and Byerlee (1976) Barker et al (1972), Griffin (1974, Ch.2), Raj (1972), Yudelman et al (1971) and Perrin and Winkelman (1976).

inappropriateness of machines and implements (see Ahmed 1976). Perhaps even more important, especially in Africa it would seem, is the inappropriate way in which equipment is often used. Poor training of operators, inefficient scheduling, ill-prepared land and low standards of care and maintenance[34/], all contribute to frequent machinery breakdowns often at critical periods when timeliness of operation is crucial to the achievement of high yields.

There is broad agreement that the 'green revolution', where it has encouraged extensive farm mechanisation, has led to increased unemployment, increased urban drift and increasingly skewed income distribution[35/]. In other words it has been responsible for the precise opposite of the desirable developments in employment which were outlined at the beginning of this chapter. Evidence is available from a number of countries as to the extent of labour displacement which can follow farm mechanisation, at least where multiple cropping has not also been introduced[36/]. A man can typically

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34/. Kline et al (1969), for example, note that in African conditions tractors typically last half as long and tractor repairs cost twice as much as in Britain or the U.S. See also Clayton (1972).

35/. On the employment effects see for example Gotsch (1974), Clayton (1974), Barnett (1974) and ILO (1973). On income, distribution see especially Griffin (1974, Ch.3). In one case at least there is evidence that the 'green revolution' in the absence of gross disparities in the level of farm mechanisation apparently led to a reduction in income inequality. (Raju, 1976).

36/. Where multiple cropping has been introduced the net employment effects of mechanisation may not be negative as new employment opportunities replace old ones (See Griffin, 1974, Ch.3, Barker et al, 1972, and Nulty, 1972, Ch. 6 for examples). Multiple cropping has not however generally resulted from the 'green revolution' in Africa because of climatic factors.

develop in the region of ¼ horsepower, so that a 50 h.p. tractor can in theory replace 200 men engaged in manual cultivation. At a more empircal level Griffin (1974 Ch.3) quotes evidence from the Punjab (based on an admittedly small sample) that an investment of Rs 240 per acre enables a farmer to dispense with 52 man-hours of employment per acre under wheat. He also notes that the introduction of a four-wheel tractor releases an average 613 man-days in Thailand and 907 in Malaysia while that of a two-wheel tractor, again in Malaysia, releases only sixty man-days. Abercrombie (1972) shows from Latin American data that a tractor releases the labour of five or six horses which is perhaps equivalent to displacing two or three men for every tractor driver employed. The same author provides evidence from Colombia that the modernisation of traditional agriculture would increase labour input per unit area by 45 percent without mechanisation and reduce it by 34 percent with mechanisation (quoted by Marsden, 1973, p.8).

Some commentators evidently see the above process as the inescapable price of agricultural modernisation, while others seem totally opposed to mechanisation as such[37/]. A more generally-accepted view widely expressed in the recent literature and based on the acceptance of the arguments against indiscriminate farm mechanisation and the wholesale replacement

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37/. Owen (1970) and Ahmed (1976) respectively provide good examples of these extreme viewpoints.

of smallholders, is to recognise that when the new seed-fertilizer technology has made multiple cropping possible, seasonal peaks in energy demands become very much more pronounced, so that selective mechanization is necessary in order at least to ease these new bottlenecks[38/]. This selective process, which need not be identified with the latest capital-intensive techniques even in the most crucial bottleneck processes, can bring about an increase in labour productivity without causing labour displacement. It should however be remembered that the aim of employment policy nowadays tends to be to increase the potential of the agricultural sector to provide productive employment, rather than simply to maintain it.

In areas where weather patterns are not suitable and irrigation is not feasible (and as was noted earlier this is generally speaking the case in sub-Saharan Africa) the new seed-fertilizer technology has not led to multiple cropping, so that any increase in land productivity is attributable to increased yields alone. In this situation it is sometimes assumed that the introduction of fertilizer and new high-yielding varieties will make little difference to the seasonal labour demands associated with a particular crop enterprise[39/].

38/. See among others, Barker et al (1972) Singh and Day (1975) and Stout and Downing (1976).

39/. Simpson (1974), for example, has asserted that the use of fertilizer creates little extra work apart from the scattering of the fertilizer itself and 'possibly' some additional harvesting.

This is an important point, since as was noted earlier, there is now a fairly wide measure of agreement that traditional farming in developing countries has, through a process of trial-and-error by many generations of farmers operating within a relatively static technological environment, selected from the available crop and livestock enterprises combinations which will, insofar as seasonal factors will permit, allow them to match the competing demands of such enterprises to supplies of the farm's energy resources[40/]. If it is true that seasonal labour requirements are not affected by the introduction of improved seed and/or fertilizer, then the traditional compromise will be maintained and there is no additional case to be made for selective mechanization as a result of the new inputs.

There is, however, good reason to question this view a priori, as will be made clear from the following examples. (a) Fertilizer must be transported to the fields, spread and incorporated with the soil during the busy period of land preparation. (b) The use of fertilizer tends to encourage weed growth - increasingly so the later the crop is sown after the onset of the rains. (c) Short-strawed wheat varieties (which have been bred for higher yields, fast maturation, resistance to 'lodging' and high grain-to-straw ratios) find difficulty in competing with weeds for nutrients and

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40/. Some writers, following Schultz (1964), go so far as to assert that at least as an approximation, on many peasant holdings the marginal value products of resources are equal in competing enterprises and equal to their marginal costs. These arguments have been well summarized by Mellor (1969).

sunlight and therefore respond greatly to extra-careful seedbed preparation and early sowing (two requirements which are themselves difficult to reconcile) and repeated intensive weeding. (d) The shorter the straw the more difficult it is to reap with a sickle. (e) The case of threshing is an especially interesting one, since it is most probable that traditional varieties of grain have over the centuries been selected naturally through a quasi-Darwinian process for ease of threshing by whatever traditional method is in use.[41/]. The newer high-yielding varieties are very often more difficult to thresh by traditional methods, partly because they have not been bred with this characteristic specifically in view, so that threshing these new varieties demands more time and effort unless a higher proportion of the grain is to remain with the straw. (f) Finally, higher yields by themselves impose additional burdens during the harvest and throughout the various post-harvest operations simply because of the greater volume of material to be handled.

41/. This process would operate as follows. Suppose a farmer starts operation with a seed stock comprising a mixture of several varieties of the same grain, some of which are more threshing-resistant than others. Assuming all other things to be equal, his harvest will contain the same proportions as the initial seed stock, but in threshing, the heads which remain unthreshed will, by definition, contain a relatively high proportion of the threshing-resistant strains, so that the grain from which the new seed stock is drawn will contain a higher proportion of the other varieties than previously. This process could continue in successive years until only relatively easily threshed grain remained in the seed stock. (I am grateful to Drs. Kirkwood and Burge of the Department of Biology, University of Stranthclyde, for confirming the plausibility of this hypothesis.)

It is therefore quite likely that existing seasonal peak periods in energy requirements will be exaggerated and traditional balances disturbed by the introduction of fertilizer and improved seed, even without multiple cropping. Thus selective mechanization (using the term in its widest possible sense) may be desirable in order to eliminate bottlenecks and thus help realize the full productive potential of the new inputs. The questions which remain to be answered concern the identification of processes which have become bottlenecks or in which existing constraints have become intensified, and how these constrictions may best be eased if not entirely eliminated. M.P. Collinson has pointed out in this regard that "the surge of interest in intermediate technology has appropriately stressed the need to get away from advances ideas of machinery. It has, however, faltered by touting machines rather than diagnosing problems and devising mechanical techniques as a solution" (1972, p.64). The study which provides the empirical content of the present work was undertaken in an attempt, in one area of one developing country, to diagnose problems as a first step towards finding appropriate solutions.

CHAPTER 2 BACKGROUND TO THE STUDY

2.1 AGRICULTURE IN THE ETHIOPIAN ECONOMY[1/]:

Ethiopia had at one time the reputation of being an extremely fertile country, and travellers' reports from the time of Marco Polo until the eighteenth century often compared it favourably with contemporary Europe in this respect.[2/] Whether or not this reputation was justified, Ethiopian agriculture is certainly in some ways unique, and several crops which are extensively cultivated there are seldom encountered elsewhere. These include <u>teff</u>[3/], <u>enset</u>,[4/] or false banana, <u>chat</u>[5/] and <u>gesho</u>,[6/] while arabica coffee is believed by many botanists to have originated in the forests of Kaffa where it is still to be found growing wild today. Botanical studies have in fact shown that the region comprises one of the eight geographical 'centres of origin' of the world's cultivated plants, possessing rich concentrations of certain plant genes, notably wheat and barley.[7/] Ethiopia's

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1/. The standard reference work on agriculture in Ethiopia is still Huffnagel (1961), although this information is by now becoming a little dated. Some more recent studies are SRI (1969), Westphal (1975) and those brought together by Gill (1974, pp.29-113).

2/. See Pankhurst (1961, Ch.1).

3/. Eragrostis tef: A very small grain used to make an unleaven bread (enjera).

4/. Ensete edulis; The pseudostem and root provides a starchy staple in southern areas.

5/. Catha edulis: A shrub whose leaves are chewed for their narcotic effects.

6/. Rhamnus prinoides: A shrub whose leaves are used to flavour beer (and mead) as hops are used in Europe.

7/. This was chiefly the work of the Russian botanist N.L.Vavilov, who pioneered work in this field in the 1920's. He listed the eight centres in the following order; (i) India; (ii) China; (iii)Central Asia; (iv) the Near East; (v) the Mediterranean region; (vi) Ethipia (vii) South Mexico and Central America (viii)South America.

traditional agricultural technology is more advanced than that of most of sub-Saharan Africa; plough cultivation is widespread and there exist irrigation works and man-made terraces of some antiquity. Until quite recently, however, the country was completely bypassed by modern advances in farming techniques.

Even more than most developing countries, Ethiopia's economy is dominated by agriculture. This sector, employs an estimated 80 to 85 percent of the total economically active population and contributes around half of the national income[8/] - although this proportion has been declining with the growth of the non-farm sector. The share of agricultural produce in total exports, although also gradually declining (Table 2.1)

Table 2.1: SHARE OF AGRICULTURAL PRODUCE IN ETHIOPIAN EXPORTS, 1964 - 74

AGRICULTURAL EXPORTS	1964	1974	AVERAGE ANNUAL RATE OF GROWTH[a/] (percent)
EthS million at current prices	257.1	491.0	8.3
EthS million at 1964 prices	257.1	364.8	3.9
Percentage of total exports	99.2	89.7	-0.9

a/ These figures have been calculated from the appropriate exponential trend equation. Values for intervening years, although not shown in the tables, were used in the trend calculation.

Source: Computed from the National Bank of Ethiopia QUARTERLY BULLETIN (various issues).

8/. Available estimates of total agricultural production are subject to wide margins of error (see Gill 1977a), so that it would be rash to attempt to be very precise here.

is still overwhelming, even when compared with most of the other agriculturally-dominated countries in eastern Africa (Table 2.2). Ethiopian agriculture is still mainly subsistence-oriented although commercialisation (both in the sense of the establishment of modern estimates and in the sense of a gradual shift towards market-orientation in the traditional sector) has made steady advances in the past few decades. Within the subsistence sector, however, the rate of growth of output is

TABLE 2.2 PERCENTAGE SHARE OF AGRICULTURAL PRODUCE IN TOTAL MERCHANDISE EXPORTS FOR SELECTED EAST AFRICAN COUNTRIES (1969 - 74)

COUNTRY	PER CENT	COUNTRY	PER CENT
Ethiopia	93.6	Somalia	92.8
Kenya	58.0	Tanzania	72.9
Madagascar	79.0	Uganda[a]	85.6
Malawi	88.7	(United Kingdom	7.7)

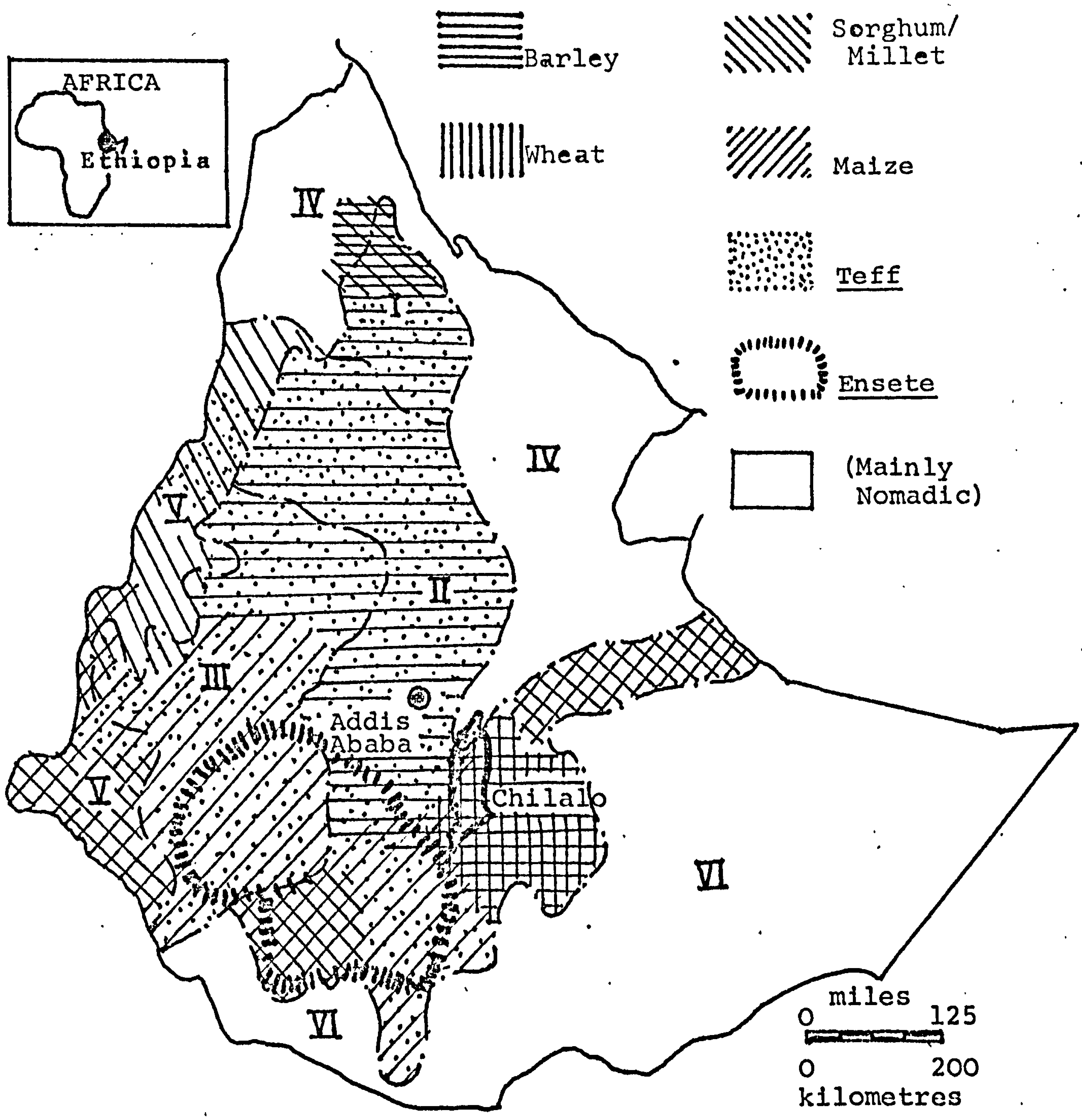
a/ 1967-72. Source: Computed from FAO (1976).

almost certainly no greater than that of population, and in some areas such as the northern part of the Central Highlands, where soil exhaustion and soil erosion[9] can be serious problems, the average rate of growth of production is almost certainly less than that of population, as recent tragic famines have testified.

9/. Mesfin (1973) quotes figures to suggest that half of Ethiopia's crop land loses upwards of 2,000 tons of topsoil per square kilometre per annum. These figures, although conceivable at least in the short term, are certainly very high and probably rather alarmist.

Ethiopia is, however, a land of enormous geographical and climatic variation and it is very difficult to generalize from experiences in one area.

Basically the country's 1.2 million square kilometres are divided more or less equally between a central highland mass, which is split diagonally by the Rift Valley, and the surrounding lowland region of savanna and desert - the highlands in this context being defined as lands above the 1500 metre contour (See Map 2.1). Thus across the country there is enormous diversity in altitude, topography and geology, which is accompanied by a corresponding variation in climate, soil type and natural vegetation. The rainfall regime for example, ranges from the ten month wet season zone of the south-west highlands to the arid desert of the Danakil depression and parts of the Ogaden, and natural vegetation varies from lush rain forest to desert scrub. Generally speaking, for a given altitude rainfall tends to be much higher in the south and west of the country than in the north and east, although a major problem in all areas outside the southwestern highlands is the seasonality of rainfall which, as was shown in the previous chapter, often limits the potential for agricultural development. Soil fertility too is generally significantly higher in the south: many of the soils of the southwestern highlands for example possess excellent inherent fertility, while in many northern areas the land is typically stony and badly eroded.



AGRICULTURAL ZONES: I Northern Highlands; II Central & Southern Highlands; III Western Highlands; IV Northern & Eastern Lowlands; V Western Lowlands; VI Southern Lowlands.

MAP 2.1: ETHIOPIA: MAJOR FOODCROP ECONOMIES AND AGRICULTURAL ZONES

Sources: Adapted from (i) Unpublished IBRD Report of 1973; (ii) CSO (1975); (iii) SRI (1969); (iv) Mesfin (1970).

Ethiopia's land base is quite adequate to support her population at a consistently higher level than today's given appropriate measures to conserve resources and improve productivity. The exceptional ranges in altitude and climate make it possible to produce a wide range of both tropical and temperate crops and some of the river basins have very favourable potential for irrigated farming. The country as a whole (and Chilalo District in particular) is also geographically well-placed to serve the food-deficit markets of the Middle East. At the moment one of the more serious agricultural problems is the degree of soil erosion, particularly in northern areas, although expert opinion differs sharply as to the extensiveness, magnitude and causes of this.[10/]. To the extent that erosion is man-made, it has resulted from defective agricultural practices such as the cultivation of steep hillsides, ploughing with the slope and the trekking of livestock which destroys the grass cover of the land. Such practices expose the topsoil to removal by wind and rain and also impair the water-retaining capacity of the land, so that rain falling on exposed hillsides - or even on fairly gentle slopes - quickly runs off carrying top-soil with it (sheet erosion). This water gathers speed as it travels downhill, forming swift-flowing streams which in turn contribute seriously to gully erosion. Not only is irreplaceable top-soil removed in this way, but streams which were once clear and perennial can be turned into raging muddy torrents which dry up after only a few months, thus aggravating the problem of water shortages during the dry season.

10/. See for example, Brown (1973) and Watson et al (1973) which advance sharply confliding views on this subject.

2.2 CHILALO DISTRICT[11/]

Chilalo is rather better favoured than many other parts of the country. In most parts of the District soils are reasonably fertile and rainfall adequate if highly seasonal. The area is also well placed to serve the Addis Ababa market and is close to the road and railway which link the Ethiopian highlands with the Red Sea (See Map 2.1). The District comprises an area of just over 10,000 square kilometres (4,000 sq. miles), measuring approximately 160 kilometres (100 miles) from north to south and 60 km from east to west. The northern boundary of Chilalo is situated about 120 km by road from Addis Ababa, and the district capital, Asella, 55 km further south, is connected by an excellent all-weather road to the capital. All of Chilalo lies in the Southern part of the Central Highlands, but as can be seen from Map 2.1, the north-western edge of the District lies on the very edge of the escarpment (of the Rift Valley). Within Chilalo there are great ranges in altitude, and farming is practiced at elevations ranging from 1600 to 3000 metres (5,250 to nearly 10,000 feet) above sea level.

Of Chilalo's estimated 400,000 population only five or six percent live in towns, while a similar percentage could be described as 'rural, non-agricultural' (traders, craftsmen, priests, etc.). Of the agricultural population an estimated eighty-two percent are engaged in settled farming, the remainder being for the most part semi-nomadic pastoralists. The familiar

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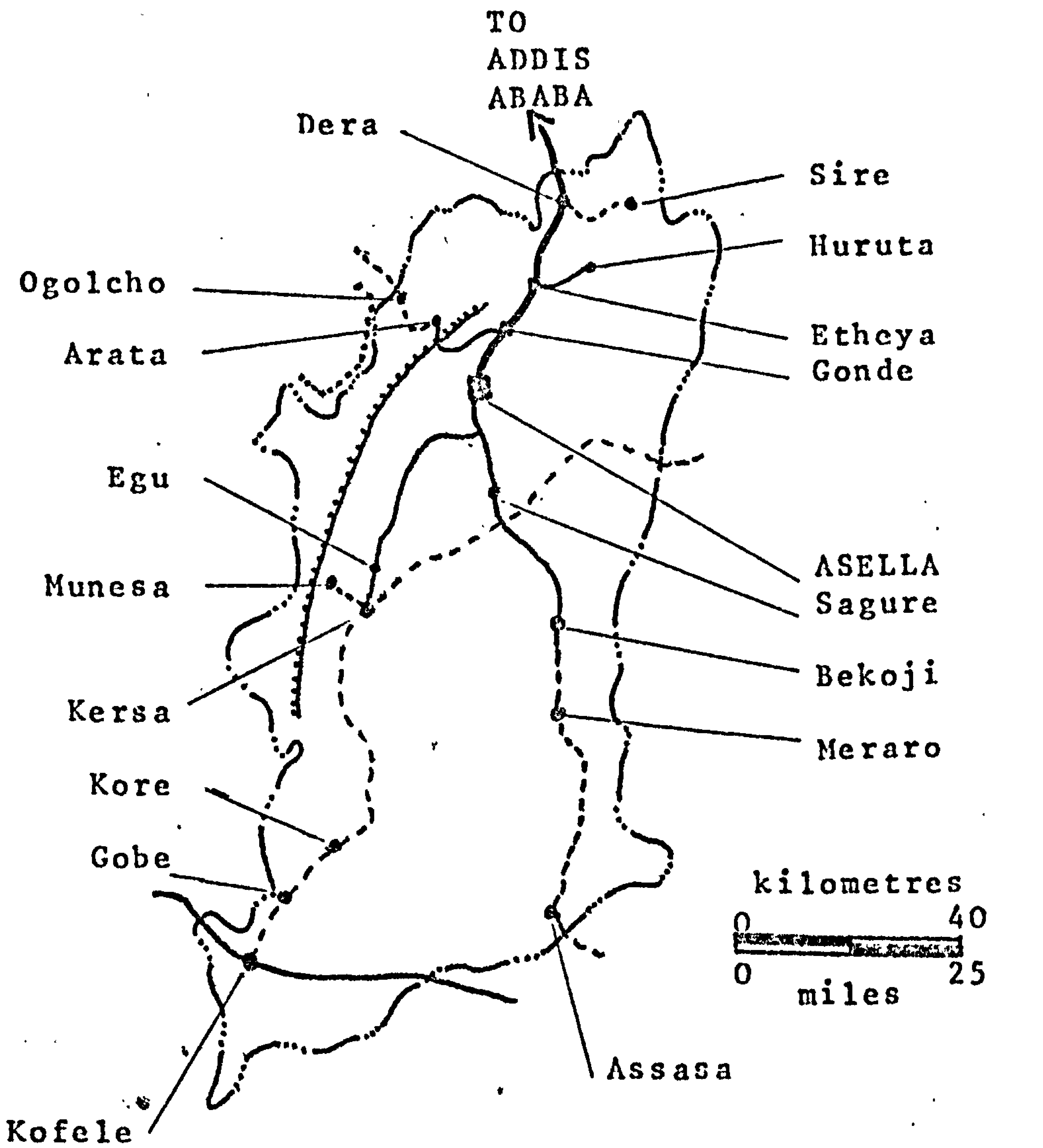
11/. Most of the statistics on Chilalo in this section are derived from Cohen (1974, 1975) and CADU (1971).



All-Weather Road (Bitumen)
All-Weather Road (Gravel)
Dry-Weather Trail
District Boundary
Escarpment (Rift Valley to North-West)
Lake Shore (Lake Zwai)

MAP 2.2: CHILALO DISTRICT: COMMUNICATIONS AND PRINCIPAL TOWNS AND VILLAGES

Source: Adapted from Cohen (1974, p602).

signs of poverty are to be seen in the Chilalo countryside: inadequate health and educational facilities, a poorly developed infrastructure, low levels of literacy and so on. However the rural population, although poor, certainly appears to be better nourished, clothed and housed than is the case in many northern parts of Ethiopia.

The total cultivated area of the District has been estimated to be between 175 and 200 thousand hectares (430-500 thousand acres) which is seventeen to twenty percent of the total surface area. Average cultivated area per farm is though to be around four hectares, but the typical smallholding is probably much closer to three hectares. Even so, this is very much larger than the average for the country as a whole: a number of independent surveys suggest that perhaps two-thirds of Ethiopian peasants farm less than two hectares[12/]. The principal foodgrains of Chilalo are wheat and barley in the higher elevations and maize, sorghum and teff at lower altitudes. Other traditional crops are limited, flax, field peas, horse beans, haricots, rapeseed and lentil.

2.3 THE TRADITIONAL FARM TECHNOLOGY OF CHILALO

This undoubtedly seems primitive by today's standards. The seedbed is prepared with an ox-drawn ard, a breaking plough which simply digs a rut in the soil, unlike the disc and mould-board

12/. The most recent and geographically comprehensive of these are CSO (1975) and Ministry of Agriculture (1975).

ploughs familiar in the temperate zones which invert it. Traditionally in many parts of the District, after the first ploughing the topsoil and crop residues are gathered into mounds which are then set on fire[13/]. This has the advantage of destroying weeds, weed seeds and crop pests and also increases the phosphate content of the soil, but at the expense of reducing its content of both nitrogen and humus. The ashes are later scattered over the land and ploughed in. The number of ploughings depends on the crop to be grown; each successive ploughing is directed across the previous furrows so as to break up large clods and produce as fine a tilth as possible. Drainage 'ditches' are often ploughed diagonally across the fields. The use of manure is unusual except on small garden plots of vegetables and spices and sometimes on maize, which requires a quite fertile soil.

The traditional method of sowing is to broadcast the seed by hand. It is then covered in a final pass with the plough. Weeding, when it is done at all, is by plough or by hoe in the case of tall-growing crops like maize, or by hand in the case of shorter crops. Handweeding is generally a family affair with even small children contributing to the work.

The universal reaping tool for small grains such as wheat and barley is the sickle. The crops are transported to the threshing area by pack animal or on crude ox-drawn sleds and they are threshed by oxen and other livestock trampling them

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13/. The same practice could be observed in England, where it was known as 'Devenfiring', as recently as the late nineteenth century, but it was discontinued as inorganic fertilizers became increasingly available. The present survey suggests that the process of abandoning soil-burning is now underway in Chilalo, as will be shown later.

on a hand-packed earth-and-cowdung threshing floor. From time to time the heap of produce is turned over with wooden pitch-forks so as to expose fresh grain on the surface. The threshed product is then winnowed by being thrown into the wind to separate grain from chaff. Large wooden 'paddles' or shovels are used for this purpose. Crops which are not sold immediately are stored in thatched clay-lined storage bins made of straw and mud packed between wooden slats, which stand on stilts as a protection against rodents. Crops which are marketed are transported by pack animal.

The above technology may be criticised on the grounds that it requires arduous labour, and therefore tends to increase the relative unattractiveness of farming as an occupation, or alternatively (or additionally) that it impairs farm productivity[14/]. Productivity may be inhibited either through factors which prevent plant growth from reaching its full potential (pre-harvest factors) or those which result in wastage of produce (harvesting and post-harvest factors). The question of arduousness is one which is probably best answered by the farmers themselves and will therefore be dealt with later. On the question of productivity, however, a number of observations can be made at this stage.

14/.. These two facets of traditional technology are of course interrelated. In the case of a very arduous task, which will often mean one in which timeliness is crucial, limitations on the supply of labour may mean that it can be applied only up to a point at which its marginal productivity is still relatively high.

It has become a common practice to divide modern agricultural technology into those components which are 'labour augmenting' and those which are 'labour displacing' ('landesque' or 'labouresque' in Sen's (1966, Ap. A) picturesque terminology). Thus fertilizer and improved seed, for example, enter the production function as complements of, rather than as substitutes for, energy inputs and therefore do not by themselves cause labour displacement. Indeed the opposite is more likely to be the case. In the case of mechanical innovations[15/], on the other hand, it is too simplistic to dismiss these as 'labour displacing'. That they can be and have been so is irrefutable, but they can also, paradoxically, be labour augmenting, at least to the extent that labour-saving innovations introduced in the 'peak period' can augment the demand for labour at other times of the year[16/]. More to the point, mechanical innovations can be labour augmenting insofar as they improve cultivation standards and consequently result in higher, output and improved labour productivity. This issue is worth pursuing more closely in the specific context of traditional farm practices in Chilalo.

The traditional ard ploughs to a depth of only five to ten centimetres (2-4 inches), whereas periodic ploughing to at

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15/. Again it must be stressed that 'mechanical innovation' need not necessarily (and this last word also deserves emphasis) imply engine power.

16/. The introduction of machinery which permits realization of a new HYV's potential for multiple cropping is one example and one which is widely recognised as such. Other examples are the introduction of tractors which make it possible to bring under cultivation land which was previously reserved for grazing workstock. In areas where land is not scarce, the introduction of ox-ploughing to replace hoe cultivation would also make it possible to bring more land into cultivation.

least twenty centimetres is desirable in many soils to achieve efficient soil aeration and the mixing in of organic matter. It is also impossible, using only the traditional technology, to perform a number of other operations, such as subsoiling, the turning in of a green manure crop and the tillage of very dry land before the onset of the rains. The practice of soil burning, as was noted earlier, can be a cause of infertility where nitrogen content is low. Broadcasting is an inefficient method of sowing seed: it results in uneven crop stands and precludes mechanical weeding in most cases. This problem is intensified moreover by the state of the farmers' seed, which is not chemically treated and is sometimes contaminated with weed seeds. Seed-covering by plough is another source of loss, since some seeds are covered too deeply and some too thinly, with the result that germination rates are lower, and/or seeding rates higher, than they might otherwise be.

Traditional technology also results in problems of wastage. Reaping with sickle is arduous and slow, so that some grain can be lost through depredation by animals (or humans), 'shattering' or spoilage by rain before the harvest is complete. Threshing by trampling is also slow and results in high losses, partly because the grain becomes trampled into the threshing floor and partly because the oxen eat it. Threshing in this way also produces a rather contaminated product and is thought to be injurious to the health of the oxen which are forced to work hard at a time in the dry season when they are in poor physical condition (Kline et al, 1969).

Transportation by pack animal is another apparent example of inefficiency, since an animal can put twice as much on a cart as it can carry on its back. Replacement of pack animals by wheeled vehicles would therefore release grazing land for cultivation or for the raising of slaughter stock. Traditional storage methods have also met with criticism on the grounds that they leave the crop open to spoilage by rodents, insects and the weather.

Evidence as to the extent of production losses - either of potential yield or through wastage - arising from indigenous cultivation and post-harvest practices in Chilalo is fragmentary. The studies which do exist are, however, mostly mutually supportive and indicate that there are in some cases quite considerable losses. One important cause of lost yield potential arises from weed infestation of fields, a problem which can be extremely serious, as can be seen from Table 2.3. Controlled experiments in agricultural research stations in Chilalo have demonstrated that wheat yields can be increased on average by 37 percent by handweeding (CADU, 1975) all other things being equal. In absolute terms the mean yield gain to one handweeding was 5.8 quintals per hectare (9.4 bushels per acre)[17/] which would be

TABLE 2.3 WEED INFESTATION OF FARMERS' FIELDS IN CHILALO

CROP	Mean No. of CROP plants per sq.metre	Mean No. of WEED plants per sq.metre	Weeds per crop plant
Wheat	149	743	5
Barley	149	465	3
Maize	25	705	28
Beans	27	898	33
Peas	43	688	16

Source: Bengtsson (1968).

17/. The evidence from these trials also shows that handweeding increases the protein content of wheat by an average 2.5 percent.

worth Eth$ 1.38 per hectare at the then current market price[18/]. Unfortunately no figures are available from these trials concerning time required for weeding, but reports of local farmers derived from the present study suggest 20 man-days per hectare to be a reasonable figure, so that the average and marginal physical product of labour for weeding in these circumstances is around 30 kg. of wheat per man-day and the average and marginal value product Eth$ 7.00 per man-day[19/]. This compares with a local modal agricultural wage rate of Eth.$ 1.50 (6.5 kg. of wheat) per day.

It must be remembered, moreover, that in experimental trials of the type reported above, cultural practices other than that which is under investigation are likely to be of a much higher standard than can be achieved by traditional methods. Tractor cultivation will probably have done a better job of eliminating weeds in the seedbed and the use of clean certified seed will have ensured that the seed is free from weed contamination. Thus, especially if fertilizer is used, weed contamination is likely to be a greater problem, and the returns

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18/. Prices are based on unpublished CADU figures. The then current offical exchange rate was US $1 = 2.07. Eth $.

19/. This equality derives from the way in which farmers weed their land, which is to start at the edge of the field and move across it, weeding each patch before moving on the the next. Thus over the relevant range of the production function output per unit area is a linear function of the number of labour days devoted to weeding and constant returns obtain. Average and marginal products are therefore equal for a given weeding. However, as will be shown later, Chilalo farmers, or at least those in the present sample, weed wheat more than once, and it can be assumed that the marginal product of each successive weeding will tend to diminish. The marginal product per man-day of labour in the last weeding should therefore approximate more closely to the local modal day wage.

to weeding are in consequence likely to be higher, in the farmers' fields than in experimental plots.

In the case of post-harvest operations, some eivdence is available concerning losses during threshing and storage. In the former case Kline et al (1969), using data supplied by CADU[20/], report that traditional methods cause losses of only 0.1 to 0.2 percent through broken kernels (compared with around two percent losses from this factor in mechanical threshing), but that the former method results in as much as 30 to 35 percent of the grain not being recovered from the threshing floor. A CADU publication of the same year does not, unfortunately, include figures for grain lost through being trampled into the threshing floor but, does indicate that ten percent of grain is not recovered owing to improper and incomplete treading and that an additional 3 to 4 percent is eaten by the oxen (approximately 5 kg. per ox). It would, however, be a questionable practice to describe grain eaten by the oxen as 'wastage' rather than as a variable cost of production. Even unthreshed grain is not entirely lost, since the straw is often fed to livestock.

Crop storage is one area in which estimates of losses vary quite widely. One possible source of confusion concerns the question as to whether reported losses relate only to produce which has been stored throughout a relatively long period or to

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20/. The Chilalo Agricultural Development Unit; more information on this organization is provided later in the chapter.

average losses over a period during which produce is continually being withdrawn for consumption. Obviously the former figure will exaggerate the average. Thus the study by Kline et al (1969) suggests losses after six months storage of 30 to 50 percent in addition to losses caused by rodents, while Green, one of the co-authors of that study and presumably basing his results on the same data, uses a figure of ten percent for average losses in his model of Chilalo smallholding (1974, p.41). The Stanford Study (SRI, 1969) rejected as too high estimates of 50 percent storage losses and 'tentatively' concluded that "losses.... are small enough for farmers to consider them a minor problem." Two CADU studies provide empirical support for this latter view. A recent study (CADU, 1975, pp.150-51) of losses to insect damage after five to eight months storage showed that these amounted in most cases to less than one percent and in no case to more than 2.7 percent. An earlier study by the Implements Research Section (CADU, 1969, pp.41-50) discovered (a) no losses due to insect damage after six months

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21/. If farmers considered losses due to consumption by oxen to be a serious problem, they could, and occasionally do, muzzle them. Their failure to do so in most cases may, however, be due to religious as much as economic reasons, in view of the biblical injunction "Thou shalt not muzzle the ox when he treadeth out the corn" (Deuteronomy, XXV, 4.) Most of Chilalo's farmers are Coptic Christians.

storage, (b) that losses due to rodents averaged only one percent[22/] and (c) that moisture losses were negligible. These CADU findings, although limited in geographical coverage, do suggest that storage losses, at least in Chilalo, are not nearly as serious as is sometimes assumed.

Before any attempt is made to improve upon the traditional technology of an area like Chilalo, it is essential (if a brief restatement of a major theme of this essay is permissible) to appreciate fully the rationale behind it. A basic source of resistance to change in this regard lies in the fact that the typical farmer has over the years acquired certain implements and the skills necessary for their effective use. These implements combine a number of favourable features, and improvement upon any one of them is likely to be achieved at the expense of one or more of the others, since they, like virtually all engineering designs, reflect a set of pragmatic compromises between various technical and economic desiderata. Consider, for instance, the traditional Ethiopian plough: it is light and requires relatively little draught power; it can be made and repaired locally, as tolerances are not critical,

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22/. Rodent damage, is of course more serious than simply the percentage of grain which is eaten: the risk of infection of remaining food supplies must also be considered. The farmers, however, state that they keep cats as a measure against rodents, a precaution not apparently taken in the CADU field experiments. If rodents are really a problem, rat baffles on the existing stilts would be an inexpensive solution.

and the materials - a tree branch , some scrap iron, and a leather or rubber strap - are available almost everywhere; it is capable of performing a wide range of tasks (the equivalent of primary cultivation, harrowing, seed covering, and weeding) and, finally, it costs only four or five Ethiopian dollars. Any modern agricultural engineer faced with the above set of specifications would probably produce something very similar to the traditional Ethiopian plough! This implement has been criticized on the grounds that it "is very insufficient, since it only breaks up the surface of the soil and lacks mould-boarding properties" (Bengtsson, 1968). The implication behind such a statement is that the mouldboard plough is inherently superior to the traditional implement, but this is not necessarily true, even from a technical viewpoint. The mouldboard plough, by inverting the soil, buries weeds and other organic matter, at once killing the weeds and increasing the organic content of the soil. However, this process leaves a bare surface which, especially in an area like Chilalo with a mainly wet growing season increases the prospect of soil erosion and water loss. The indigenous plough, on the other hand, leaves a 'trash mulch' on the surface of the field which, to some extent, counters both soil and water loss. The traditional plough also kills weeds, although not as effectively as the inverting plough, by exposing their roots to desiccation.

There are many other examples of misconceptions about the disadvantages of traditional methods. For example, it is sometimes assumed that the farmer must await a favourable wind before he can winnow his grain and that this can delay the start of cultivation for the next crop year (CADU 1969). CADU has in fact developed its full-cleaning thresher instead of a much lighter and cheaper noncleaning version, mainly on this premise. It is, however, quite possible to winnow on a windless day, because of the different aerodynamic characteristics of grain and chaff. The farmer tends to wait for a wind because it makes his task easier. Traditional storage methods provide another example of this type of misconception. Storage losses under the conditions described above are often thought to be high because of 'sprouting' In fact, grain which begins to sprout is consumed immediately by the farm family rather than discarded (SRI, 1969). A third example has been provided by Ellis (1972). The sowing of seed at some biologically determined optimum date would increase yields, but it would also create severe bottlenecks in harvesting and threshing because all of the crop would ripen at the same time. Ethiopian farmers therefore deliberately stagger planting dates in order to avoid such constraints. Transportation provides yet another example. While it is generally true to say that an animal can pull twice as much as it can carry, cart transport is not possible in the roadless mountainous type of terrain which characterizes much of rural Chilalo. Even if only part of a given journey is over such country, produce must be pack-loaded for the entire trip.

Even when redesigned implements can achieve higher technical standards than traditional ones, some advantages are likely to be sacrificed. Cost is a most important factor: CADU's mould-board plough is sold for Eth. $ 40, its spike-tooth harrow for Eth $ 30 and its excart for Eth. $ 200; the cost of a multipurpose cultivator is Eth. $ 150, and that of an ox-drawn reversible mouldboard plough Eth. $ 80. It is also sometimes forgotten that new implements usually require new skills: fertilizer and improved seed may be broadcast in the traditional fashion, but a higher degree of skill and more control over the oxen are required to use a mouldboard plough than is necessary for the traditional implement. Similarly, row planting of seed requires quite different skills from those required to broadcast it. Reaping provides another example: a scythe will cut grain more than twice as fast as a sickle (if the condition of the land is suitable), but the scythe is much more difficult to use. In addition a reaper using a sickle can leave weeds standing in the field, whereas the scythe cuts all plants indiscriminately. The relative merits of sickle and scythe in fact provide an interesting further example of the possibility of substituting labour between tasks which was mentioned in the previous chapter (Section 1.3). The use of the scythe can, as was noted earlier, speed up the process of harvesting, but it cuts the crop much closer to the ground than is the case when the reaper uses a sickle, so that the scythe produces a larger volume of straw to be transported to the threshing floor and to be handled during threshing. The substitution of the scythe for the sickle therefore reduces labour requirements for reaping but increases these requirements for two other tasks.

Another factor which must be considered is that Ethiopian oxen are not particularly strong, and the new implements often place higher demands upon their strength. Finally, the effective replacement of the local plough would require a range of tools - plough, harrow, and cultivator - or a multipurpose implement like a toolbar, which would obviously increase capital costs. For example, a SISCOMA (Senegalese) 'Ariana' toolbar with six units costs the equivalent of Eth. $2,667 ex-factory. Such animal-drawn toolbars have been highly successful in certain other countries notably the Francophone countries of West Africa, but such farming systems are much further removed from subsistence orientation than Chilalo, and such implements are to be found mainly where groundnuts (peanuts) are the major cash crop[23/].

2.4 RECENT CHALLENGES TO TRADITIONAL AGRICULTURE

Traditional farming arrangements in Chilalo, have in recent years met with three successive exogenous disturbances

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23/. Kinsey (1976, pp.14-15) notes several disadvantages of using toolbars in Eastern Africa, including the fact that although this implement can perform a number of different operations it can only perform them one at a time which, given its expense and the relatively large investment required can be an important drawback where timeliness of operation is essential and where several family or hired workers are available.

each of which has been of very far-reaching importance. These were the introduction and spread of modern mechanized farming since the late 1950's, the establishment of the Chilalo Agricultural Development Unit (CADU) in 1967 and nationalization of rural land in 1975.

2.4.1 Agricultural Mechanization

Chilalo's general fertility, adequate rainfall and accessibility combine to make the District very suitable for modern, market-oriented farming with improved seed and agro-chemicals[24/]. However a landowner with more than five or six hectares of cultivable land would, for the reasons listed in Chapter 1, find it increasingly difficult the larger his holding to farm it with traditional methods and hired labour. In the past the standard solution was to rent out surplus land to other farmers on a crop-share basis. Typically the rental was one-third if the landowner supplies only land, increasing to a half share if he supplied seed and oxen also. The advent of modern farm machinery, however, made it possible for such landowners to farm large areas with a small easily-controlled labour force.

There are many large tracts of land in Chilalo which are flat and free from such obstructions as tree stumps and rocks

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24/. Estimates of costs and returns will be presented in Chapter 9.

and are therefore physically suited to mechanized agriculture, while the policy of the Ethiopian government has been (and the revolutionary changes dn governments since 1974 have not as yet affected this policy[25/]) to encourage farm mechanization. This was done in the past by making foreign exchange easily available for imports of farm machinery, equipment and spares, by exempting such imports from duty[26/] and by granting very cheap credit (interest charges being as low as seven percent per annum in some cases) for purchases of agricultural machinery. Probably more important still was the complete absence of legal protection for tenant farmers who had no security of tenure and no right to compensation in the event of eviction.

It was the view of government planners at least until the end of the 1960's that there was a clear dichotomy between "....the problem of production and the problem of the peasantry" (Ethiopia, 1968, pp.189-90), and policy-makers operated on the explicit assumption that only large-scale mechanized farming could provide the rapid increase in agricultural productivity necessary to provide food and raw materials for the domestic urban and export markets. The "problem of the peasantry", on the other hand, was seen as requiring a much more long-term approach, and it was apparently not realized - or perhaps more likely, it was not considered particularly important - that the strategy chosen to deal with the first problem could in many

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25/. Under the present regime, of course, farm machinery is now owned collectively rather than privately.

26/. Until the 1973 Budget fuel for agricultural machinery was also exempt from duty.

instances seriously impair the chances of coping successfully with the second.

This conflict between ends certainly became manifest in the case of Chilalo. By 1972, 150 large-scale farms had been established, covering a total of 30,000 hectares (fifteen to seventeen percent of the total cultivated area), with 250 tractors and fifty combine harvesters all told. (Cohen, 1974). The rate of increase in mechanization is more difficult to quantify, but it is known that between 1967, when CADU was first established, and 1972 the area under mechanized farming had increased five-fold and was still continuing to rise, for the most part following CADU's road-building programme which was 'opening up' additional suitable sites. This process was however brought to a halt by the political uncertainty which began in 1974.

The process of mechanization aggravated the "problem of the peasantry" because it was accompanied by tenant eviction, in this case on a quite massive scale. It is estimated that upwards of five thousand tenant farmers were evicted between 1966 and 1972 (Henock, 1972). If each of these tenants had say five or six dependents, then 30-35,000 people (around eight or nine percent of the Region's estimated total population) would have lost their livelihood in the process. Owners of mechanized farms themselves reckoned that on average one tractor could do the work of about thirty ox-teams and one combine that of 200 men (Croon, 1974). These figures are certainly consistent with the above estimates of numbers of tractors, combines and evicted tenants in the District, if reasonable allowance is made for under-utilization of farm machinery. In the Gonde-Etheya area of northern Chilalo (See Map 2.2) which is particularly suited to mechanized farming, the proportion of all farmers who were tenants declined from forty-eight percent in 1968 to only twelve percent in 1972 with evictions still continuing (Henock, 1972). Some of the evictees were able to lease land elsewhere, usually in less favourable locations, some were able to obtain seasonal employment on the smaller mechanized farms, many were forced to migrate to the urban areas, but the net effect was for virtually all of them a loss of income and of what little independence they had previously enjoyed.

These were not the only ill-effects of mechanization on small-scale farmers in Chilalo. Land prices rose steeply, in many cases doubling, and rents rose likewise, making it almost impossible for remaining tenants to buy the land and making it much more difficult for them to introduce modern innovations requiring some cash outlay. Pasture land was brought under the plough, as were traditional easements, so that it became increasingly difficult for smallholders to graze their livestock or to have access to their land or to grazing, water and markets. Although total production from Chilalo Region did increase as a result of the mechanization process, the foreign exchange costs of this development cannot be ignored. Croon (1974) estimated (although on what basis it is not entirely clear) that with a fully mechanized farm (i.e. all operations mechanized except some supplementary weeding), around half of the total output would have to be exported in order to meet the foreign exchange costs of production. Finally, by opting for a growth strategy which concentrated the resultant increase in wealth in a very few hands, the opportunities for demand-induced linkages which could have stimulated domestic manufacturing were lost, since those who benefited most from the strategy could afford quite sophisticated consumer goods which had to be imported.

2.4.2. The Chilalo Agricultural Development Unit

This was the first 'package project' to be established in Ethiopia. This approach, which involves the provision to farmers of a simple set of improvements - improved seed, fertilizer, credit, marketing facilities,extension advice - had been pioneered in India, Israel and Pakistan. The CADU project was designed for the most part along the lines of the Comilla programme in East Pakistan (now Bangladesh) and was established with substantial Swedish assistance in 1967, as part of the Ethiopian government's attack on the "problem of the peasantry". The target population comprised small-scale farmers, defined in this instance as owner-cultivators farming not more than twenty-five hectares or tenants farming not more than forty.

The stated objects of the project were ambitious. They aimed at bringing about the economic and social development of Chilalo, at increasing the 'awareness' of the local population by giving them responsibility for work of a developmental character, at 'verifying' methods for agricultural development and at training Ethiopian staff for the project and for other similar ventures. The aim was not simply to increase production, which, it was realised, could probably best be achieved through the type of development that was already taking place in Chilalo. More important was the wish "to develop the ability of local people to deal with their own problems and to completely lead the progress of their society" (SIDA, 1966). Chilalo District was chosen for this experimental effort because of suitable natural conditions, accessibility, "relatively favourable" tenurial conditions, "the progressive outlook of the farming population" and the possibility of later expansion into neighbouring areas (SIDA, 1966). The original rather vague goals were later expanded and stated in more concrete terms and were seen as including the avoidance of adverse employment effects. Activities were to be directed mainly towards farmers in the lower income brackets (CADU, 1971).

The initial approach was to provide improved seed and fertilizer on credit, together with extension advice which was to be channelled to the target population through a network of 'model farmers'. However the first type of assistance to be provided was a marketing service which would purchase the farmers' produce at fair and reasonable prices, in stark contrast to the existing local system which was characterised by low prices and dishonest calculations[27/]. The project soon expanded from this initial base to provide a wide range of facilities which included, in addition to the original services, road construction, forestry development, implements research, improved livestock, water supplies, co-operative development - in the words of one CADU official, virtually everything from town planning to family planning! The Ethiopian government as part of its contribution to the project guaranteed to submit to Parliament within two years legislation which would provide for effective land reform. This legislation was to include provision for rent reform and control, security of tenure and compensation for unexhausted improvements made by the tenant. Successive drafts were in fact presented to Parliament, but none had been passed by the time that body was dissolved in 1974.

Nevertheless CADU staff could by that time claim considerable success for their endeavours. By the end of the 1973/74 crop season the project was providing inputs, ninety percent on credit, to 22,000 smallholders[28/], and the indications were that the incomes of participants had roughtly doubled since

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27/. One of CADU's earliest studies was of local marketing systems. A local farmer was provided with one quintal (2 cwt) of grain which he took to various merchants for weighing. Their scales were found to register 10 to 12½ percent below the true weight (Leander, 1967).

28/. Unpublished CADU data.

1968 (Hunter et al 1974). Moreover a number of other projects along similar lines, but based on CADU's experience, had been launched in other parts of the country.

2.4.3. The 1975 Land Reform Proclamation:

The military junta which overthree Haile Selassie in September 1974 issued a very far-reaching land reform proclamation the following year (Ethiopia, 1975). The main features of this decree were as follows:

(i) The nationalization of all agricultural land; compensation would be payable for moveable property and for permanent works on the land, but not for the land itself or for any permanent crops thereon.

(ii) The abolition of all farms rents and similar levies[29/].

(iii) The formation of a network of 'Peasant Associations', each based on an area of at least 800 hectares, with responsibility for land distribution and adjudication of future land disputes;

(iv) In any area family holdings were to be as far as possible equal, but in any case the maximum permitted size of holding would be ten hectares;

(v) No individual, with the exception of widows, old people, the sick and minors, was to be allowed to hire labour for agricultural purposes;

29/. In 1976 the government introduced a "land utilization fee" - a rent in all but name - to be paid by all cultivators.

(vi) Until the establishment of the Peasant Associations, existing cultivators were permitted to retain usufruduray rights to the land, subject to the ten hectare ceiling;

(vii) Tenants were to be permitted to keep oxen and implements supplied by the former landlord, but would be required to pay "full compensation" within three years;

(viii) Large-scale farms were to be taken over by the state and the land distributed among tenants, farmed co-operatively or operated as state farms;

(ix) Farmers were to be permitted to pass usufructuary rights to their children, but not of course to sell the land[30/].

The land reform proclamation, although in many ways admirable in theory, added to an already troubled situation in many parts of rural Ethiopia. In Chilalo Region, however, early indications are that its implementation had reasonable initial success[31/]. Large landowners, most of whom were absentees, surrendered their farms quite peacefully and by the end of 1975 CADU officials were reporting that almost all of the smallholders and former tenants, as well as large numbers of landless labourers, had become members of Peasant Associations. Land redistribution, however, had not begin at the beginning of the 1976/77 crop season, although some of the larger

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30/. A useful commentary on the provisons of the land nationalization decree is provided by Bruce (1975).

31/. In a situation as fluid as that pertaining in Ethiopia at the time of writing, any prediction as to the future course of developments would be rash indeed.

commercial farms were indeed broken up to provide land for evictees. Most of these farms, though, were in fact turned into state farms under CADU supervision, presumably (and in these early stages, quite reasonably) in order to guard against the possibility of food shortages in the urban areas. Early attempts by over-enthusiastic local officials of the Ministry of Land Reform to force peasants to farm collectively met with a very hostile reaction from the peasants themselves, and in the midst of the ensuing uncertainty ploughing for the 1976/77 season was very seriously delayed until assurances were received from the central government in June 1976 that individual cultivation would be allowed to continue. Sowing did in fact then take place on time, but on very poorly-prepared fields. These and other early problems will hopefully transpire to have been no more than teething troubles, but even if this is the case some important questions remain to be answered.

2.5 THE CHALLENGE OF THE NEW LAND TENURE REGIME

Assuming that the new land tenure system can be implemented as planned (which is of course no small assumption), it will represent a very great improvement on the previous pattern - not only on the grounds of equity but also on economic grounds, insofar as it has abolished sharecropping and to the extent that it succeeds in providing security of tenure.

However, although the most socially damaging feature of previous developments, that of tenant eviction, should now have been removed, the underlying phenomenon of surplus labour will remain if indiscriminate mechanization is to continue. This could happen if, as at present seems quite possible, Peasant Associations are encouraged, either individually or in groups, to buy the most up-to-date farm equipment. The surplus labour would then no doubt surface in the socially more acceptable form of underemployment, but there would still have been a substitution of scarce resources for more plentiful ones.

On the other hand it has been demonstrated that the traditional farm technology of Chilalo is seriously deficient in certain respects and as will be shown later these deficiencies have become more serious with the introduction of fertilizer and improved seeds. Whereas in the past the farmer could (and did) respond to seasonal bottlenecks by hiring casual labour, the new land tenure regime has removed this option. More important than legal strictures is the fact that if land is indeed made available for previously landless labourers, the supply of casual labour can be expected to dwindle.

This indicates that a strong prima facie case exists for the introduction of selective mechanization, provided that the technology chosen is appropriate to Ethiopia's present relative resource endowment. This prospect is the more promising in that the new Peasant Associations could take responsibility for the purchase, repair and maintenance of equipment which is beyond both the resources and the needs of the individual member. This is therefore an opportune moment at which to examine past problems and explore the scope for selective improvement of farm equipment in order to ease or eliminate labour supply bottlenecks without indiscriminate farm mechanization.

CHAPTER 3 ORIGINS, SCOPE AND METHODOLOGY OF THE PRESENT STUDY

3.1 ORIGINS OF THE STUDY

The present study had its immediate origins in the apparent failure of attempts by CADU's Agricultural Engineering Section (AES - formerly called the Implements Research Section) to make significant progress in its attempts to improve the standard of equipment used by smallholders in Chilalo. CADU was the first organisation in Ethiopia to embark upon this task, and it has undertaken more research in this direction than any other organisation in the country. Indeed the quality of the Section's research performance, at least initially, seems to have been well above average even for the whole of Eastern Africa[1/]. Yet there has been scant success in persuading farmers to buy CADU's implements. Of the many prototypes tested, four - a mould-board plough, a spike-toothed harrow, an ox-cart and a stationary threshing machine - have been put into production, but, as can be seen from Table 3.1, the rate of adoption of these implements has not approached that at which farmers have availed themselves of fertilizer and improved seed sold by CADU. Sales of implements have been very limited and the threshing service has, until very recently at least[2/], failed to cover costs.

1/. This conclusion was reached by Kinsey on the basis of studies of agricultural mechanisation in six Eastern African countries (1976, pp.10-11).

2/. In the 1976 harvest season radical alterations were made to the threshing service provided by CADU. This will be discussed in Chapter 7.

TABLE 3.1 SALES OF FERTILIZER, IMPROVED SEED AND IMPROVED FARM IMPLEMENTS BY CADU 1971/72 TO 1974/75 (Number of Participants)

	1971/72	1972/73	1973/74	1974/75	FOUR YEAR TOTAL
Fertilizer/ Seed	14,164	12,642	13,318	24,892	65,016
Implements	18	99	281	472	870

a/ Credit sales only (at least 90 percent of total sales)

Source: CADU credit unit: unpublished data.

It may of course be the case that Chilalo smallholders are too apathetic to adopt new implements. However their widespread adoption of fertilizer and improved seed suggests that this is not so. A number of alternative explanations could in fact be advanced to account for the relatively poor performance of implements. It may be that technical factors are to blame: for example it is possible that the implements are badly designed or poorly constructed; they may be inappropriate for local conditions or their power requirements may be beyond the capabilities of local oxen. Alternatively it may be that financial considerations predominate: CADU's implements and services may be too expensive in comparison with the traditional alternative, the return on the investment may be insufficiently attractive or inadequately assured, or perhaps CADU's credit conditions are too harsh or the demonstration and sales strategy may be at fault, so that for example farmers may be insufficiently aware of what is available.

A third possibility is that the implements themselves may be inappropriate in that the operations for which they are designed are not, relatively speaking, important bottlenecks. The first two possibilities have received some attention at CADU: designs have been somewhat improved and costings scrutinized in order to see if prices can be reduced[3/], but the third and most important set of questions has not been tackled up to now.

What has happened at CADU, and it is not at all an unfamiliar experience in developing countries, is that basic designs are imported from abroad, they are tested for suitability in local physical conditions (such as soil type) and the more promising ones are then adapted to a greater or lesser degree[4/]. The criteria used in this process of selection and adaptation have been based upon considerations of technical efficiency, cost of materials and domestic manufacturing capability, but not upon questions relating to the perceived needs and available resources of local farmers. Any reciprocity between these needs and resources and the range of implements provided has been in some measure fortuitous. In terms of the categorisation of Rattan and Hayami outlined in Chaper 1, CADU's Agricultural Engineering Section is still at the 'design' stage of the transfer of technology.

3/. These points will be taken up in more detail in Chaper 9.

4/. See especially CADU (1969), for a description of how this type of procedure operated in practice at CADU.

This should not be particularly surprising, since the agricultural engineers who staff the AES have been either foreigners or Ethiopians trained abroad, mainly in disciplines which have been developed with the needs, problems and resources of only the industrialised nations in view. As a consequence, they have seldom had more than intuitive guidance as to the nature and causes of the most limiting seasonal bottleneck process(es) in different parts of the District, of the amount of resources that local farmers are likely to be willing and able to afford in order to ease such bottlenecks and as to the likely level of sales and the consequent optimum level of production of implements. Yet all of these factors, most especially the first, help determine the design of appropriate - with all that that word implies - farming equipment.

It is of course the function of the economist rather than that of the engineer to conduct market research, yet despite the existence for a number of years at CADU of a Planning and Evaluation Section staffed by economists (and other social scientists), the mutually supportive roles which the two professions can play have not materialised in practice. Kinsey writes on the basis of his East African experience:

> "Engineers have learned only ex post from economists which of their new developments were unsuitable, and why, but economists have contributed little to shaping the stream of mechanical innovations being produced by engineering facilities." (1976, p.2).

At CADU, unfortunately, even the experience of learning ex post from formal economic investigation has so far been denied to the agricultural engineering staff.

3.2 THE RELEVANCE OF CHILALO

The availability of resources for the present study were such that only one part of the country could be included. The main reason for the selection of Chilalo for this purpose has already been noted, but a number of other factors combine to make the District a very suitable choice. First, the reasons which justified the choice of Chilalo as the location for Ethiopia's first smallholder development "package programme" still obtain: the area is naturally suited to intensified farming[5/], it is accessible, tenurial conditions have been relatively favourable and the outlook of the farming population is quite progressive and receptive towards new ideas[6/]. Second, the past activities of CADU have made the District an attractive one for study: farmers are now quite familiar with the use of fertilizers and improved seed, while research by CADU staff provides very valuable additional data for a survey such as this. Third the spread of mechanized farming in the area has meant that very useful comparisons can be made

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5/. Unlike some badly eroded parts of Ethiopia which would benefit most of all from a complete moratorium on further cultivation in the foreseeable future.

6/. This is certainly the case if Chilalo's farmers are compared with those of the north-central highlands of Ethiopia (see especially LMB, 1974). Chilalo's farmers have also shown themselves in the past to be unusually co-operative, and information given by them in interviews has been found to agree well - much better than is the case in any other Ethiopian District - with information on the same subjects deriving from alternative sources (see Gill, 1977a).

between alternative technolgies[7/]. Finally, the heterogeneity of Chilalo, which because of marked altitudinal variations within its boundaries embraces several contrasting agro-climatic zones, means that findings will have more widespread applicability than would be the case in a more homogenous area.

3.3 SCOPE OF THE STUDY

The main part of the study consisted of a survey[8/] of smallholders who had adopted improved seed and/or fertilizers. Briefly the aim of this was to discover (a) if existing 'bottlenecks' had been further constricted or new ones created as a result, and (b) how farmers had reacted to such changes.

Ideally investigation of such questions would be based on farm management surveys extending over a period of several years. This would in turn require repeated, if possible daily, visits to sample farms in order to permit direct measurement of inputs, especially labour, for different operations. This approach is however very expensive, financially of course, but even more importantly in that it requires a level of resource input in the form of trained and responsible enumerators and field supervisors which is not readily available in a developing country. Such problems are, moreover, aggravated by the fact that in Chilalo, as in many other parts of Eastern Africa, the rural settlement pattern is one of scattered farmsteads unlike

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7/. The original intention was to base comparative work on data collected from private mechanized farms, but by the time the study was launched these had been nationalised and the ensuing turmoil meant that records and management staff were no longer available for consultation. The farm management records of two large mechanized seed-multiplication farms owned by CADU were used instead for this purpose.

8/. Throughout the following sections the term 'study' will refer to this entire research project; 'survey' will relate only to the questionnaire-based interviews.

the village pattern which typifies much of West Africa for example. Compared with village patterns, the scattered settlement system requires a much higher ratio of survey staff to respondent farmers was well as higher expenditure for transportation.

In this particular instance resources were not available for a farm management survey[9/] and a much less costly alternative had to be devised. The least costly method is a single visit interview, but this method is more open to memory bias since peasant farmers have no written records of their farming operations, while limitations on the attention span (or interest span) of both respondents and interviewers mean that the information sought must be kept within fairly strict lines.

A possible compromise suggested by Collinson in his excellent "Handbook" (Collinson, 1972, Ch.14) is based on a "composite design" comprising a relatively large sample from which easily enumerated data could be collected in a single visit, together with a more detailed investigation of a limited subgroup chosen on the basis of "representativeness" which would in turn be measured by such criteria as labour availability and cropped area per unit of available labour.

9/. Available resources consisted of sufficient funds for one supervisor (the author) and five enumerators, together with one Land Rover and sufficient petrol for approximately six weeks field work. (Petrol was a very scarce resource since it was strictly rationed in Ethiopia at the time of the survey). The enumerators were all high school graduates and natives of Chilalo. All had considerable previous experience of this type of work.

Collinson himself, however, notes that two practical problems have discouraged further work in this direction. First there is the probability that the sub-sample will be widely scattered and will therefore present logistic problems, and second the fact that the farmers selected for intensive investigation will, because they are few in number, possibly feel isolated from the rest of the community. In general terms the second of these problems is probably the more difficult of the two, but in a situation of severely limited fuel supplies the former difficulty was also very daunting. A modified form of composite design was therefore designed.

Most of the information was gathered through interviews with farmers based on the schedule included as Appendix A of this volume. This schedule was completed after prolonged discussion with agricultural engineers, agronomists, agricultural economists and others familiar with farming conditions in the Ethiopian highlands in general and in Chilalo District in particular. A 'pre-test' questionnaire (Appendix B) was first drawn up, tested on a small sample of Chilalo farmers and then modified in the light of the experience thereby gained. The major modification was in the length of the questionnaire. The original was found to be much too long, causing both interviewer and respondent to lose interest; the quality of answers certainly showed a marked tendency to drop off quite noticably about half way through the interview. As can be seen by comparing the two schedules, some rather drastic pruning has been done, with questions which were inordinately time-consuming, or those which were of doubtful or marginal relevance being either dropped or drastically curtailed10/. However, some new questions were also added, particularly those identifying specific varieties, while some existing questions were remodelled in the light of pre-test experience. Even so it must be admitted that a 13-page questionnaire is still rather lengthy, requiring in some cases up to one hour's interviewing time. It called for considerable interviewer skill and very careful field supervision to ensure that the quality of the responses did not tend to fall off towards the end of the interview. With this factor in mind, an attempt was made to present what were regarded as the most important or the most difficult questions in the early part of the schedule. More delicate questions, such as those concerning

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10/. One important change comparing the two schedules which deserves special mention concerns land tenure arrangements. Land tenure questions have always been among the most difficult to explore in the area. A CADU publication issued in the comparatively peaceful days of 1973 noted that "this is perhaps the single variable where error sources are most serious, owing to difficulties of definition, reluctance of farmers to reply correctly, etc." (CADU 1973 p.23). In the more turbulent days of 1976 the question was even more vexed. In the pre-test a marked reluctance on the part of farmers to discuss questions of land tenure was noted and certain CADU officials advised privately against including such a sensitive issue in the final questionnaire. Questions relating to this topic were therefore reluctantly excluded from this document in order to avoid giving a false impression which might adversely affect the quality of responses on other, less controversial issues.

cultivated area and livestock ownership, were kept to the end of the questionnaire in the hope that some level of rapport would by them have been established between interviewer and dnterviewee.

A word concerning the language of the schedule is perhaps in order. The original intention was to write the entire questionnaire in Arussi Orominya, the predominant language of Chilalo. However, a number of difficulties presented themselves, especially the fact that Orominya has not yet fully established itself as a written language. Also, since not all respondents are likely to speak this language, some of the interviews had to be conducted an Amharic, so that some translation was necessary in any event. The compromise finally adopted was to present the questionnaire in English (the usual "questionnaire language" used in Ethiopia), but to provide at the foot of each page a glossary of difficult or technical terms in Arussi Orominya written in Amharic script. Pretest experience indicated that this compromise was rather successful, although repeatec cross-checking and discussion was necessary, especially in the early stages of the Survey, to ensure that all the interviewers were using the same, correct translations in all cases.

Information obtained from the questionnaire-based interviews was supplemented through more detailed discussion with peasant association officials and, most especially, with farmers who seemed more than usually interested in the Survey or who were better equipped than most. For example, the two farmers who possessed watches were able to provide some very useful data on the time required to perform various farm tasks. Finally, CADU's records and CADU officials with considerable field experience in Chilalo were most valuable sources of supplementary data. Hence the composite nature of the study referred to earlier; structured interviews of a fairly large sample were supplemented with "in-depth" questioning of a smaller subsample and a substantial amount of information from sources outwith the sample.

Compared to the farm management approach outlined earlier, the methodology adopted here will produce rather less quantified results, since direct measurements have not normally been possible. However the present approach is based on an explicit faith in the farmer's ability as a rational being to make observations, draw conclusions and diagnose difficulties faced in his work, so that such information could not emanate from a more informed source.

3.4 SAMPLING DESIGN

Available resources of time, money, manpower and fuel indicated that a sample size of about two hundred was possible.

11/. It is also worth noting that not all of the published results based on farm management surveys are quite as precise as they purport to be. Spencer and Byerlee, for example, provide a regression equation (1976, p.876, fn 4) in which a coefficient of 0.014 is given for "labour per acre (hours)" On further enquiry, however, Byerlee acknowledged that "In general we feel comfortable with the measurement time in units of a wuarter day only" (personal communication). Perhaps economists have too readily forgotten Lord Keynes' observation that it is better to be approximately right than precisely wrong!

In the end 211 farmers were interviewed. Again, given limited resources, especially of fuel, it seemed advisable to adopt a multi-stage sampling design. This design was as follows:

(a) Chilalo District can be divided into four ecological zones shown in Table 3.2. A part of the sample was drawn from each of these zones.

(b) Within each of the four zones, one extension area (in Zone D two similar and contiguous areas) was chosen on the basis of longest exposure to CADU, above-average record in sales of modern inputs and ease of accessibility. The areas so chosen were as follows:

ZONE	CADU EXTENSION AREA
A	South Asella
B	Gonde
C	Egu
D	Arata and Ogolcho

TABLE 3.2. Ecological Zones in Chilalo District

Zone	Altitude Range	Suggested Cropping Pattern
A	2300-3000m.	Barley, Wheat, Rapeseed, Potatoes (some areas), Field Pease, Horse Beans
B	1900-2200m.	Wheat, Barley, Potatoes, Maize, Haricot Beans, Teff, Horse Beans, Sunflower
C	2000-2300m.	Wheat, Barley, Field Peas, Teff, Rapeseed, Sunflower
D	1500-1900m.	Maize, Haricot Bean, Wheat (Some areas), Barley (some areas), Teff, Soya Beans, (some areas), Buckwheat.

Source: CADU Crop and Pasture Section (unpublished data.)

(c) Once the extension areas had been chosen, a suitable sampling frame had to be selected. CADU's lists of credit participants were not suitable for this purpose since many farmers who use improved seed buy it from traders or from other farmers or purchase for cash from CADU. Fortunately, a reasonably accurate and up-to-date sampling frame now exists in the membership lists of the new Peasant Associations, to which nearly all Chilalo smallholders now belong. Within each zone, two Peasant Associations were selected with the assistance of the CADU extension and marketing agents again on the basis of maximum exposure to modern inputs and ease of accessibility. In Zones A and D, at the extreme ends of the altitude/climatic range, one extra association was chosen, again using the above criteria but with the additional criterion of unusually high (A) or low (D) altitude. In Zone A an association on the slopes of Mount Chilalo was selected and in Zone D one on the shores of Lake Zwai was chosen. The purpose of this was to extend still further the altitude/climatic range of the area under study. Thus ten Peasant Associations in all were surveyed.

(d) Not all of the members of the Peasant Associations are actually farmers. For example, some are landless labourers who have joined an association in order to obtain land. With the aid of the association chairmen and secretaries, such members were as far as possible excluded from the lists before the sample was drawn. A simple random sample of twenty-five percent of the remaining members was then drawn with the aid of a table of random numbers. If any of the selected association members then transpired to be either non-farmers or farmers who had never used modern inputs, they were then excluded from the sample.

The above approach could obviously not produce a representative sample of Chilalo farmers, nor was it intended to. The survey was intended to obtain information from those farmers who had used modern inputs and who lived in relatively accessible areas and would conseqently have the most opportunity and incentive for increased market-orientation. The farmers who were interviewed should therefore be quite representative of the vanguard of Chilalo smallholders.

3.5 TIMING OF THE SURVEY

The survey was conducted during February and March 1976. This time of year was judged to be most suitable for three reasons.

(a) It is a relatively slack period in the farming year when farmers would be able to devote more time to answering questions.

(b) It is usually a fairly dry period just before the onset of the belg rains, so that the area would then be at its most accessible.

(c) Most important, this period comes at the end of the farming year, so that information relating to the year just completed would be fresh in the farmers' memories.

Taking a rather broader view of time, the survey was conducted at a point in Ethiopia's history at which revolutionary changes were taking place. As far as agriculture was concerned the most important institutional change was the land reform proclamation discussed in the previous chapter. This study was originally planned before the new decree was issued, but, as was noted in Section 2.5 above, the reform made it a particularly opportune moment at which to have available an assessment of the issues under discussion here. The effect on the process of actually collecting the date required for such an assessment was however rather more mixed. On the one hand farmers were found to be extremely eager to discuss problems and grievances, which made for some very lively and informative interview sessions. Some farmers were extremely helpful (and hospitable) and volunteered a great deal of useful information. On the other hand the somewhat uncertain land tenure situation undoubtedly made some issues more sensitive than they would otherwise have been. The question of landlord-tenant relations has already been discussed in this regard (footnote 10). Another such issue is the size of holdings.

At the time the survey was conducted large commercial farms had already been expropriated, but smaller holdings including those in the sample had not as yet been affected by the new measures. One would expect therefore that respondents might tend to under-report the size of their holdings.

In fact however a few respondents actually reported holdings in excess of the new ten-hectare ceiling, which suggests that the extent of under-reporting may not have been as large as was feared. It would be a wise precaution, however, to treat reported plot sizes and total cultivated areas as relative, rather than absolute, orders of magnitude.[12/]

12/. The possibility of attempting physically to measure plots was not seriously considered as a practicable way out of this dilemma. First, since no cadastral survey has ever been undertaken in Ethiopia, it would have been a simple matter for the respondent who wished to under-report to do so with respect to number of plots rather than field sizes, thus defeating the object of the exercise. Second, such a procedure would unquestionably have aroused suspicion and hostility and would have put the entire survey in jeopardy.

CHAPTER 4.

TRADITIONAL FACTORS OF PRODUCTION.

4.I LAND.

Table 4.I summarizes the sample in terms of reported farm sizes. The majority of farmers in the sample had holdings in the range 1½ to 6½ hectares (3¾ to 16 acres) of which 1½ to 4½ hectares were under crops in the 1975/76 season. 'Other land' in this context refers to rough grazing and fallow land. It should be remembered that the typical Ethiopian smallholding is estimated to be in the region of 1½ hectares, so that the farms in this sample are fairly large by national standards, a fact which tends to confirm the expectation that it is the larger, wealthier smallholders who can afford a margin for experimentation and error. Most of the farms in the sample would be suit--able for tractor ploughing, since the minimum field size for economical tractor operation is around two hectares. However in most cases land consolidation would be a pre-requisite for this.

TABLE 4.1 : FARM SIZES BY ZONE.

	Zone				Total
	A	C	B	D	
SIZE OF SAMPLE	67	43	43	58	211
Cropped Land.					
1. Mean per farm (ha.)	3.1	2.9	2.9	2.7	2.9
2.Standard Deviation (ha.)	1.4	1.7	1.6	1.3	1.5
3. Maximum (ha.)	7.8	8.3	7.3	6.0	7.8
4. Minimum (ha.)	0.8	0.5	0.7	0.6	0.5

The above areas are shown broken down by crop in Table 4.2.. Although a few insignificant (in terms of acreage) crops have been omitted, all of the major crops totalling around ninety-eight percent of total reported crop areas are shown in this Table. Insignificant crops in this res--pect are certain improved wheat varieties, improved barley, millet,niger seed and improved rapeseed. In no such case was there more than four observations.

A number of interesting points emerge from Table 4.2. The first is the overwhelming importance of wheat and barley in the Survey Area, each of which crops covers about one third of the total cultivated area. The only other important crop in this respect is maize, which occupies nearly 15 percent of the total.

A second important point is that only in the case of wheat have improved varieties made significant headway in replacing local strains. It is only farly recently that CADU began to introduce new varieties other than wheat, while some of the non-indigenous wheat varieties used in Chilalo were introduced before the establishment of CADU. Overall,improved varieties of all crops cover about a third of the total cultivated area, and of this third almost ninety percent is under improved wheat.

Another important point concerns the size of plots, since this will influence the potential for mechanization. In the cases of wheat,barley and maize, mean plots sizes tend to be around one hectare, but this is much too small

Table 4.2 Areas Under Major Crops: All Zones

CROP	PERCENT (NO) OF FARMERS GROWING CROP	PERCENTAGE OF CROPPED AREA UNDER CROP	MEAN AREA PER FARM (ha.)a/	STANDARD DEVIATION (ha.)a/
WHEAT Local	13.2 (28)	3.74	0.81	0.78
WHEAT Kentana Frontana	2.8 (6)	1.03	1.04	0.25
WHEAT, Laketch	52.2 (115)	16.63	0.88	0.66
WHEAT Romany	9.4 (20)	3.45	1.05	0.52
WHEAT Supremo	20.3 (43)	7.42	1.05	0.51
BARLEY Local	78.8 (167)	31.73	1.15	0.79
MAIZE Local	31.1 (66)	12.13	1.12	0.69
MAIZE Hybrid	6.1 (13)	2.54	1.19	1.32
TEFF Local	16.5 (35)	3.87	0.67	0.38
TEFF Improved	2.8 (6)	0.62	0.63	0.26
SORGHUM Local	9.4 (20)	1.36	0.41	0.23
FIELD PEAS Local	27.8 (59)	5.41	0.56	0.40
HORSE BEANS Local	31.1 (66)	3.32	0.31	0.20
HARICOT BEANS Local	9.9 (21)	1.97	0.57	0.21
HARICOT BEANS Michigan	1.9 (4)	0.35	0.53	0.33
RAPESEED Local	4.7 (10)	0.68	0.41	0.34
FLAX Local	7.5 (16)	1.56	0.59	0.30

a/ Non-zero observations only.

for economical operation of a combine harvester, so that a good deal of land consolidation would be required for efficient use of combines.

Tables 4.3 to 4.6 show crop area information disaggre--gated to a zonal level. In descending order of altitude, the relative positions of the zones are A, C,B,D, and comparison of the four tables reveals considerable differ--ences in cropping patterns reflecting this gradation. For example, local barley is grown in all areas, but the proportion of the total cropped area under this cereal steadily increases with increasing altitude, as does the proportion of farmers who cultivate it. The mean area per farm under barley also bears a positive relationship to relative altitude.

Maize and teff were not found at all in Zones A and C, and the percentage of total acreage devoted to both crops is higher in Zone D than in Zone B. Again the percentage of farmers growing these two crops is higher in Zone D than in Zone B, and the fields of both crops tend to be larger in the former zone. Wheat provides another example. Parts of Zone A are too cold and parts of Zone D are too hot for wheat, so that the bulk of this crop is grown in the two intermediate zones. Rapeseed, flax and the remaining pulse crops show the same tendency to be ass--ociated with particular zones.

4.2.FARM LABOUR FORCE.

Table 4.3 Areas Under Major Crops: Zone A

	PERCENT (NO) OF FARMERS GROWING CROP	PERCENTAGE OF CROPPED AREA UNDER CROP	MEAN AREA PER FARM (ha.)a/	STANDARD DEVIATION (ha)a/
WHEAT, Local	10.4 (7)	2.30	0.68	0.35
WHEAT Kentana Frontana	4.5 (3)	1.69	1.17	0.29
WHEAT Laketch	77.6 (52)	24.06	0.96	0.66
WHEAT Romany	-	-	-	-
WHEAT Supremo	4.5 (3)	1.21	0.83	0.14
BARLEY Local	9.5 (66)	51.75	1.53	0.91
MAIZE Local	-	-	-	-
MAIZE Hybrid	-	-	-	-
TEFF Local	-	-	-	-
TEFF Improved	-	-	-	-
SORGHUM Local	-	-	-	-
FIELD PEAS Local	40.3 (27)	9.85	0.75	0.[illegible]3
HORSE BEANS Local	26.9 (18)	3.57	0.41	0.31
HARICOT BEANS Local	-	-	-	-
HARICOT BEANS Michigan	-	-	-	-
RAPESEED Local	4.3 (3)	0.97	0.67	0.52
FLAX Local	14.9 (10)	2.90	0.60	0.34

a/ Non-zero observations only.

Table 4.4 Areas Under Major Crops: Zone C

	PERCENT (NO) OF FARMERS GROWING CROP	PERCENTAGE OF CROPPED AREA UNDER CROP	MEAN AREA PER FARM (ha.)a/	STANDARD DEVIATION (ha.)a/
WHEAT Local	2.3 (1)	0.61	0.75	0.00
WHEAT Kentana Frontana	7.0 (3)	2.22	0.92	0.14
WHEAT Laketch	34.9 (15)	10.92	0.90	0.52
WHEAT Romany	46.5 (20)	16.99	1.05	0.52
WHEAT Supremo	37.2 (16)	16.08	1.24	0.63
BARLEY Local	90.7 (39)	37.11	1.18	0.64
MAIZE Local	-	-	-	-
MAIZE Hybrid	-	-	-	-
TEFF Local	-	-	-	-
TEFF Improved	-	-	-	-
SORGHUM Local	-	-	-	-
FIELD PEAS Local	25.6 (11)	4.85	0.55	0.37
HORSE BEANS Local	34.9 (15)	3.44	0.28	0.09
HARICOT BEANS Local	-	-	-	-
HARICOT BEANS Michigan	-	-	-	-
RAPESEED Local	14.0 (6)	1.52	0.31	0.22
FLAX Local	11.6 (5)	2.63	0.65	0.22

a/ Non-zero observations only.

Table 4.5 Areas Under Major Crops: Zone B

	PERCENT (NO) OF FARMERS GROWING CROP	PERCENTAGE OR CROPPED AREA UNDER CROP	MEAN AREA PER FARM (ha.)a/	STANDARD DEVIATION (ha.)a/
WHEAT Local	24.9 (15)	10.74	0.84	0.85
WHEAT Kentana Frontana	-	-	-	-
WHEAT Laketch	74.4 (32)	25.47	0.94	0.79
WHEAT Romany	-	-	-	-
WHEAT Supremo	51.2 (22)	18.29	0.98	0.41
BARLEY Local	86.0 (37)	23.07	0.73	0.38
MAIZE Local	30.2 (13)	4.15	0.38	0.22
MAIZE Hybrid	18.6 (8)	2.72	0.40	0.14
TEFF Local	9.3 (4)	0.85	0.25	0.00
TEFF Improved	-	-	-	-
SORGHUM Local	23.3 (10)	3.30	0.39	0.19
FIELD PEAS Local	27.9 (12)	3.30	0.32	0.25
HORSE BEANS Local	67.4 (29)	6.21	0.25	0.11
HARICOT BEANS Local	-	-	-	-
HARICOT BEANS Michigan	-	-	-	-
RAPESEED Local	2.3 (1)	0.21	0.25	0.00
FLAX Local	2.3 (1)	0.21	0.25	0.00

a/ Non-zero observations only.

Table 4.6 Areas Under Major Crops: Zone D

	PERCENT (NO) OF FARMERS GROWING CROP	PERCENTAGE OF CROPPED AREA UNDER CROP	MEAN AREA PER FARM (ha.)a/	STANDARD DEVIATION (ha.)a/
WHEAT Local	8.5 (5)	2.89	0.93	1.18
WHEAT Kentana Frontana	-	-	-	-
WHEAT Laketch	27.1 (16)	4.92	0.49	0.24
WHEAT Romany	-	-	-	-
WHEAT Supremo	3.4 (2)	0.78	0.63	0.53
BARLEY Local	42.4 (25)	8.05	0.52	0.40
MAIZE Local	89.8 (53)	43.07	1.30	0.64
MAIZE Hybrid	8.5 (5)	7.66	2.45	1.40
TEFF Local	62.7 (37)	16.42	0.73	0.37
TEFF Improved	62.7 (37)	16.42	0.63	0.26
SORGHUM Local	16.9 (10)	2.74	0.44	0.27
FIELD PEAS Local	15.3 (9)	1.64	0.29	0.13
HORSE BEANS Local	6.8 (4)	0.31	0.13	0.25
HARICOT BEANS Local	35.6 (21)	7.50	0.57	0.21
HARICOT BEANS Michigan	6.8 (4)	1.33	0.53	0.33
RAPESEED Local	-	-	-	-
FLAX Local	-	-	-	-

a/ Non-zero observations only.

4.2.1. The Farm Family: For the purpose of analysing labour availability, it was thought desirable to classify the farm family into four categories: adult men, adult women, schoolchildren(who would be available for part-time work) and other children. This seems a much better approach than the more familiar one of asking the age and sex of each member of the family (ages are not accurately known in most cases),both because it is simpler and because it allows the farmer himself to classify the members of his family according to the farm operations he or she is able to per--form. Table 4.7 shows the distribution of the sample according to the above scheme.

The overall ratio of 2.5 children per family is very low by L.D.C standards, while a proportion of thirty per--cent of all children at school is extremely high. While it is probable that relatively prosperous smallholders might have fewer children and a higher proportion of them at school, neither of the above figures is really credible. First there is very good reason to suspect that the number of 'other children' would be under-reported for reasons that need not be elaborated here since it would only affect babies and very young children and not those in the labour force.In the case of schoolchildren, the enumerators report--ed having formed a very strong impression that children were being described as being at school for reasons of prestige and that there was consequently a great deal of over-reporting here. It has therefore been decided to aban--don this particular distinction between children. It is

Table 4.7: Sample Population by Category and by Zone

	ZONE								TOTAL	
	A		C		B		D			
	TOTAL	MEAN	TOTAL	MEAN	TOTAL	MEAN	TOTAL	MEAN	TOTAL	MEAN
Adult Men	80	1.19	52	1.21	56	1.30	70	1.21	258	1.22
Adult Women	83	1.24	45	1.05	50	1.16	76	1.31	254	1.20
School-Children	60	0.90	23	0.53	54	1.26	58	1.00	195	0.92
Other children	120	1.79	103	2.40	64	1.49	160	2.76	447	2.12
Mean Family Size	5.12		5.19		5.21		6.28		5.47	

probably reasonable to assume that if there is a part--icularly severe labour bottleneck at any time in the year, either children will not be sent to school in the first place, or that they will absent themselves temporarily.

Table 4.8 Percentage of Adult Men Available for Various Farm Operations.

FARM OPERATION	ZONE				TOTAL
	A	B	C	D	
Ploughing	95.0	98.2	96.2	94.3	95.7
Sowing	91.3	91.1	96.2	92.9	92.7
Weeding	95.0	98.2	98.1	94.3	96.1
Harvesting	96.3	91.1	96.2	94.3	94.6
Threshing	96.3	92.9	96.2	94.3	95.0
Winnowing	92.5	92.9	96.2	94.3	93.8

These figures provide an interesting insight into the apportionment of work among family members. As would be expected, the adult men (apart from those who are presum--ably too elderly) are able to perform any of the six jobs listed. One exception in a few cases is sowing : since broadcasting seed requires special skills, some farmers may get outside help for this. Weeding is obviously a whole-family affair,as to a lesser extent is threshing and, rather less again,harvesting, but few women and chil--dren (except presumably the older children) are even in--volved in the most strenuous farm operation,ploughing.

Table 4.9 Percentage of Adult Women Available for Various Farm Operations.

FARM OPERATION	ZONE				TOTAL
	A	B	C	D	
Ploughing	4.8	11.8	13.3	1.3	6.6
Sowing	4.8	2.0	13.3	1.3	4.7
Weeding	83.1	82.6	82.2	77.6	81.2
Harvesting	36.1	21.6	33.3	40.8	34.2
Threshing	56.6	52.9	46.7	47.4	51.4
Winnowing	26.5	9.8	42.2	29.0	26.7

Table 4.10:Percentage of all Children Available for Various Farm Operations.

FARM OPERATION	ZONE				TOTAL
	A	B	C	D	
Ploughing	2.9	15.3	6.3	6.4	7.3
Sowing	1.1	3.4	5.6	2.8	3.0
Weeding	10.6	40.7	11.1	14.2	17.4
Harvesting	7.2	11.9	7.1	6.4	7.8
Threshing	9.4	27.1	6.3	7.8	11.5
Winnowing	5.0	12.7	7.9	4.6	6.9

Tables 4.11 to 4.13 are frequency distributions of the number of each category of worker available for each of the six farm operations (eg. there are 23 farms with two adult men able to plough and two farms with four adult women able to weed). These figures have not been presented on a zonal basis since the four zonal patterns are very similar.

Table 4.11 Number of Adult Men per Farm Able to Perform Various Farm Operations.

FARM OPERATION	NONE	NUMBER AVAILABLE				TOTAL
		ONE	TWO	THREE	FOUR	
Ploughing	2	179	23	4	2	245
Sowing	4	183	30	4	1	239
Weeding	4	178	22	6	2	248
Harvesting	2	182	23	4	1	244
Threshing	2	181	24	4	1	245
Winnowing	4	180	23	4	1	242

Table 4.12. Number of Adult Women per Farm Able to Perform Various Farm Operations.

FARM OPERATION	Number Available					TOTAL
	NONE	ONE	TWO	THREE	FOUR	
Ploughing	197	11	3	0	0	17
Sowing	200	12	0	0	0	12
Weeding	37	148	23	7	2	208
Harvesting	127	64	10	1	0	87
Threshing	95	104	12	1	0	131
Winnowing	151	55	5	1	0	68

Table 4.13 Number of Children per Farm Able to Perform Various Farm Operations

FARM OPERATION	NUMBER AVAILABLE							
	NONE	ONE	TWO	THREE	FOUR	FIVE	SIX	TOTAL
Ploughing	391	26	8	2	0	1	0	53
Sowing	411	4	2	8	0	1	0	13
Weeding	365	19	12	11	1	2	2	102
Harvesting	392	10	6	4	0	1	0	39
Threshing	381	17	11	8	0	1	1	68
Winnowing	398	12	8	3	0	1	0	43

From the above three tables, the typical family in the Survey Area could be described as having one fulltime adult man able to perform all farm tasks, one or two addit--ional family workers for weeding and possibly one extra for harvesting and threshing.

4.2.2 MUTUAL LABOUR EXCHANGE.

The'debo' and 'jigge' are mutual help organizations which are found throughout Chilalo - as indeed similar organizations are found in many parts of Africa. Table4.14 shows that the great majority of farmers in the Survey Area belong to such an organization.

This table shows no very striking evidence that farmers have tended to join such associations as a result of the 1975 land reform procamation and the prohibition on the hiring of labour by able-bodied farmers.

The type of work done by these associations is shown in Table 4.15, which indicates that across the Survey Area as a whole labour is mutually exchanged, in order of imp--ortance, for the following tasks: Harvesting,Ploughing, Weeding,Threshing,Transporting Crops,Sowing and Winnowing. Within the four zones there are a few minor variations in this order, but in every case harvesting is the tasks for which these associations are mostly used.

Table 4.14: Membership of Mutual Labour Exchange Groups

	ZONE									
	A		C		B		D			
	No	%	No	%	No	%	No	%	No	%
Belonged in Past & still Belong	52	77.6	37	86.0	38	88.4	56	96.6	183	86.7
Belonged in Past But not Now	5	7.5	0	0.0	1	2.3	0	0.0	6	2.8
Belong Now but not in Past	5	7.5	3	7.0	1	2.3	1	1.7	10	4.7
Never Belonged	5	7.5	3	7.0	3	7.0	1	1.7	12	5.7
TOTAL	67	100.0	43	100.0	43	100.0	58	100.0	211	100.0

Table 4.15 Number and Percentage of Farmers by Zone Using Mutual Labour Exchange Associations for Various Farm Operations

FARM OPERATION	ZONE								TOTAL	
	A		B		C		D			
	No	%	No	%	No	%	No	%		
Ploughing	26	38.8	24	55.8	30	67.8	44	76.6	124	58.5
Sowing	10	14.9	9	20.9	16	37.2	20	33.9	55	25.9
Weeding	14	20.9	24	55.8	22	51.2	45	75.3	105	49.5
Harvesting	45	67.2	33	76.7	31	72.1	52	88.1	161	75.9
Threshing	16	23.9	11	25.6	19	44.2	28	47.5	74	34.9
Winnowing	5	7.5	6	14.0	10	23.3	13	22.0	34	16.0
Transporting Crops	12	17.9	14	32.6	9	20.9	26	44.1	61	28.8
Not Stated	12	17.9	2	4.7	4	9.3	1	1.7	19	9.0

Three out of the seven operations listed in Table 4.15 (sowing,harvesting and winnowing) are done by human labour,only while,while another three require animal power (ploughing,threshing,and transporting crops). Weeding is done by hand in most cases, but for tall-growing crops like maize and sorghum it is done by ox-plough. It is worth noting in this respect that in the regions where maize and sorghum are grown,Zones B and D, the mutual labour exch--ange group is widely used for weeding - especially in Zone D where most maize and sorghum are grown. It is possible when such groups are used for tasks requiring animal power that what is being exchanged is animal labour rather than human labour alone.

At first glance it may not appear that this type of arrangement would in any way reduce the severity of peak energy demands in traditional farming, since one could reas--ably assume that peaks on different farms in the same lo--cality would tend to coincide. Farmers, however, report four ways in which this institution is beneficial in this regard. First, there are some tasks, particularly threshing, in which economies of scale obtain. The optimum threshing team comprises seven to ten oxen and three or four labour--ers, so that co-operation in this task is essential for (relatively) efficient operation. This type of co-operat--ion also increases returns to another scarce resource, the threshing floor itself. Even at a task like weeding or reaping, where no teamwork is required and therefore no no scale economies exist, farmers are of the opinion that a group of people working collectively can achieve more than they could individually, principally for reasons of morale. Third, because of differences in cropping patterns which arise from such factors as individual pref--erences or the requirements of crop rotation, seasonal peaks, although in close proximity, do not exactly co-incide. Finally, even if a group of neighbouring farm--ers have identical crop mixes, seasonal peaks may still not coincide because of local differences in, for example, soil fertility, micro climate and fertilizer application rates. Farmers also appear deliberately to schedule sowing dates in order to avoid having crops mature simultaneously.1/

This device of the mutual labour exchange group then provides an excellent example of the way in which tradit--ional agricultural technology in Chilalo has been ration--ally modified in order to reduce the restrictions imposed by seasonal factors. As is shown in Chapter 1 such phenom--ena are widely spread in the developing world.

4.2.3. HIRED LABOUR.

Since the hiring of farm labour is now for the most part illegal in Ethiopia, the question relating to this practice referred to the period before the Procamation.

1/ Ellis(1972) gives further examples of this type of activity in Ada District which borders on Chilalo.

Table 4.16 shows the breakdown by zone of farmers hiring either temporary or permanent labour.

A quarter of the sample farmers used hired labour and about nine-tenths of this was temporary. Table 4.18 also, however, shows a marked regional pattern, with farmers in the two lower zones,B and D, much more likely to hire labour than those in Zones A and C.

The figures in Table 4.17, like those in Table 4.15, indicate that harvesting is the period in the farm year when supplementary labour is most in demand, so that if the hiring of labour at this period is to be stopped,an important bottleneck can be expected to develop at harvest time,unless effective remedial measures are taken. A secondary, but less important, bottleneck may be created in weeding for the same reasons.

Rates of pay for hired labour fall into three categor--ies: yearly rates for permanent employees, daily rates and piece rates for temporary workers. These rates are shown as frequency distributions in Tables 4.18 to 4.20. A number of important points emerge from these tables. First,labourers who were hired on a daily basis were ob--viously paid a good deal more per day than permanent workers, presumably reflecting the seasonality of farm work. Second, again reflecting the seasonality of farm work, almost ninety per cent of the workers hired by rep--orting farmers were employed on a temporary basis. Third, the range in wage rates, espcially for piece work

Table 4.16 Farmers Hiring Agricultural Labour Before 1975 by Zone

	ZONE									
	A		B		C		D		TOTAL	
	No	%	No	%	No	%	No	%	No	%
Hiring Permanent Labour Only	1	1.5	4	9.3	0	-	1	1.7	6	2.9
Hiring Temporary Labour Only	5	7.5	15	34.9	3	7.0	24	40.7	47	22.5
Hiring Both Types	-	-	1	2.3	-	-	-	-	1	0.5
Not Hiring Labour	61	91.0	23	53.5	40	93.0	33	56.9	157	75.1

Table 4.17 Number and Percentage of Farmers by Zone Using Hired Labour for Various Farm Operations (Temporary Labour Only)

FARM OPERATION	ZONE								TOTAL	
	A		B		C		D			
	No	%	No	%	No	%	No	%	No	%
Ploughing	2	3.0	5	11.6	-	-	2	3.4	9	4.3
Sowing	-	-	5	11.6	-	-	2	3.4	7	3.3
Weeding	1	1.5	9	20.9	-	-	8	13.8	18	8.5
Harvesting	5	7.5	19	44.2	2	4.7	22	37.9	48	22.7
Threshing	2	3.0	10	23.3	-	-	3	5.2	15	7.1
Winnowing	1	1.5	6	14.0	-	-	1	1.7	8	3.8
Transporting Crops	1	1.5	-	-	-	-	4	6.9	5	2.4
Not Stated	-	-	1	2.3	1	2.3	-	-	2	0.9

Table 4.18 Yearly Wage Rates by Zone

	ZONE				TOTAL
	A	B	C	D	
Eth $100.00	-	1	-	-	1
Eth $110.00	-	1	-	-	1
Eth $120.00	1	1	-	1	3
Mean Rate (Eth$/an)	120.00	110.00	-	120.00	103.33
Modal Rate (Eth$/an)	120.00	110.00	-	120.00	120.00

Table 4.19 Daily Wage Rates by Zone

DAILY WAGE	ZONE				TOTAL
	A	B	C	D	
Eth $ 1.00	-	-	2	-	2
Eth $ 1.25	-	1	-	2	3
Eth $ 1.50	1	4	-	6	11
Eth $ 1.75	-	2	-	1	3
Eth $ 2.00	1	2	-	-	3
Mean Rate (Eth$/day)	1.75	1.64	1.00	1.47	1.52
Modal Rate (Eth$/day)	-	1.50	1.00	1.50	1.50

Table 4.20 Piece Rates (Per Hectare) by Zone

RATE/HECTARE	ZONE				Total
	A	B	C	D	
Eth $ 12.00	-	1	-	1	2
Eth $ 14.00	-	2	-	1	3
Eth $ 20.00	-	-	1	1	2
Eth $ 22.00	-	1	-	3	4
Eth $ 24.00	-	-	-	2	2
Eth $ 28.00	-	1	-	3	4
Eth $ 32.00	-	1	-	-	1
Eth $ 34.00	-	-	-	1	1
Eth $ 36.00	-	-	-	1	1
Eth $ 40.00	1	-	-	-	1
Eth $ 50.00	1	1	-	-	1
Mean Rate (Eth$/ha)	45.00	24.57	20.00	22.62	24.82
Modal Rate (Eth$/ha)	45.00	14.00	20.00	24.00	23.00
Median " "	45.00	22.00	20.00	24.00	-
Crop Share	-	1	-	- -	1

is very large, reflecting for the most part different rates for different jobs.

4.2.4 Religious Holidays.

It is often stated that the productivity of Ethiopian is severely limited by the number of compulsory religious holidays which must be observed. All of the farmers interviewed were either Christians or Muslim (Table 4.21), about three-quarters being Christian overall, but with a tendency for the Muslims to be found mostly in Zone D.

Table 4.22 shows the reported weekend workloads of the sample farmers. About two-thirds of farmers abstain from work on at least one day over the weekend, and about 45 per cent on two days. Less than 20 per cent of farmers reported working normally at weekends, and one-third work less than a normal working day.

Table 4.21:Classification of Sample Farmers by Religious Affiliation and by Zone.(Percentage of Farmers)

	ZONE.				Total
	A	B	C	D	
Christian	80.6	97.6	88.4	34.5	72.7
Muslim	19.4	2.4	11.6	65.5	27.2

Table 4.22: Weekend Workloads (Percentage of Farmers).

WORK LOAD	CHRISTIAN		MUSLIM	
	Saturday	Sunday	Friday	Sunday
Usually Work	39.6	4.5	8.8	15.8
Occasionally Work	18.2	4.5	7.0	17.5
Work Part of Day	1.3	7.8	-	-
Light Work Only	18.8	14.3	22.8	29.8
Never Work	18.8	67.5	61.4	30.1
Not Stated	3.2	1.3	-	1.8

Christian families often abstain from work on a number of important feast days each month (eg. St Mich--ael's day is celebrated on the twelth day of each month). The number of days'lost' in this way ranged from one to seven per month. The modal number of days 'lost' was four and the mean 4.4, so that the typical Christian farmer usually abstains from work on two days per week. Muslims do not celebrate monthly feast days but, as can be seen from Table 4.22, they tend not to work on Sundays or Fridays (the latter being the nearest equivalent to a Muslim Sabbath), so that the standard working week for both sets of farmers is the same and the normal working month may be assumed to total twenty-two days.

Muslim farmers,it should be noted,have a special problem to contend with during the month of 'Ramadhan' (early September - early October), when they are required to abstain from food and drink between dawn and sunset. Only a third of Muslim farmers reported working a normal full day during this month, although only one such farmer reported that he did not work at all. The remaining two-thirds either worked only during part of the day or did light work only. This period, however, is a fairly slack one in the farming year, when the main form of activity would be weeding (see Figure 5.3).

The final point regarding religious holidays concerns annual feast days, such as Christmas and 'Id el Fitre'. These are shown in Table 4.13. At its present state of development, Ethiopian agriculture is unlikely to be very seriously affected by a few holidays such as these annual feast days. One possible exception, however, is the Christmas - Epiphany - St Michael's day period, which occurs during the period of threshing and could lead to some crop losses. (See section 5.6 of Chapter 5.)

4.3 WORKSTOCK.

4.3.1 Ownership of Animals.

Table 4.24 shows the frequency distribution of the ownership of working animals in the Survey Area. In the case of oxen, the great majority of farmers own two oxen (one team) or more. The only exception is Zone B, where there was extensive mechanization in the past and which

Table 4.23 Number and Percentage of Farmers Celebrating Annual Religious Feasts

CHRISTIAN		No	%
St John	(Early September	144	93.5
Maskal	(late September)	153	99.4
Christmas	(early January)	150	97.4
Epiphany	(mid-January)	147	95.5
St. Michael	(mid-January)	147	95.5
Good Friday	(late April)	142	92.2
Easter Monday	(early May)	146	94.8
Assumption Day	(late August)	128	83.1

Table 4.23 (Cont'd.)

MUSLIM		No	%
1st *Mahuram*	(end December)	15	26.3
Ashura	(end December)	6	10.5
Maulid	(mid-March)	39	68.4
Mehraj	(end July)	6	10.5
Id el Fitre	(end September)	54	94.7
Ara fa	(mid-December)	57	100.0

Table 4.24: Ownership of Workstock (Frequency Distribution)

WORKSTOCK TYPE	ZONE A		ZONE B		ZONE C		ZONE D		TOTAL	
	No	%	No	%	No	%	No	%	No	%
1. OXEN										
None	8	11.9	5	11.6	6	14.0	3	5.2	22	10.4
One	11	16.4	11	25.6	7	16.3	11	19.0	40	19.0
Two	43	64.2	21	48.8	28	65.1	38	65.5	130	61.6
Three	1	1.5	3	7.0	2	4.7	2	3.4	8	3.8
Four	4	6.0	3	7.0	-	-	4	6.9	11	5.2
2. DONKEYS										
None	50	74.6	25	58.1	21	48.8	20	34.5	116	55.0
One	12	17.9	12	27.9	19	44.2	21	36.2	64	30.3
Two	5	7.5	5	11.6	3	7.0	11	19.0	24	11.4
Three	-	-	1	2.3	-	-	4	6.9	5	2.4
Four	-	-	-	-	-	-	2	3.4	2	0.9
3. MULES										
None	59	88.1	41	95.3	42	97.7	50	86.2	192	91.0
One	8	11.9	2	4.7	1	2.3	8	13.8	19	9.0
4. HORSES										
None	24	35.9	34	39.1	19	44.2	41	70.7	118	55.9
One	32	47.8	7	16.3	20	46.5	17	29.3	76	36.0
Two	11	16.4	1	2.3	4	9.2	-	-	16	7.6
Three	-	-	1	2.3	-	-	-	-	1	1.5

area has only begun to be re-settled by small-holders; in this area there tend to be fewer oxen per farm. The reported ownership of donkeys is surprisingly low, given the importance of this animal as a beast of burden throu--ghout the Ethiopian highlands. Horses and mules are of lesser importance, as they are for the most part riding animals and are seldom used as pack-animals.

4.3.2 Values and Working Lives.

Farmers estimates of the values and working lives of workstock are summarised in Table 4.25. Respondents were asked to provide estimates of the prices of work--stock when young, trained and ready to begin work. In the case of oxen, however, there is a salvage value also, since an ox which is too old for work can be sold for slaughter. Table 4.25 shows that although a young ox is significantly more valuable than an old one,[2/] the depr--eciation over the animal's working life is remarkably small.

The mean values shown in Table 4.25 accord well with the general level of prices for workstock obtaining in local markets. The degree of variation of these estimates about the mean, as indicated by the standard deviations, is not at all excessive, given their subjective origin.

2/ Analysis of variance, level of significance 0.1 per cent.

Table 4.25: Farmers' Estimates of Values and Working Lives of Workstock

	Number of Estimates	Mean	Standard Deviation
OX: Working life, yrs.	200	9	7.3
" Value (young), Eth$	193	90	31.3
" Value (old) Eth$	194	72	25.6
DONKEY: Working life yrs.	127	11	4.6
" Value, Eth$	142	37	8.5
MULE: Working life, yrs.	81	17	7.4
" Value, Eth$	90	150	53.9
HORSE: Working life, yrs.	111	12	5.4
" Value, Eth$	130	107	50.6

Table 4.26: Farmers' Estimates of Values and Useful Lives of Implements

	Number of Estimates	Mean	Standard Deviation
PLOUGH TIP: Life, yrs.	201	3.3	1.8
" Value, Eth$	199	2.2	0.8
PLOUGH HOOK: Life, yrs.	200	4.6	2.9
" Value, Eth$	200	0.8	0.4
OX-SLED: Life, yrs.	41	2.9	1.8
" Value, Eth$	10	2.3	0.8
LOCAL SICKLE: Life, yrs.	17	3.8	3.2
" Value, Eth$	16	0.8	0.2
FACTORY SICKLE: Life, yrs.	198	3.7	1.9
" Value, Eth$	199	2.9	0.8
OX-HARNESS: Life yrs.	183	3.1	1.5
" Value, Eth$	52	1.4	0.7

4.4 FARM IMPLEMENTS AND EQUIPMENT.

Six types of traditional agricultural implements and equipment were investigated on the basis that either (a) they tend to be purchased rather than home-made or (b) that they are used for farming operations where CADU has been trying to introduce improved implements or equipment. These last operations are seedbed preparation, threshing and transportation. The metal implements are, as might be expected, almost exclusively purchased, while equipment made of wood or leather is for the most part home-made. Table 4.26 shows the estimated values of the six implements and their estimated useful lives.

CHAPTER 5.

TRADITIONAL FARM ORGANIZATION.[1]

5.1 CROP MIXES.

The mix or 'portfolio' of different crops grown on any farm will have an important bearing on the seasonal distribution of demands on that farm's energy resources. An indication of the relative importance of various crops on an aggregate level has already been provided (Tables 4.2 to 4.6). If a typical farm were to be postulated for each of Chilalo's four ecological zones on the basis of this information and on mean cropped areas shown in Table 4.1, the picture would be similar to that shown in Table 5.1 [2]. At the level of the individual farm,however,

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1/ Throughout the present chapter traditional implements, techniques, power sources and crop varieties are implied. Some organizational features, however, namely the number of times ploughing and weeding are repeated and the dates of certain crop operations, are reported on the basis of current practice, which, as will be shown in Chapter 6 , will in some instances have chan-ged as a result of the adoption of modern inputs like fertilizer.

2/ For the sake of simplicity only major crops, defined in this instance as those occupying at least two per cent of total cropped area in the sample and at least three per cent of total reported cropped area in any one zone, have been included in this table.

Table 5.1: Notional Crop Mixes in the Four

(areas in hectares)

CROP All varieties)	ZONE			
	A	C	B	D
Wheat	1.0	1.5	1.7	0.2
Barley	1.7	1.1	0.7	0.2
Maize	-	-	0.2	1.5
Teff	-	-	-	0.5
Field Peas	0.3	0.2	0.1	-
Horse Beans	0.1	0.1	0.2	-
Haricots	-	-	-	0.3
Mean Cropped Area	3.1	2.9	2.9	2.7

Table 5.2: Percentage Distribution of Sample Farms by Number of Different Crops Grown

No of Different Crops[a/]	ZONE				TOTAL
	A	C	B	D	
ONE	6.0	4.7	0.0	8.6	5.3
TWO	36.0	32.6	12.2	19.0	25.8
THREE	30.0	25.6	12.2	25.9	24.4
FOUR	19.4	23.3	19.5	29.3	23.0
FIVE	9.0	9.3	24.4	5.2	11.0
SIX	0.0	0.0	19.5	5.2	5.3
SEVEN	0.0	4.7	12.2	6.9	5.3

a/ Including different varieties of the same crop.

the mosaic is a great deal more complex.Table 5.2 shows a frequency distribution of the sample farms according to the number of different crops reported and reveals some interesting contrasts. The degree of diversification is greatest in Zone B, which is in fact the most accessible of the four areas studied and has in the past been the most market-oriented and the most mechanized. The main reason for the diver--sification, however, is almost certainly the intermediate position of this zone within the altitude spectrum. In the area of highest elevation, Zone A, crops like teff, maize and haricot beans cannot be grown successfully, a fact which explains the relatively small number of crops in Zone A.

The degree of association between different crops can be seen from Tables 5.3 and 5.4, which indicate that there is a sometimes very marked tendency for certain crops to be associated with each other and for others seldom if ever to be encountered together on the same farm. Thus wheat,barley, field peas and horse beans are so closely correlated as to be regarded as a standard crop mix. Maize,teff and haricot beans form another such mix. Between crops there is a sometimes quite pronounced negative relationship, which is of course largely a function of agro-climatic zone.This is most apparent in the case of starchy staples. Barley, and to a lesser extent wheat, are grown mainly at the higher elevations and maize and teff at lower

Table 5.3: Negatively Correlated Crop Areas All Zones

CROPS[a/]		Coefficient of Determination (r2)	Level of Signif(%)
Laketch,[b/]	Romany[b/]	0.0243	2.3
" ,	Maize	0.0654	0.1
"	*Teff*	0.0441	0.2
"	Haricots	0.0436	0.2
"	All other wheats	0.0203	3.8
Romany[b/],	All other wheats	0.0193	4.3
Supremo[b/]	Maize	0.0237	2.5
"	*Teff*	0.0219	3.1
"	Haricots	0.0189	4.5
Barley,	Maize	0.1392	0.1
"	Hybrid Maize	0.0235	2.6
"	*Teff*	0.0973	0.1
"	Improved *Teff*	0.0273	0.2
"	Haricots	0.0657	0.1
Maize,	Field Peas	0.0226	2.9
"	Horse Beans	0.0029	2.8
"	All Wheats	0.1238	0.1
Teff	Horse Beans	0.0277	1.5
"	All Wheats	0.0875	0.1
Horse Beans,	Haricots	0.0199	4.0
Haricots,	All Wheats	0.0995	0.1

a/ Indigenous varieties unless otherwise stated.
b/ Non-indigenous wheats
c/ 0.1 is listed if the level of significance is 0.1% or better.

TABLE 5.4: Positively Correlated Crop Areas, All Zones

CROPS[a]		Coefficient of Determination (r^2)	Level of Signif(%)
Laketch[b],	Barley	0.0250	2.1
"	Field Peas	0.0937	0.1
"	Horse Beans	0.0739	0.1
Romany[b],	Maize	0.0238	2.5
Supremo[b],	Field Peas	0.0186	4.8
"	Horse Beans	0.0264	1.8
Barley,	Field Peas	0.0456	0.2
"	Horse Beans	0.0290	1.3
"	All wheats	0.0469	0.2
Maize,	*Teff*	0.0601	0.1
"	Haricots	0.2922	0.1
"	Michigan Haricots	0.0370	0.5
Hybrid Maize, Improved *Teff*		0.1738	0.1
Teff, Haricots		0.3433	0.1
Improved *Teff*, Michigan Haricots		0.0386	0.4
Field Peas, Horse Beans		0.0767	0.1
"	All Wheats	0.0599	0.1
Horse Beans, All Wheats		0.0915	0.1

a/ Indigenous varieties unless otherwise stated.

b/ Non-indigenous wheats.

c/ 0.1 is listed if the level of significance is 0.1% or better.

altitudes.

Among the various varieties of wheat, some signif--icant inter-relationships exist, as is shown by the negative correlations between varieties of this crop in Table 5.3. This would suggest at first glance a tendency on the part of farmers to produce one var--iety of wheat to the exclusion of all others, but in fact this tends to be the case only for 'romany' 3/ and 'laketch' , two varieties with very dissimilar characteristics as will be shown later. Many wheat producers,particularly those in the two main wheat growing areas, Zones B and C, include two or even three different varieties of this crop in the same pattern, as can be seen in Table 5.5 . The importance of this feature will be considered in the next chapter.

Table5.5:Distribution of Wheat-producers in Sample by Number of Different Wheat Varieties Grown (Percentage of Farmers).

No of Varieties Grown	ZONE				Total
	A	C	B	D	
One	88.5	69.8	37.5	92.3	72.4
Two	11.5	23.3	52.5	7.7	23.5
Three	0.0	7.0	10.0	0.0	4.1

The number of different crop mixes - 77 in a sample of 211 - is obviously large, so that it becomes difficult to speak of a 'typical' crop mix in the area with any great degree of precision. However the picture is not quite as confused as this would suggest, since many of the crops in the mixes occupy only very small plots. Sorghum, for example, is grown by a quarter of all farmers in Zone B, but covers only 3 per cent of reported cropped area in that zone. The crop mixes shown in Table 5.7 are broadly representative of those found in the four zones. Within a given mix in this table, the areas recorded for each crop are the means of the areas under that crop reported by sample farmers growing that particular mix. These areas have been attached to the crops for the purposes of calculating energy re--quirements in Section 5.6 below.

Table 5.6: Number of Different Crop Mixes, by Zone.

Zone	No of Farmers	No of Crop Mixes	Ratio of Crop Mixes to Farmers
A	67	10	6.7
C	43	12	3.6
B	41 a/	27	1.5
D	58	37	1.6
Overal	209	77	2.7

a/ Excludes two 'not stated'.

TABLE 5.7: Representative Crop Mixes and Mean Crop Areas in the Four Zones (Percentage of each Zone's Reporting Farmers in parentheses)

ZONE.A

1	1.67 ha.barley + 0.9 ha.wheat	(49.3)
11	1.25 ha.barley + 0.2 ha.wheat + 0.7 ha.field peas	(22.4)
111	1.4 ha.barley + 1.2 ha.wheat + 0.8 ha.field peas + 0.5 ha.horse beans	(12.9)

ZONE C.

1	1.2 ha.wheat + 0.9 ha.barley	(37.2)
11	1.5 ha.wheat + 1.25 ha.barley + 0.25 ha.horse beans	(20.9)
111	1.65 ha.wheat + 1.5 ha.barley + 0.6 ha.field peas + 0.25 ha.horse beans	(20.9)

ZONE B

1	1.2 ha.wheat + 0.75 ha.barley + 0.25 ha.horse beans	(22.0)
11	1.8 ha.wheat + 0.8 ha. barley + 0.4 ha.maize + 0.25 ha.horse beans	(17.1)
111	3.4 ha.wheat + 0.9 ha. barley + 0.5 ha.maize + 0.4 ha.field peas + 0.25 ha.horse beans	(12.2)
IV	1.1 ha.wheat + 0.65 ha.barley	(9.8)

ZONE D

1.	1.25 ha.maize + 0.75 ha.teff + 0.5 ha.haricots	(10.3)
11	1.5 ha.maize + 0.7 ha.teff + 0.6 ha.wheat	(10.3)
111	2.6 ha.maize	(8.6)
IV	1.2 ha maize + 0.6 ha.barley + 0.6 ha.wheat	(7.0)

5.2 Repetitions of Crop Operations.

A second factor helping to determine the pattern of a farm's energy requirements for crop cultivation is the standard of husbandry devoted to each individual crop in the mix. Tables 5.8 and 5.9 provide frequency distribut--ions of the number of ploughings before, and the number of weedings after, the seven crops of Table 5.7 are sown. Information on teff and haricots was gathered from farmers in Zone D who did not cultivate wheat, horse beans or field peas so that the number of observations for these crops is small.

The figures shown in these two tables reveal some interesting contrasts both between the same crop in diff--erent zones and between different crops in the same zone. The latter difference is the more obvious. Wheat tends to receive most attention, with the land being ploughed three or four times before sowing and the crop being weeded nor--mally once and often twice. At the other end of the scale, the land is ploughed only once for field peas and the crop is seldom weeded. The maize crop tends to be weeded most often, but, as noted earlier, this tall grow--ing crop can, at least after the first weeding, be weeded by plough, unlike the other crops listed in the tables.

In general the standard of husbandry tends to be highest in Zone B, with more frequent ploughings and, more especially weeding, than is the norm. The cereals

Table 5.8: Number of Ploughings Before Sowing Various Crops, by Zone (Percentage of Reporting Farmers)

CROP/PLOUGHINGS		ZONE				TOTAL
		A	B	C	D	
WHEAT:	TWO	4.9	2.5	27.9	6.5	10.0
"	THREE	70.5	42.5	65.1	52.2	58.9
"	FOUR	23.0	35.0	7.0	32.6	24.2
"	FIVE	-	17.5	-	8.7	5.8
"	SIX	1.6	2.5	-	-	1.1
BARLEY:	ONE	1.5	-	-	-	0.5
"	TWO	19.7	12.5	68.3	33.3	31.8
"	THREE	71.2	45.0	31.7	50.0	52.3
"	FOUR	6.1	27.5	-	16.7	11.8
"	FIVE	1.5	10.0	-	-	2.6
"	SIX	-	5.0	-	-	1.0
MAIZE:	ONE	-	3.6	-	1.8	2.4
"	TWO	-	57.1	-	19.6	32.1
"	THREE	-	25.0	-	57.1	46.4
"	FOUR	-	14.3	-	14.3	14.3
"	FIVE	-	-	-	5.4	3.6
"	SIX	-	-	-	1.8	1.2
FIELD PEAS	NONE	25.7	7.7	7.1	10.6	13.7
"	ONE	65.7	80.8	82.1	71.4	74.4
"	TWO	8.6	11.5	10.7	17.9	12.0
HORSE BEANS	NONE	3.3	-	5.9	-	2.5
"	ONE	10.0	10.0	-	-	5.7
"	TWO	30.0	30.0	11.8	38.9	25.2
"	THREE	33.3	37.5	44.1	61.1	41.8
"	FOUR	10.0	20.0	35.3	-	18.9
"	FIVE	13.3	2.5	2.9	-	4.9
TEFF	TWO	-	-	-	10.0	22.2
"	THREE	-	-	-	60.0	66.7
"	FOUR	-	-	-	33.0	61.1
HARICOT BEANS	NONE	-	-	-	14.3	14.3
"	ONE	-	-	-	28.6	28.6
"	TWO	-	-	-	42.9	42.9
"	THREE	-	-	-	14.3	14.3

Table 5.9: Number of Weedings for Various Crops by Zone

(Percentage of Reporting farmers)

CROP/WEEDINGS		ZONE				TOTAL
		A	B	C	D	
WHEAT	NONE	8.2	-	-	2.2	3.3
"	ONE	67.2	20.6	65.1	77.8	60.7
"	TWO	24.6	67.6	30.2	17.8	32.2
"	THREE	-	5.9	4.7	2.2	2.7
"	FIVE	-	2.9	-	-	0.5
"	SIX	-	2.9	-	-	0.5
BARLEY	NONE	23.9	5.1	2.4	16.7	13.8
"	ONE	70.1	64.1	75.6	79.2	72.3
"	TWO	6.0	23.1	19.5	4.2	11.8
"	THREE	-	5.1	2.4	-	1.5
"	FOUR	-	2.6	-	-	0.5
MAIZE	NONE	-	-	-	1.7	1.2
"	ONE	-	-	-	15.5	10.5
"	TWO	-	28.6	-	74.1	59.3
"	THREE	-	50.0	-	8.6	22.1
"	FOUR	-	17.9	-	-	5.8
"	FIVE	-	3.6	-	-	1.2
FIELD PEAS	NONE	92.1	81.5	96.4	78.6	88.9
"	ONE	2.9	18.5	3.6	21.4	11.1
HORSE BEANS	NONE	3.3	-	8.8	-	3.3
"	ONE	46.7	67.5	14.7	57.9	46.3
"	TWO	50.0	30.0	61.8	42.1	45.5
"	THREE	-	2.5	14.7	-	4.9
TEFF	ONE	-	-	-	55.6	55.6
"	TWO	-	-	-	44.4	44.4
HARICOT BEANS	ONE	-	-	-	85.7	85.7
"	TWO	-	-	-	14.3	14.3

tend to receive more attention in Zones B and D, while horse beans are rather better cared for in Zones A and C. Maize provides an interesting case: the seedbed is generally more carefully prepared in Zone D, but the crop is more frequently weeded in Zone B. It was noted earlier (Table 4.24) that there is a relative scarcity of oxen in Zone B, so that this is possibly a case of a bottleneck in ploughing being partially eased by more frequent weeding afterwards, when timeliness of operation is not so crucial and when plough-weeding can be supplemented by hand-weeding.[4/]

At the level of the individual farm it is interesting to compare the degree of attention paid to seedbed prepar--ation (indicated by the number of times the land is ploughed) and that paid to weeding (indicated by the number of times the crop is weeded). As noted previously these two types of operation may be regarded as substitutes. Alternatively, however, they may be complimentary,reflect- the general standard of husbandry on a given farm. In fact the latter relationship appears to hold for at least two crops, wheat and horse beans, since in both cases a positive corr--elation exists between the number of ploughings and the number of weedings.[5/] In the cases of the other three major crops the evidence is not conclusive in either direction.

4/ The test for a negative relationship between the number of times maize land is ploughed and the number of times it is weeded is inconclusive. The correlation coefficient was indeed negative as expected, but only in the 15 per cent level of significance which does not justify reject--ion of the null hypothesis.

5/ Wheat: $r^2 = 0.024$, level of significance 1.6%
Horse Beans: $r^2 = 0.108$, level of significance 0.1%.

TABLE 5.10: Correlations Between Number of Repetitions of Ploughing and Weeding for Major Crops

CROPS		No of times Ploughed		No of times Weeded	
		r^2	Signif.(%)	r^2	Signif.(%)
wheat,	barley	0.448	0.1	0.281	0.1
"	maize	0.075	0.9	0.308	0.1
"	field peas	-	n.s.	-	n.s.
"	horse beans	0.058	0.4	-	n.s.
barley,	maize	-	n.s.	0.078	0.8
"	field peas	-	n.s.	0.031	3.0
"	horse beans	0.025	3.9	0.031	2.7
maize,	field peas	-	n.s.	-	n.s.
"	horse beans	0.086	2.3	-	n.s.
field peas	horse beans	0.133	0.1	-	n.s.

n.s. = not statistically significant at the 5% level.

5.3 CALENDAR OF OPERATIONS.

Figure 5.1 indicates the seasonal distribution of rainfall and temperature, the first of which, as was noted in Chapter 1, is the major factor determining seasonal peaks in energy requirements for agriculture in the tropics. Figures for only one year are available so that a few words of comment on the representativeness of 1974 for this purpose are in order. These comments are mainly based on the same publication (CADU,1975) from which the meteor--ological observations were taken. During the period of the 'belg' rainy season (the March peak) in 1974,rainfall was slightly less and temperature slightly higher than usual. In the 'kerempt' rainy season (June to September),rain--fall in Zones A and C were rather less, and in Zone B slightly more, than average. In Zone D rainfall was normal. Temperature was normal throughout the 'kerempt' rains. During the long dry season (Oct to Jan) rainfall and temper--ature conditions were normal. Peaks of rainfall during the month of May in Zones A and C are also unusual; normally this rainfall would be spread much more evenly over the period April to June. The dotted lines on the diagrams serve as an indication of a rather more 'typical' rainfall pattern.

Both the inter-seasonal and the inter-zonal climatic patterns of Chilalo are revealed in Figure 5.1. Comparing the four zones, it can be seen that the level of precipit--ation is positively related, and the mean temperature

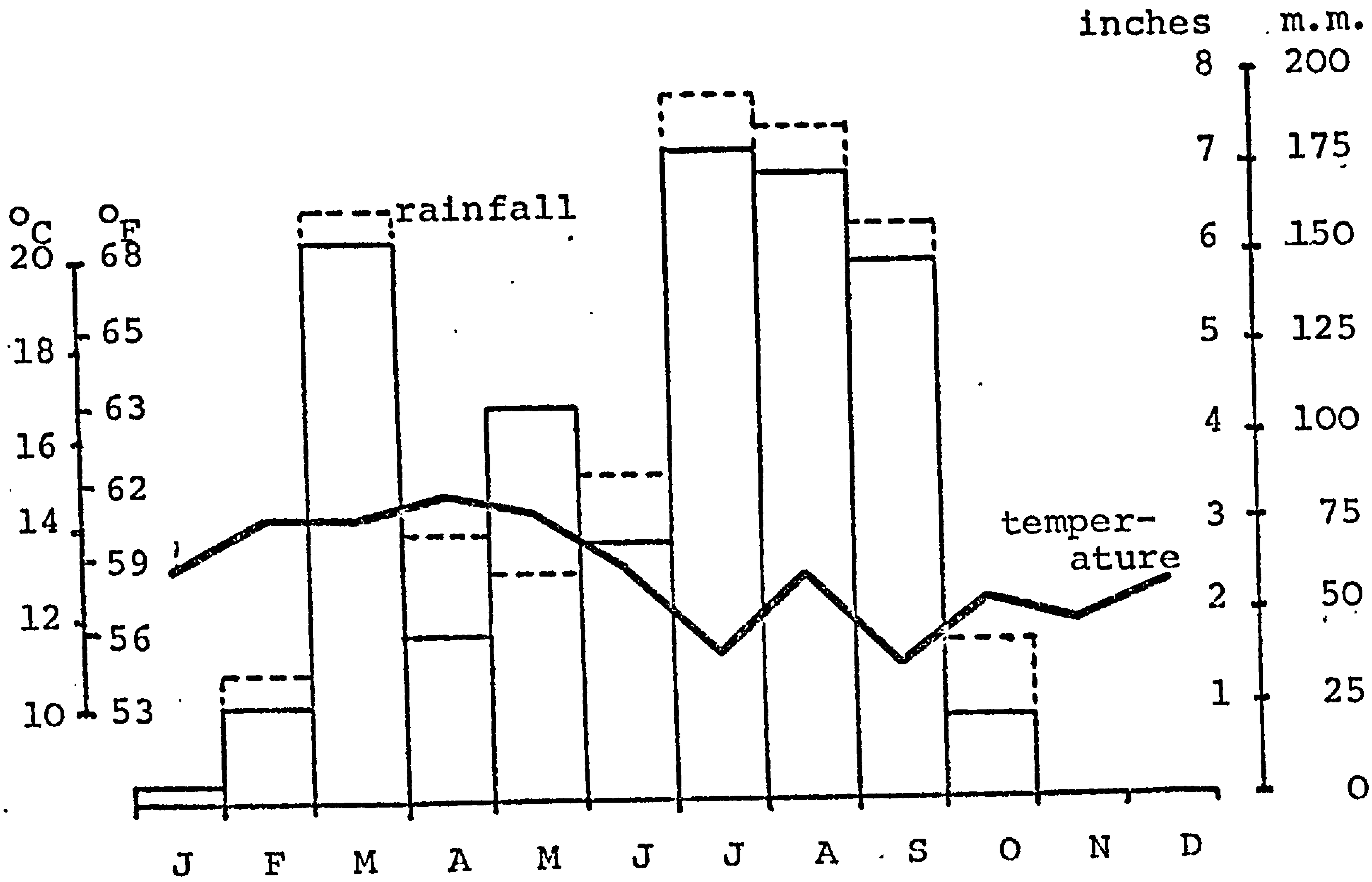

Diagram 5.1.1: Zone A (Mean elevation of sample sites: 2627 metres (8620 ft).))

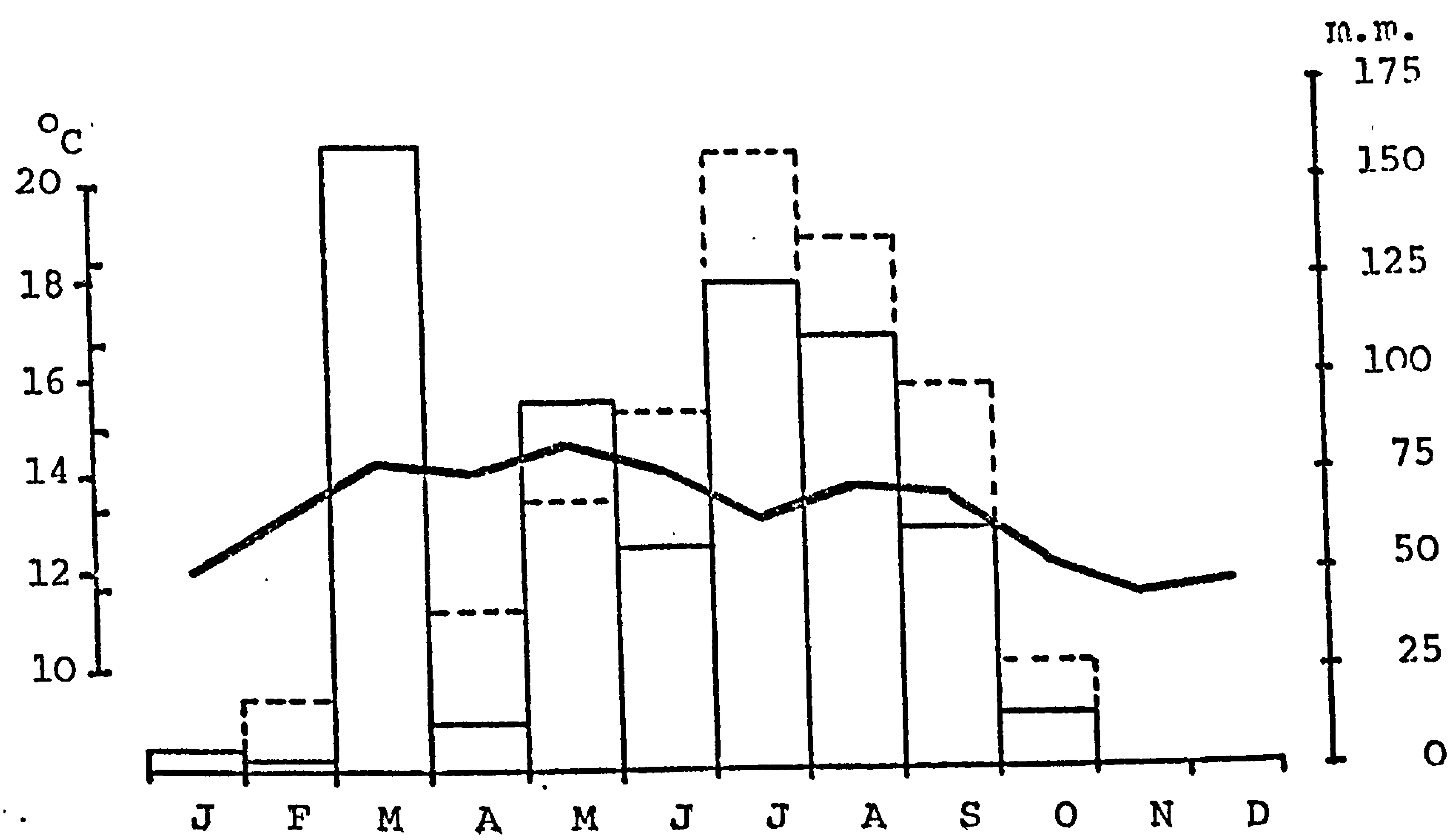

Diagram 5.1.2: Zone C (Mean elevation of sample sites: 2490 metres (8170 ft).)

FIGURE 5.1: CHILALO: MONTHLY DISTRIBUTION OF RAINFALL AND TEMPERATURE IN FOUR ZONES, 1974

Source: Adapted and drawn from figures given in CADU (1975) pp3-10

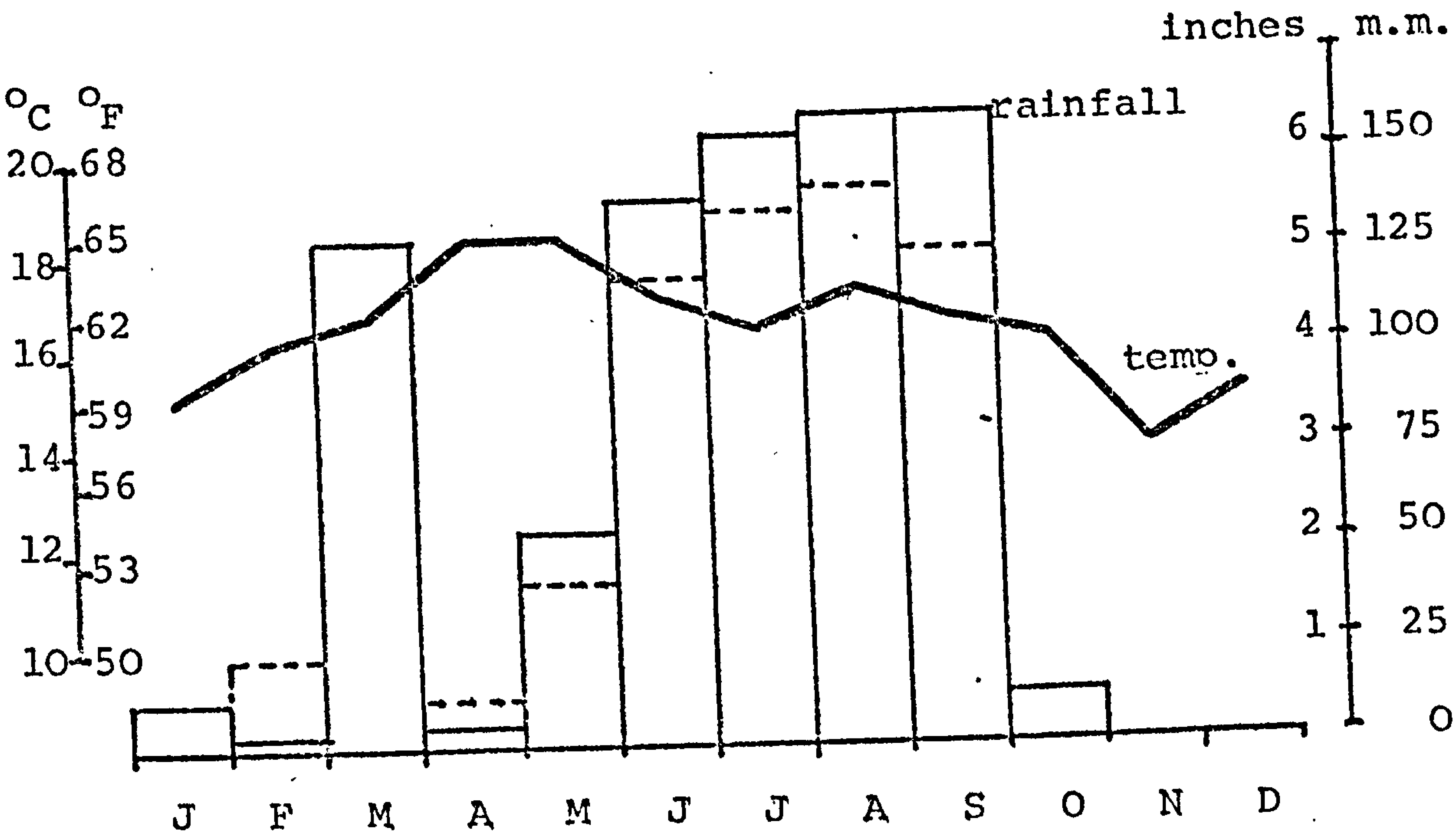

Diagram 5.1.3: Zone B (Mean elevation of sample sites: 2188 metres (7180 ft).)

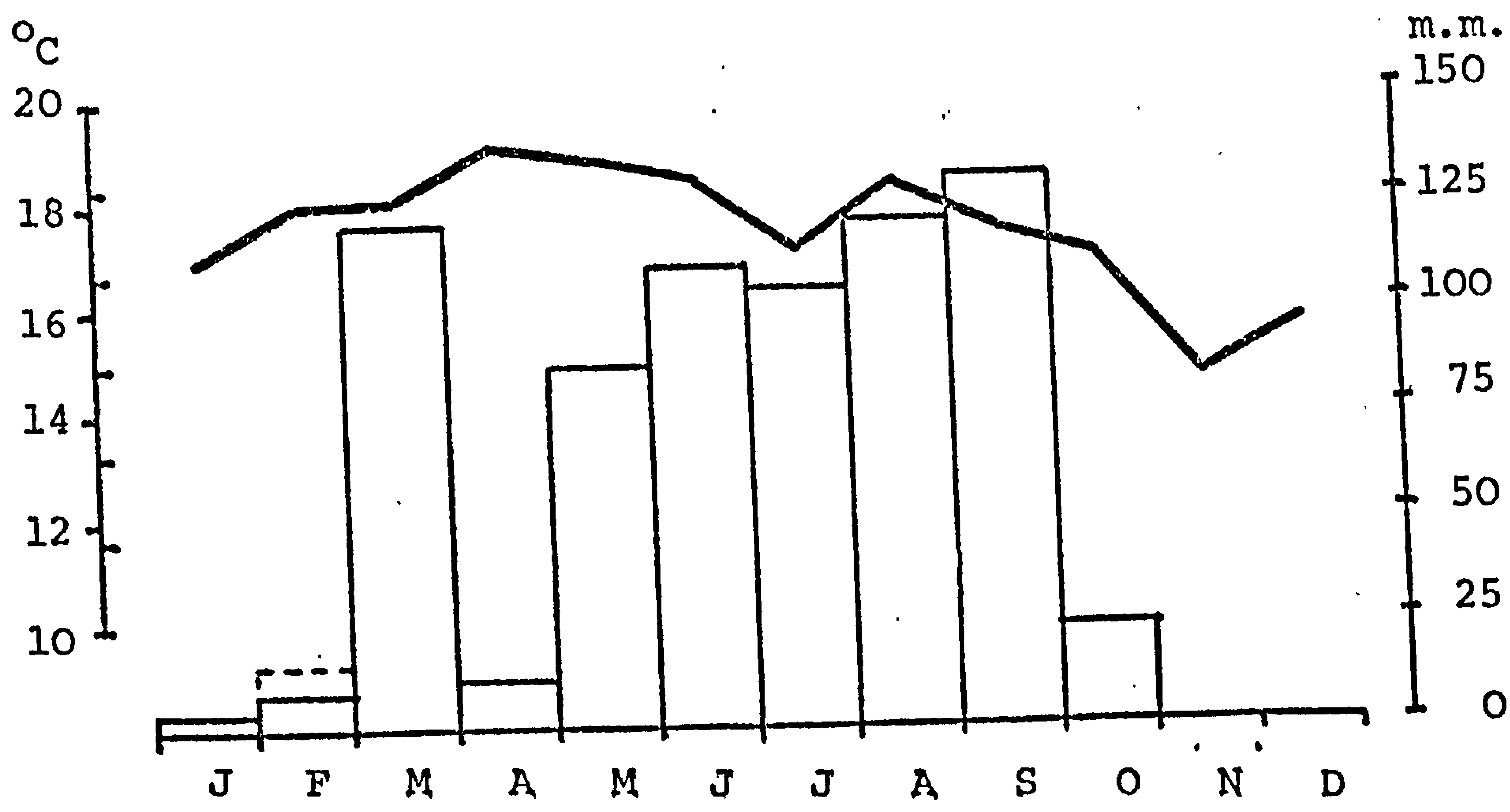

Diagram 5.1.4: Zone D (Mean elevation of sample sites: 1676 metres (5500 ft).)

FIGURE 5.1 (contd)

negatively related to altitude, both of which factors have important bearings on the crop season, as will be shown below. The inter-seasonal pattern of variations is also clear: two rainy seasons of unequal length and two(relat--ively) dry seasons the longer of which occurs at the turn of the year.6/

The influence of rainfall on crop cultivation can clearly be seen when Figures 5.1 and 5.2 are compared.7/ The onset of the 'belg' rains softens the land and signals the beginning of the farm year. The land is first ploughed to allow the rain to soak into the soil and successive ploughings before the crop is sown destroy the weeds which have sprouted with the first rains. Most of the crops are sown at the onset of the main ('Kerempt') rains and are harvested in the long dry season. Threshing and other post-harvest operations follow as soon as possible after the harvest is competed.

One characteristic to emerge very clearly from Figure 5.2 is the relationship between altitude and the growing

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6/ This pattern can be seen to conform quite closely to the schematic representation of the relationships between rainfall and latitude shown in Figure 1.1.The latitude of Chilalo is between 7° and 8° 30' North.

7/ Not all farmers in a given Zone reported exactly the same month for a given operation on a given crop.Figure 5.2 gives in each case the time of year reported by the majority - and in most cases the majority is very substantial - of respondents.

MONTH	Zone	J	F	M	A	M	J	J	A	S	O	N	D
WHEAT													
	A			P_1		P_2	P_3S		W_1	[P_1]			H
	C			P_1		P_2	P_3S		W_1			H	
	B			P_1		P_2		P_3S	W_1	W_2		H	
	D					P_1	P_2	P_3S	W_1			H	
BARLEY													
	A			P_1		P_2	P_3S		W_1	[P_1]		H	
	C			P_1			P_2S		W_1		H		
	B			P_1		P_2		P_3S	W_1		H		
	D					P_1	P_2	P_3S	W_1		H		
MAIZE													
	B		P_1		P_2S	W_1		W_2		W_3			H
	D			P_1 P_2	P_3S		W_1			W_2			H

FIGURE 5.2: CHILALO: CALENDAR OF OPERATIONS FOR SEVEN CROPS IN THE FOUR AGRONOMIC ZONES (continues overleaf)

P_1 = first ploughing; P_2 = second ploughing, etc
W_1 = first weeding; W_2 = second weeding, etc
S = sowing and seed-covering; H = harvest.
P = breaking new (fallow) land for next season.

MONTH		J	F	M	A	M	J	J	A	S	O	N	D
FIELD PEAS													
ZONE	A						P_1S					H	
ZONE	C						P_1S					H	
ZONE	B						P_1	S				H	
ZONE	D						P_1	S			H		
HORSE BEANS													
ZONE	A			P_1		P_2	P_3S		W_1	W_2		H	
ZONE	C			P_1		P_2	P_3S		W_1	W_2		H	
ZONE	B			P_1		P_2	P_3S		W_1		H		
ZONE	D					$P_1P_2P_3$S			W_1	W_2	H		
TEFF													
ZONE	D					$P_1P_2P_3$S			W_1	W_2		H	
HARICOTS													
ZONE	D					P_1P_2S			W_1		H		
		J	F	M	A	M	J	J	A	S	O	N	D

FIGURE 5.2 (continued)

season for each crop. Generally speaking, in the lower zones the lower level of rainfall necessitates a later start to the cropping season, but the higher temperatures ensure that crops mature more quickly than at higher ele--vations. The net effect is that for any given crop the season is more concentrated and seasonal effects more pronounced at lower altitudes. A second important feat--ure of the cropping season which is highlighted in Figure 5.2 is the extent to which different crops impose either complementary or competing demands on energy supp--lies. Thus most crops are in competition as far as plough--ing and weeding are concerned but wheat and barley for example are harvested at different times. Maize appears to be a particularly useful crop in this respect, since its requirements are complementary to those of most other crops during the growing season. This question will be taken up again in greater detail in Section 5.6

5.4 TIME REQUIRED FOR CROP OPERATIONS.

Information on this topic derives from two sources. First those sample farmers who were interviewed in detail provides information on the number of man-days required for each operation. Two farmers who possessed functioning watches supplied supplementary data which was supported by reports of extension agents on the len--gth of a normal working day. This transpires to be seven, occasionally eight, hours for purely manual tasks like weeding and harvesting. However, in operations where oxen are employed, five hours is more usual, or if the work is especially strenuous as in the first ploughing, the working day is only three or four hours after which, according to the farmers, their oxen are exhausted. For ploughing, figures are available on a 'per hectare' basis from two CADU studies in which farmers have actually been timed when working.

Obviously the time required to compete a given oper--ation is far from being constant and will vary in resp--oncse to variations in, for example, soil type and condition, quality of oxen, field sizes and slope, crop type and condition, the strength of the farmer and the standard of husbandry achieved (and, of course,Parkinson's 'Law' applies too). Variations in reports of times required are therefore inevitable. The range of estimates recorded in the CADU studies referred to earlier and those reported by farmers who had themselves timed their operations were perfectly consistent, as can be seen from Table 5.11[8/]. A sample of four is of course very small, but these results do create confidence in the reliability of estim--ates provided by farmers on operations for which no

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8/Figures are also available from CADU (1969,pp25-9) on the number of man-hours for threshing grain on a 'per quintal' basis. Using reasonable yield assumptions (see Chapter 8), these are also broadly consistent with the farmers' reports.

TABLE 5.11: Estimates of Times Required for Ploughing.

(Man-hours per Hectare)

	SOURCE OF ESTIMATE			
	CADU(I) [a/]	CADU(2) [b/]	FARMER A	FARMER B
First Ploughing	38	48	40	48
Second Ploughing	(32) [c/]	37	28	40
Third Ploughing	26	25	28	30

a/ CADU (1969): b/ CADU (1970) p3. c/ Author's estimate.

corroborative evidence is available.

Estimates of the number of man-days and ox-days required for each major crop operation are given in Table 5.12. A few words of comment on this table are necessary. First the figures are given in man-days rather than hours in order to allow for variability in the former period. Second in the case of transportation, only the movement of the crop (and its straw) between the fields and the threshing floor is included.

The times given for the harvest and for post-harvest operations in Table 5.12 refer only to the two major crops of Chilalo, wheat and barley. In the case of minor crops the same times can be assumed, except in the following cases where observation and report suggest otherwise. First apart from 'teff' , none of the minor crops (of Table 5.7) requires winnowing. Second, field peas and haricot beans are not cut with a sickle but are simply uprooted, so that possibly only half the time would be needed to harvest these crops. Third, the pulse crops are shelled rather than threshed, so that oxen are not required. Fourth, the second and subsequent weedings of maize are done by plough rather than by hand so that the time required is similar to that for seed-covering. Finally farmers find the transportation of maize, either on the stalk or on the cob more difficult than other crops, so that the estimate of time required has been doubled in this case.

TABLE 5.12: ESTIMATES OF TIME REQUIRED FOR CROP OPERATIONS (per hectare).

OPERATION	MAN-DAYS	OX-DAYS
FIRST PLOUGHING	11-14	22-26
SECOND PLOUGHING	6- 8	12-16
THIRD PLOUGHING	5- 6	10-12
SOWING	0.5	---
SEED COVERING	5-6	10-12
FIRST WEEDING	23-34	---
SECOND WEEDING	17-20	---
HARVEST	20-25	---
TRANSPORTATION	0.5- 1	1-2
THRESHING	12-24	40-50
WINNOWING	4-5	---
TOTAL	108-145	96-120

5.5 ON-FARM SOURCES OF ENERGY.

'Energy' is used here in the sense of what is some--times called 'biological energy', i.e the labour of human beings and animals, In Chilalo the only animal used in the process of crop production (as distinct from trans--portation) is the ox, so that the number of oxen owned by the farm family can serve as a convenient surrogate measure of energy supply from farm animals.9/ In the case

9/ One exception is that haulage of crops from the fields is usually on ox-sleds.

of human energy supplies, the situation is rather more complex, because of specialisation in farm tasks,and because of differences in the capacity for work,com- -paring sexes and age groups.

One important limitation on farm energy supplies arises from the fact that the women must perform many household chores in addition to any farming activities in which they are engaged, so that even where they are able to perform certain farm operations they will be available only part-time; here it will be assumed that they can devote half as much time as the men to farm- -ing. There are also certain tasks which are more stren- -ous than others and therefore are more time-consuming for women and children than for men. In weeding a woman can work as quickly as a man, but for other tasks it will be assumed that one unit of adult female labour is equal to 0.75 man-equivalents (m.e). For similar reasons a unit of child labour which is used only in weeding is assumed to equal 0.5 m.e. Children able to do more strenuous work will be considered to equal 0.75 m.e. [10] When these estimates are used to adjust the sample farmers' re- -ports of family labour summarised in Section 4.2, the family labour available for the various crop operations can be calculated.

10/ These coefficients are somewhat crude estimates based on the author's observations. The latter two figures do however tally with WHO "nutritional consumption units" in which children up to ten years are equated to 0.5 adult (male) equivalents and those of 10-15 years to 0.75 m.e.

The sample is in fact fairly uniform in regard to both sources of energy, as can be seen in part from the modal values presented in Table 5.13. There is, however, some degree of positive skew in the distributions,aris--ing largely from the few farmers who report unusually large families and/or an unusually large number of oxen on the farm. In fact the modal values tend to some extent to conceal the positive relationship which exists between on-farm supplies of biological energy sources and the area under cultivation, a feature which emerges rather more clearly upon examination of Table 5.14.11/

5.6 FARM ENERGY REQUIREMENT-AVAILABILITY PROFILES 12/

The data contained in Tables 5.8, 5.9, 5.12, and 5.14, when combined with the calendar of operations(Figure 5.2), can be used to compute (a) the labour and oxen input re--quirements of the fourteen crop mixes of Table 5.7,and (b) the availability of family labour and farm oxen. This information is summarised in annual terms in Table 5.15, from which it can be seen that for virtually every crop mix the farm's potential energy supplies would be more than adequate to meet requirements if the latter were .

11/Correlation analysis of the whole sample shows that the relationships which exist between on the one hand total reported cultivated area and on the other family labour available for each task,number of different crops grown and number of oxen,are positive and statistically sign--ificant at the one per cent level or better.

12/These concepts are not of course equivalent to 'demand' and'supply' as conventionally used in economics.

TABLE 5.13: Modal Availability of Oxen and Family Labour for Various Farm Operations by Zone and by Crop Mix (see Table 5.7)

	FAMILY LABOUR AVAILABLE (man-equivalents)						NO. OF
ZONES/MIXES	PLOUGHING	SOWING	WEEDING	HARVESTING	THRESHING	WINNOWING	OXEN
AI, AII, CII, BI, DIII	1	1	1.5	1	1.4	1	2
CIII, DI	1	1	1.5	1	1.4	1.4	2
BIII, DII	1	1	1.5	1	1	1	2
AIII	1	1	1.5	1.4	1.4	1	2
CI	1	1	1.5	1.4	1.4	1.4	2
BII	1	1	3.0	1.9	1.4[a]	1	2
BIV	1	1	1.5	1	1.4	1	0
DIV	1	1	1.5	1	2.2	1	2

[a] No modal value; overall mode used instead.

TABLE 5.14: Mean Availability of Oxen and Family Labour for Various Farm Operations by Zone and by Crop Mix

Zone/ Crop Mix	Family Labour Available (Man-day equivalents/month)						Ox-days per -month
	Plough.[b]	Sow.	Weed.	Harvest.	Thresh.	Winnow.	
AI (2.57 ha)	28.6	24.2	35.2	30.8	28.6	37.4	37.4
AII (3.15 ha)	24.2	24.2	46.2	30.8	35.2	37.4	37.4
AIII (3.90 ha)	28.6	28.6	52.8	37.4	41.8	35.2	48.4
CI (2.10 ha)	28.6	28.6	35.2	30.8	30.8	30.8	30-8
CII (3.00 ha)	35.2	35.2	48.4	48.4	31.4	35.2	30.8
CIII (4.00 ha)	30.8	28.6	48.4	33.0	39.6	39.6	46.2
BI (2.20 ha)	33.0	24.2	59.4	37.4	55.0	35.2	35.2
BII (3.25 ha)	48.4	33.0	61.6	41.8	55.0	44.0	52.8
BIII (5.45 ha)	41.8	35.2	96.8	50.6	55.0	46.2	57.2
BIV (1.25 ha)	33.0	22.0	35.2	22.0	37.4	28:6	17.6
DI (2.5 ha)	35.2	33.0	46.2	39.6	39.6	35.2	39.6
DII (2.8 ha)	33.0	33.0	44.0	37.4	24.2	22.0	48.4
DIII (2.6 ha)	22.0	22.0	30.8	26.4	28.6	22.0	52.8
DIV (2.4 ha)	26.4	22.0	48.4	33.0	37.4	37.4	44.0

a/ Roman numerals refer to the standard crop mixes of Table 5.7.

b/ Calculated on a basis of 22 working days per month (see Section 4.2.4).

TABLE 5.15 ENERGY REQUIREMENTS AND ON-FARM ENERGY AVAILABILITY FOR FOURTEEN CROP-MIXES (days per annum)

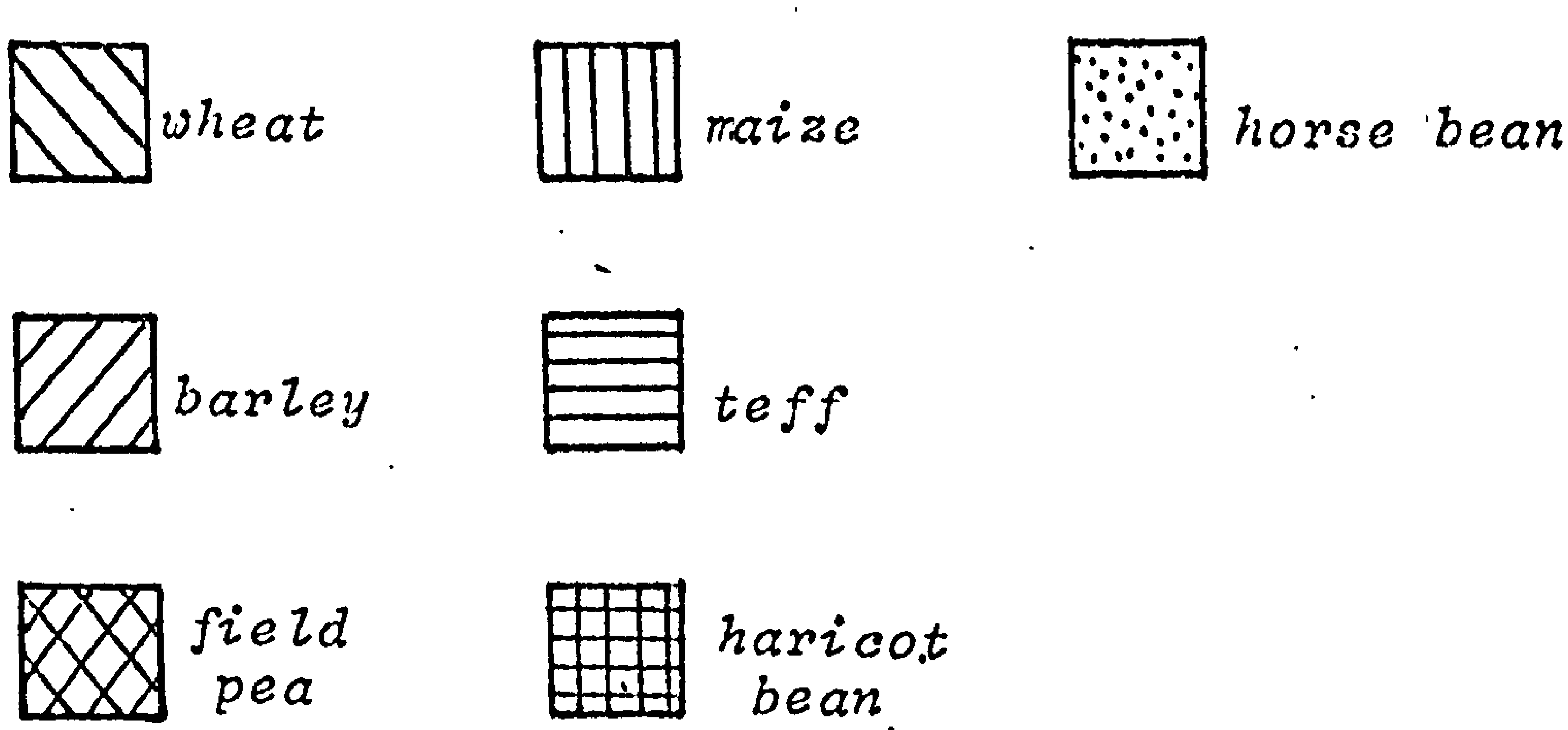
ENERGY REQUIREMENTS/ AVAILABILITY[a]	ZONE AND CROP-MIX													
	AI	AII	AIII	CI	CII	CIII	BI	BII	BIII	BIV	DI	DII	DIII	DIV
Labour Requirements (min)	240	253	326	184	265	325	217	357	411	127	238	269	241	223
" " (max)	321	346	440	255	361	430	244	466	537	152	313	363	331	318
Available On-farm labour	375	423	459	370	491	445	495	604	644	371	444	403	304	385
Ox-day Requirements (min)	242	241	287	182	265	318	200	284	486	178	211	275	249	242
" " (max)	309	301	383	239	346	392	248	401	627	228	263	345	333	290
Available On-farm ox-days	449	449	581	320	370	554	422	634	686	211	475	581	634	528

a/ Labour requirements and availability in non-equivalents; maximum and minimum based on ranges shown in Table 5.11.

Sources: Derived from Tables 5.8, 5.9, 5.11 and 5.13.

Notes on Figure 5.3

1. *REQUIREMENTS are represented by the 'bars' of the bar chart. Within each bar, the total shaded area represents the total input required by all crops in the mix in that particular month. All of those areas are based on the* minimum *time requirements shown in Table 5.13. Within each bar each shaded portion represents the minimum requirement of the given acreage of a particular crop from the mix. The dashed extensions to the bars show the total time required if the maximum estimates from Table 5.13 are used. The shaded area for each crop would also require to be adjusted in proportion if the higher estimates are used.*
2. *AVAILABILITY figures are based on Table 5.14 modified in accordance with the calendar of operations. In the case of Zone D, the 50 per cent 'dip' in labour availability in September reflects the reduction in the labour potential of Muslim farmers during* Ramadhan. *In the case of the other three zones whose farmers are predominantly Christian, the 'working month' in January is assumed to be three days shorter than usual because of religious holidays noted in Section 4.2.4.*
3. *The following crop keys have been used throughout Figure 5.3:*



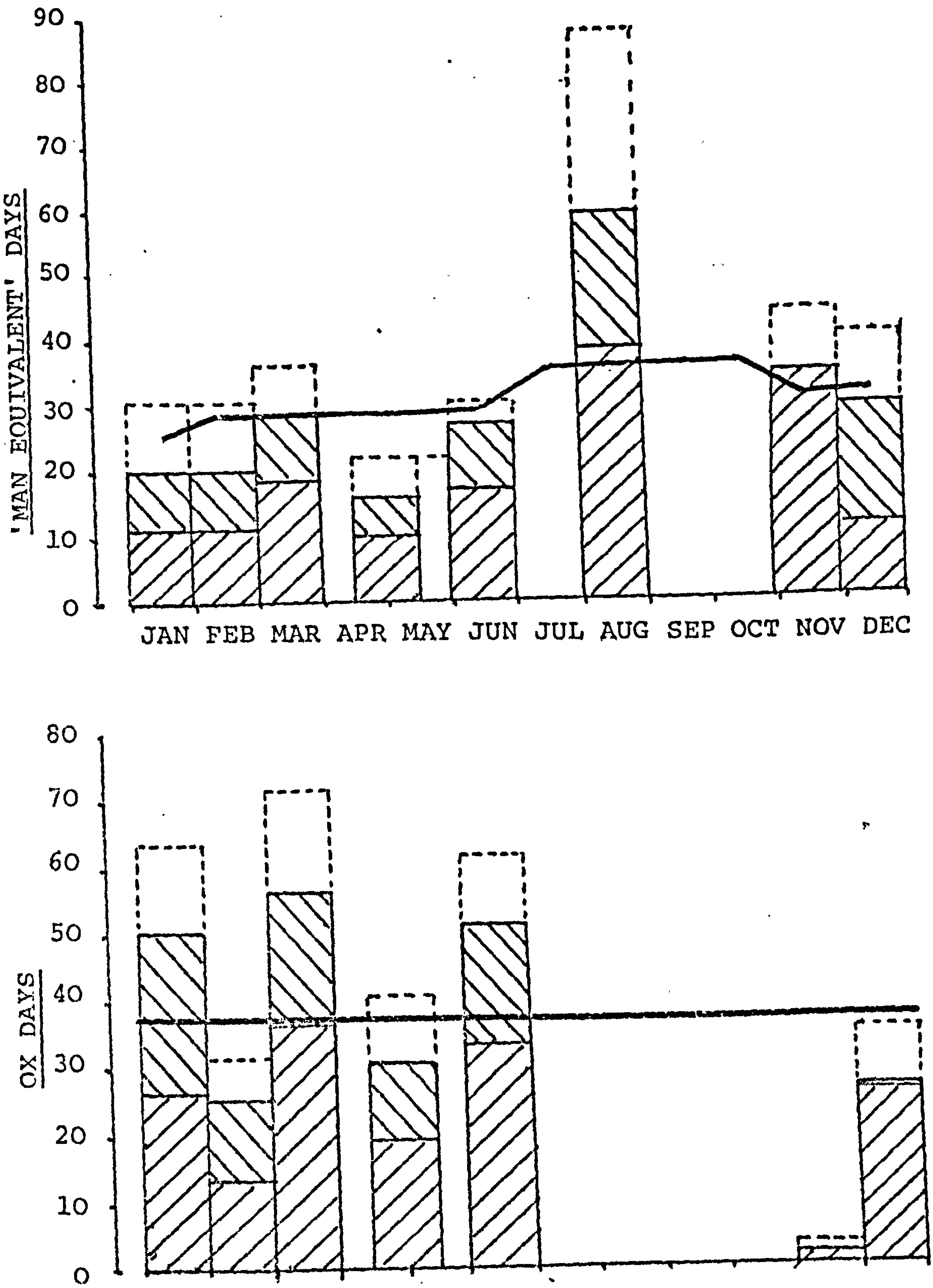
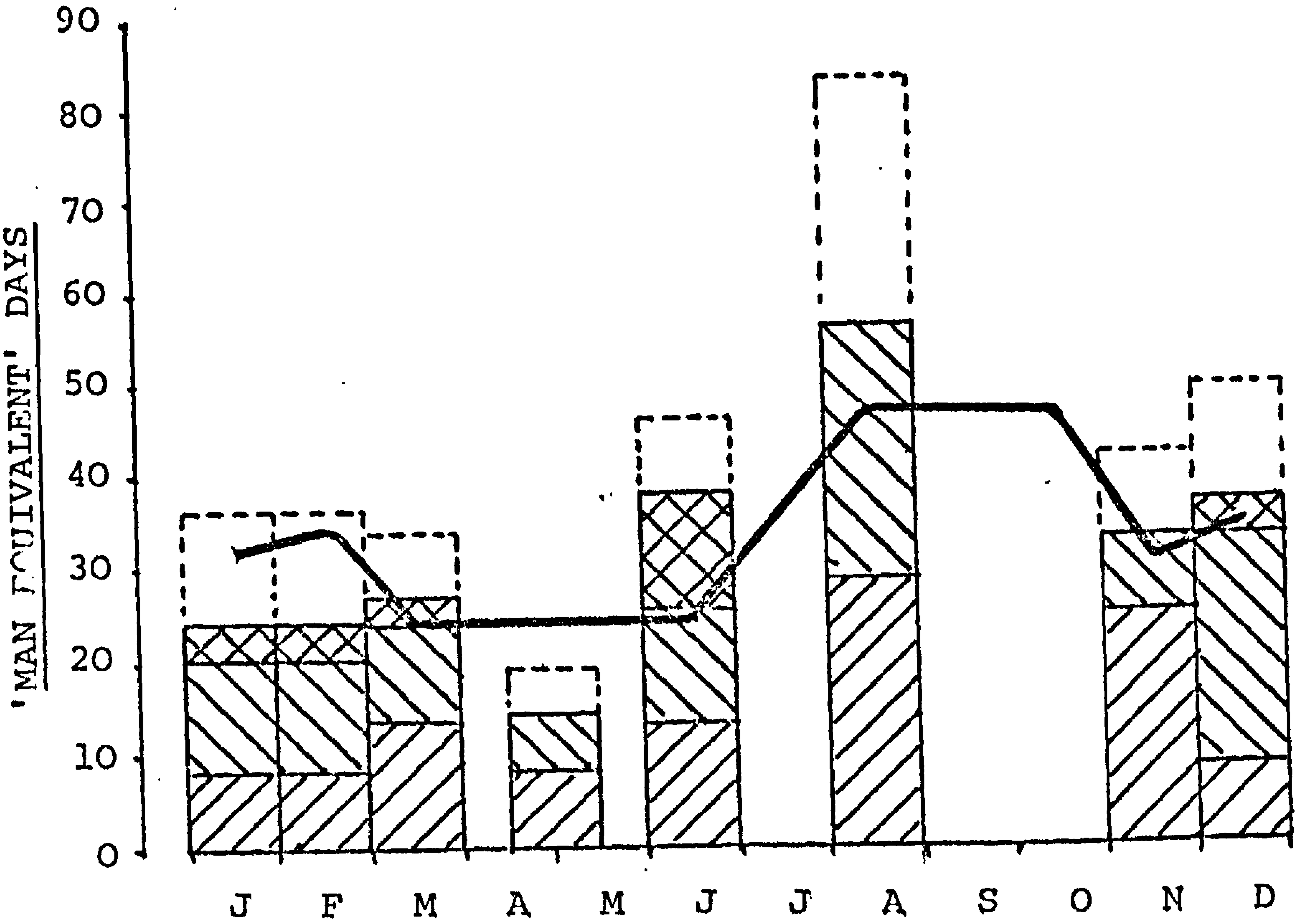


Diagram 5.3.1: Zone A, Crop Mix I

FIGURE 5.3: FARM ENERGY REQUIREMENT-AVAILABILITY PROFILES



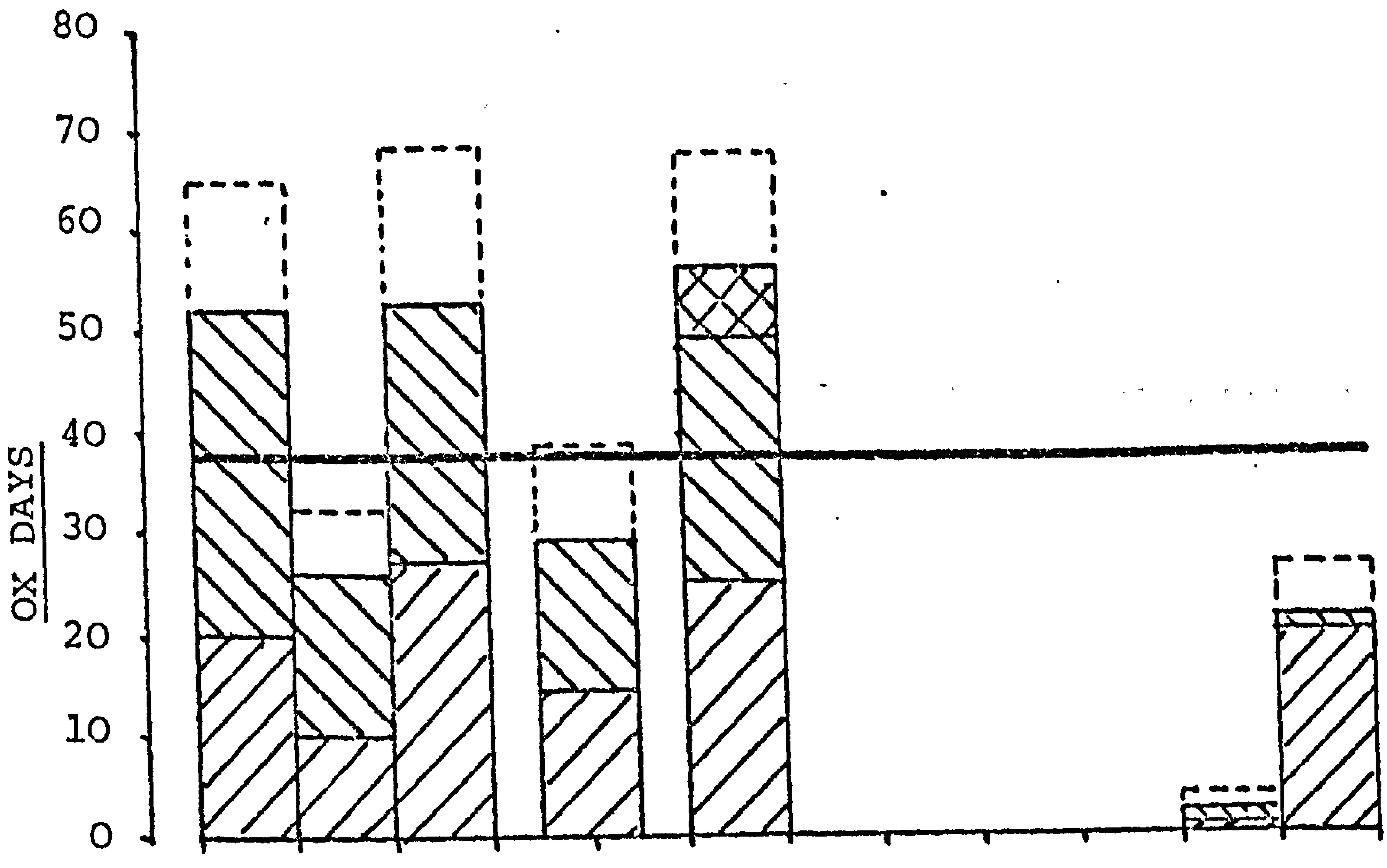
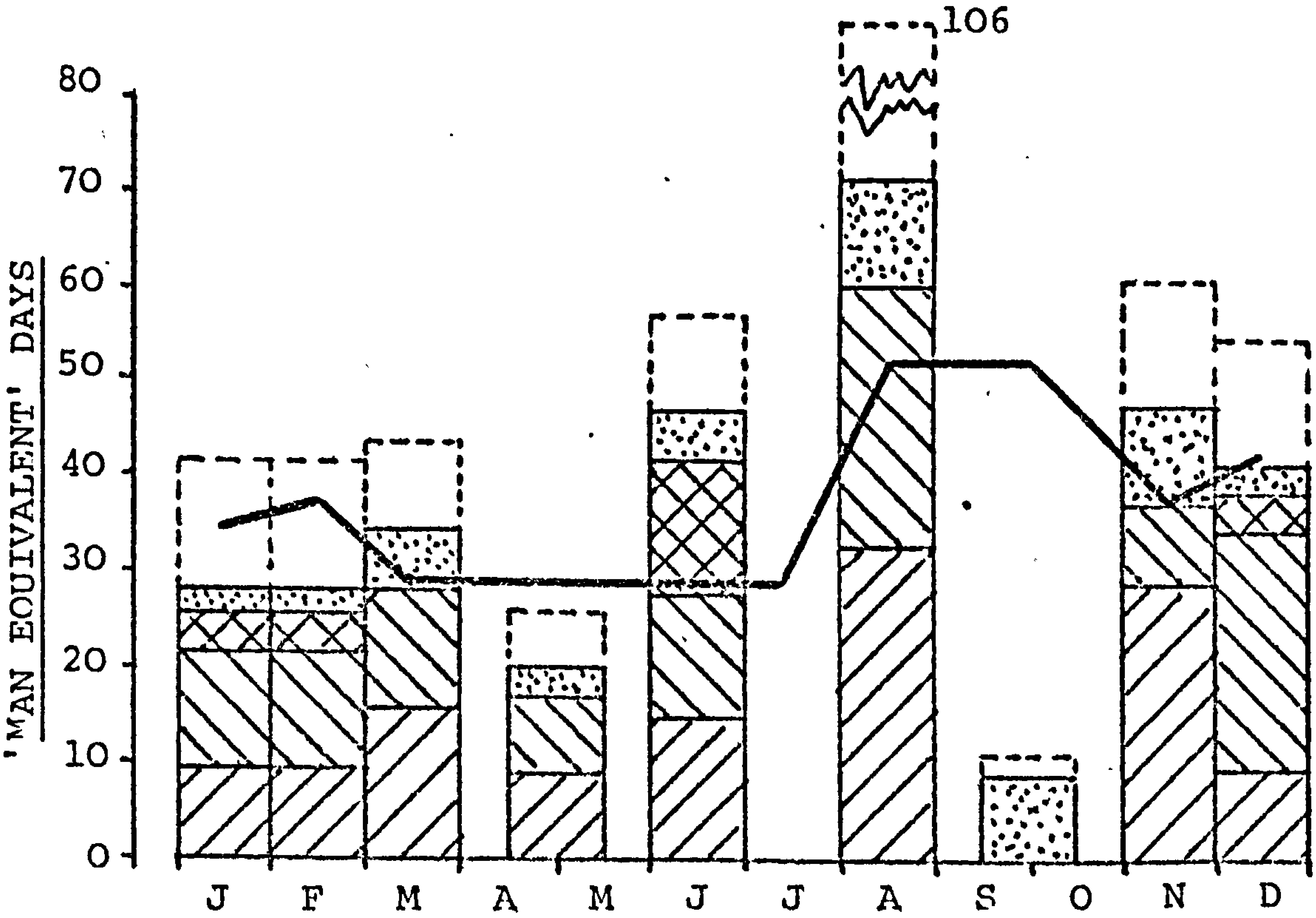


Diagram 5.3.2: Zone A, Crop Mix II

FIGURE 5.3 (contd)



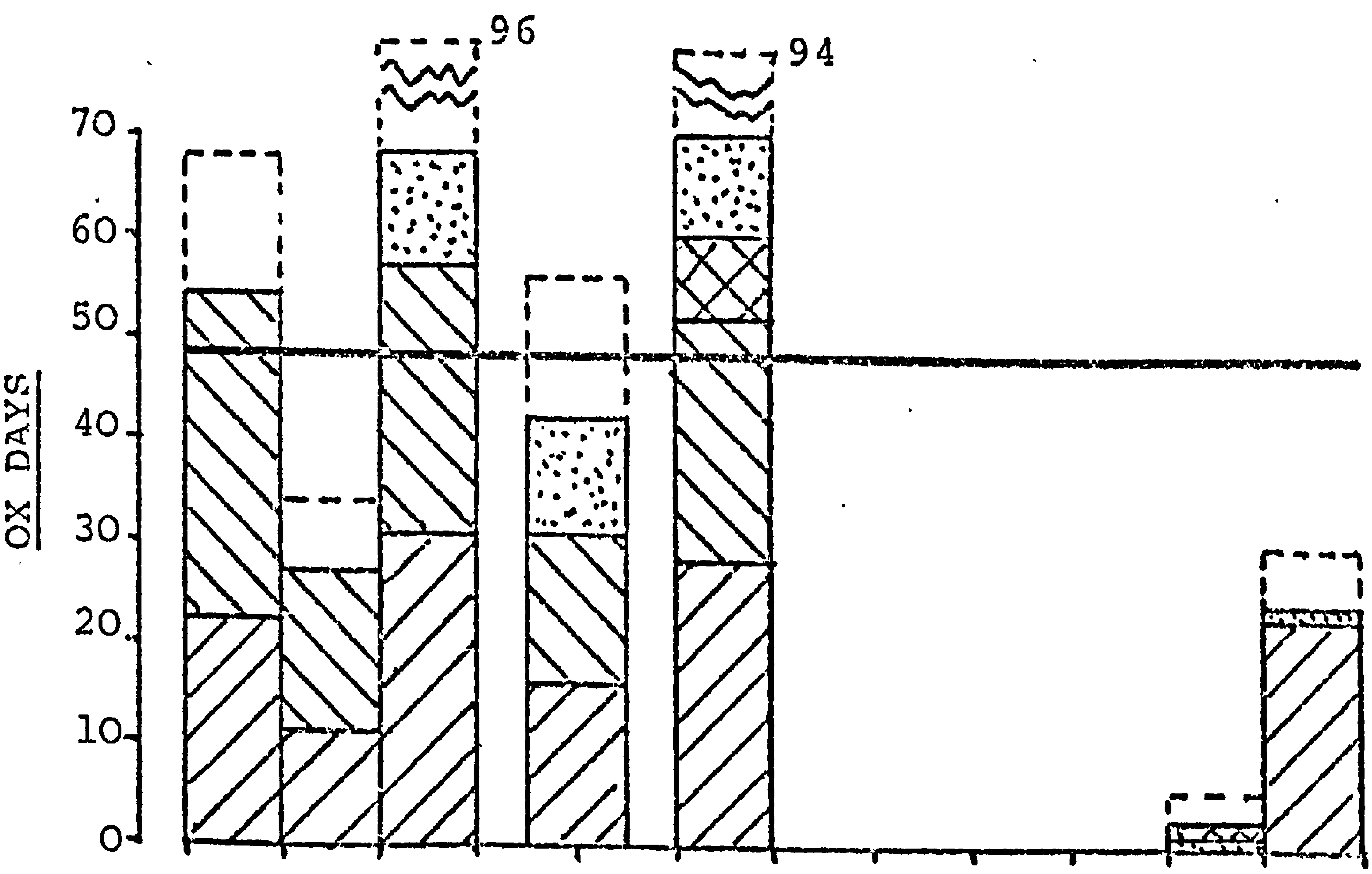
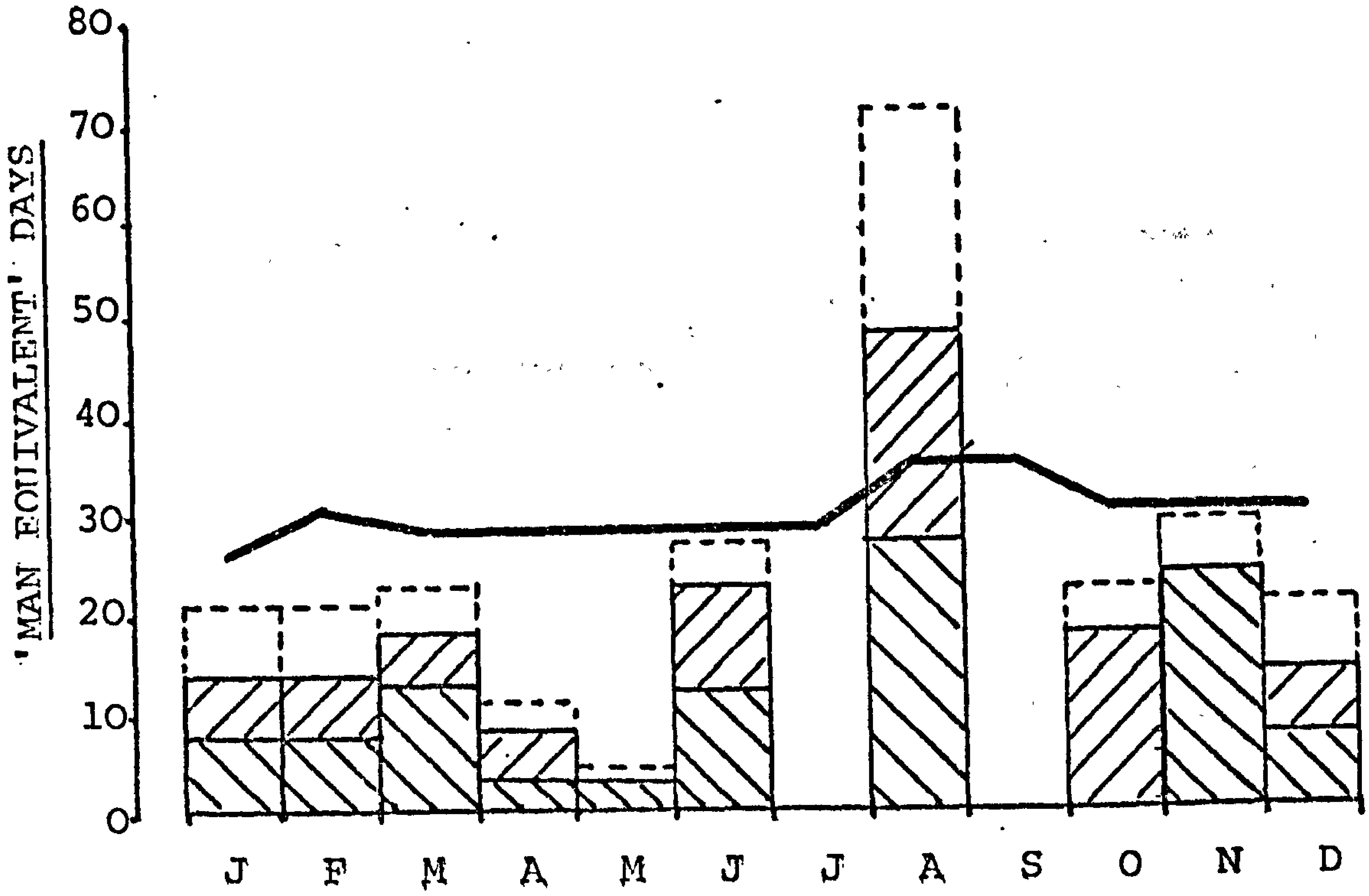


Diagram 5.3.3: Zone A, Crop Mix III

FIGURE 5.3 (contd)



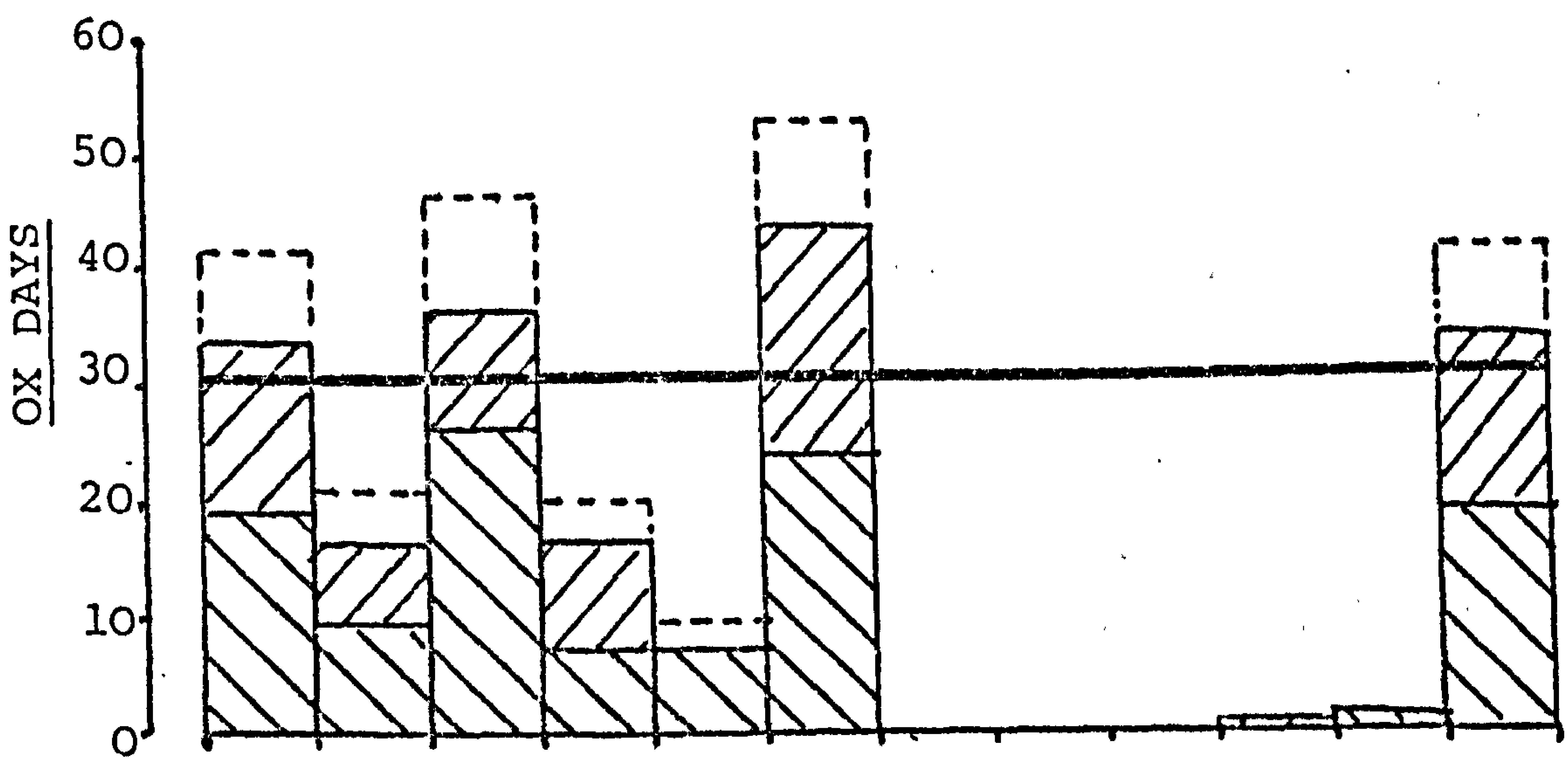


Diagram 5.3.4: Zone C, Crop Mix I

FIGURE 5.3 (contd)

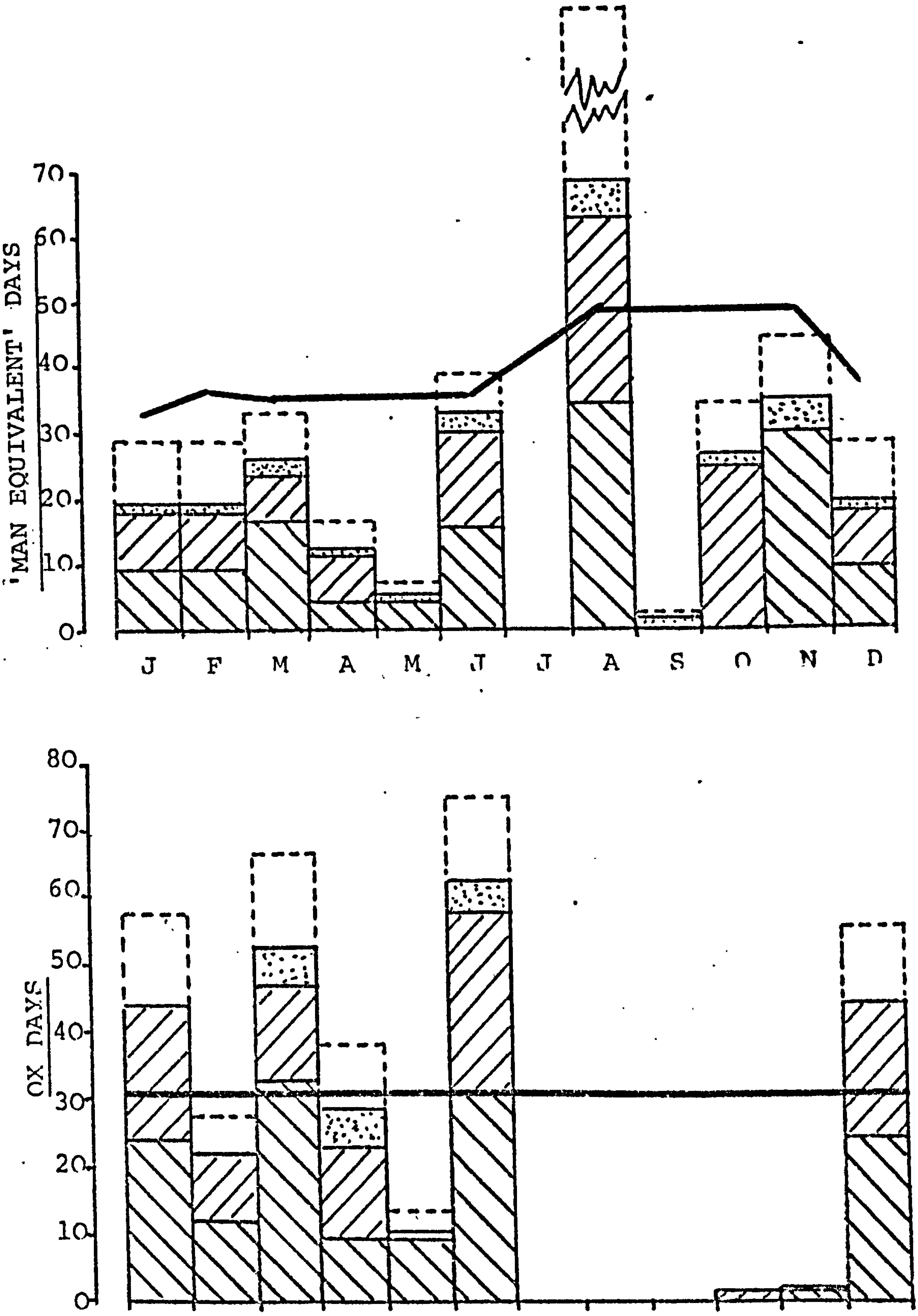


Diagram 5.3.5: Zone C, Crop Mix II

FIGURE 5.3 (contd)

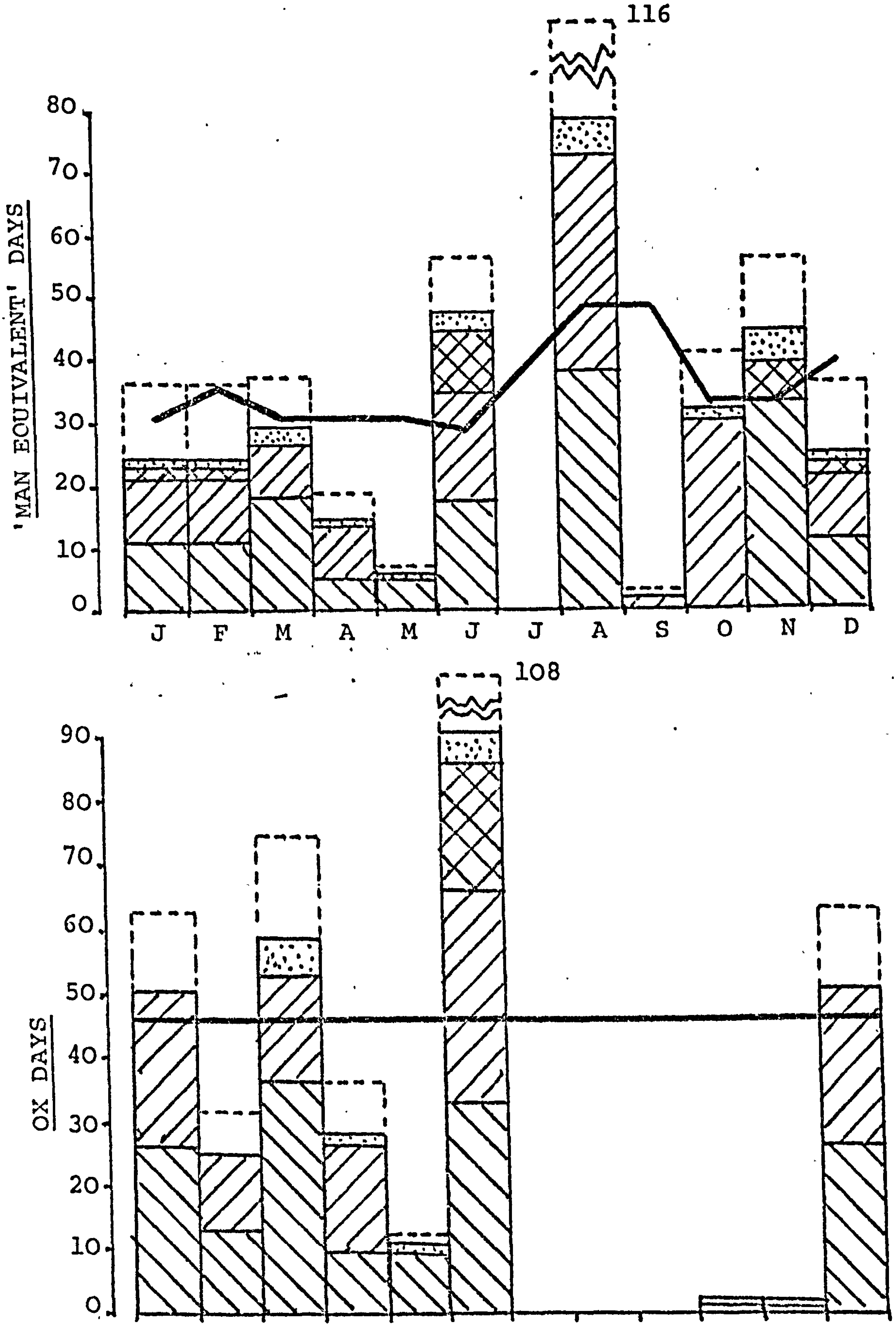


Diagram 5.3.6: Zone C, Crop Mix III

FIGURE 5.3 (contd)

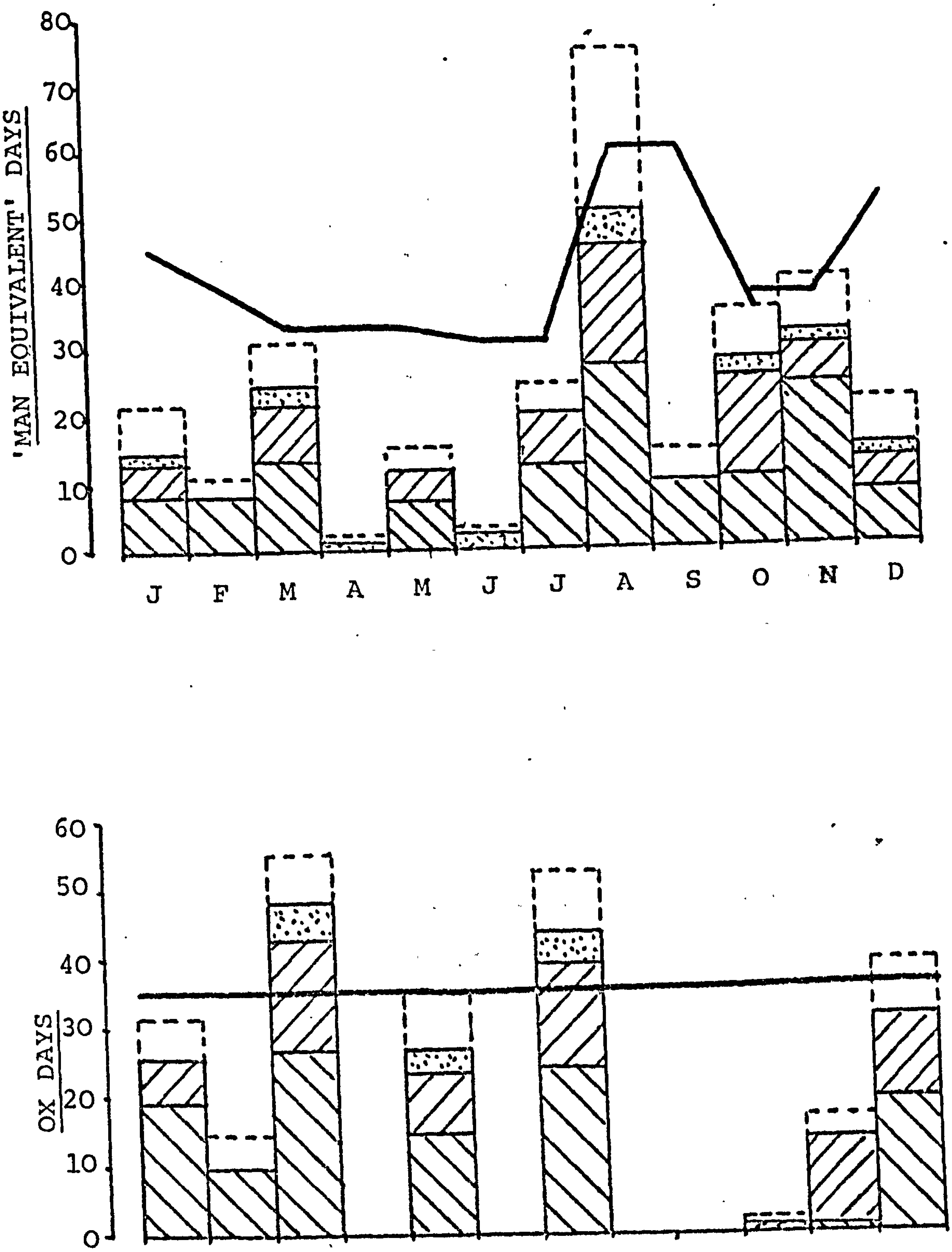


Diagram 5.3.7: Zone B, Crop Mix I

FIGURE 5.3 (contd)

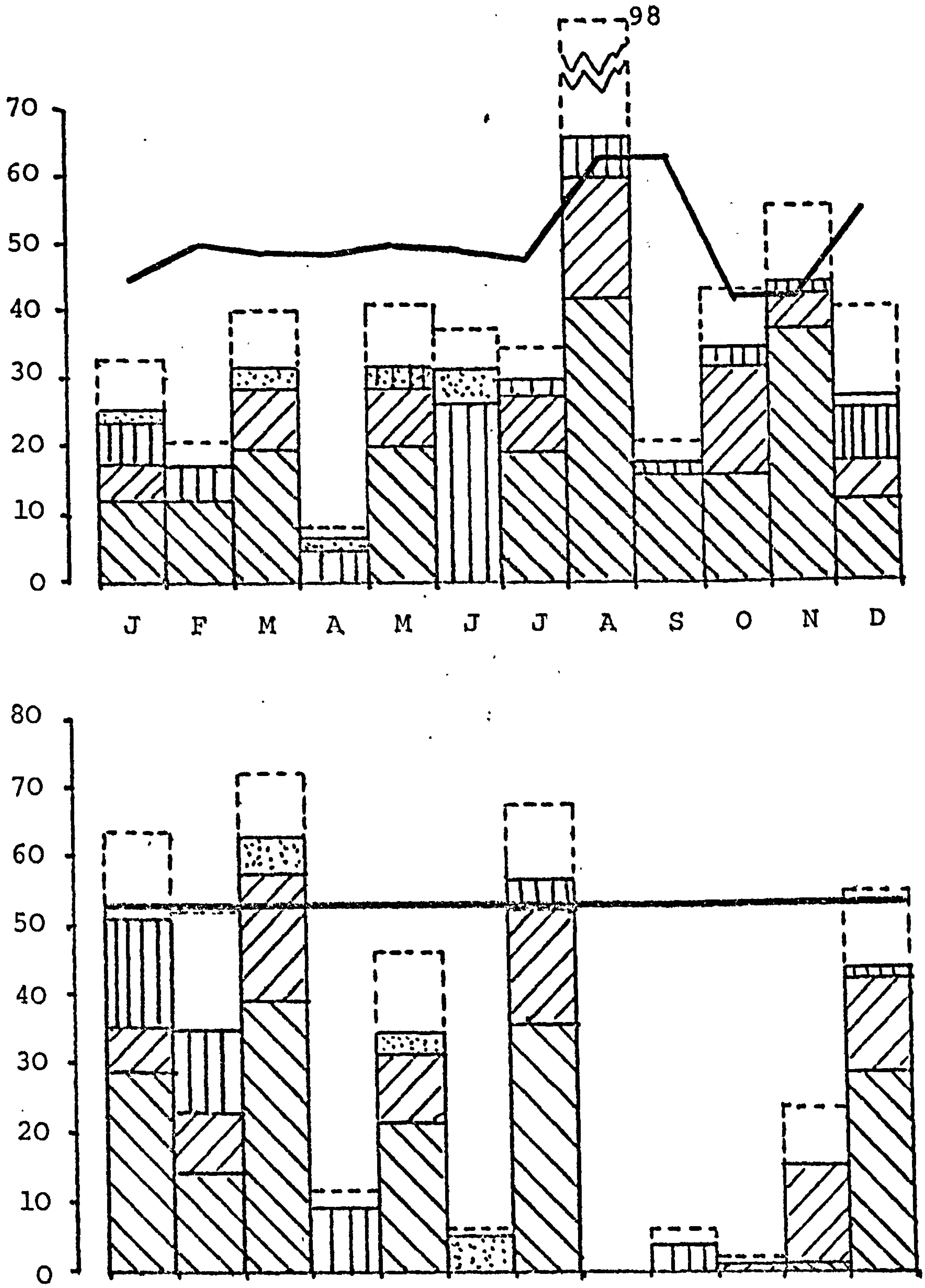


Diagram 5.3.8: Zone B, Crop Mix II

FIGURE 5.3 (contd)

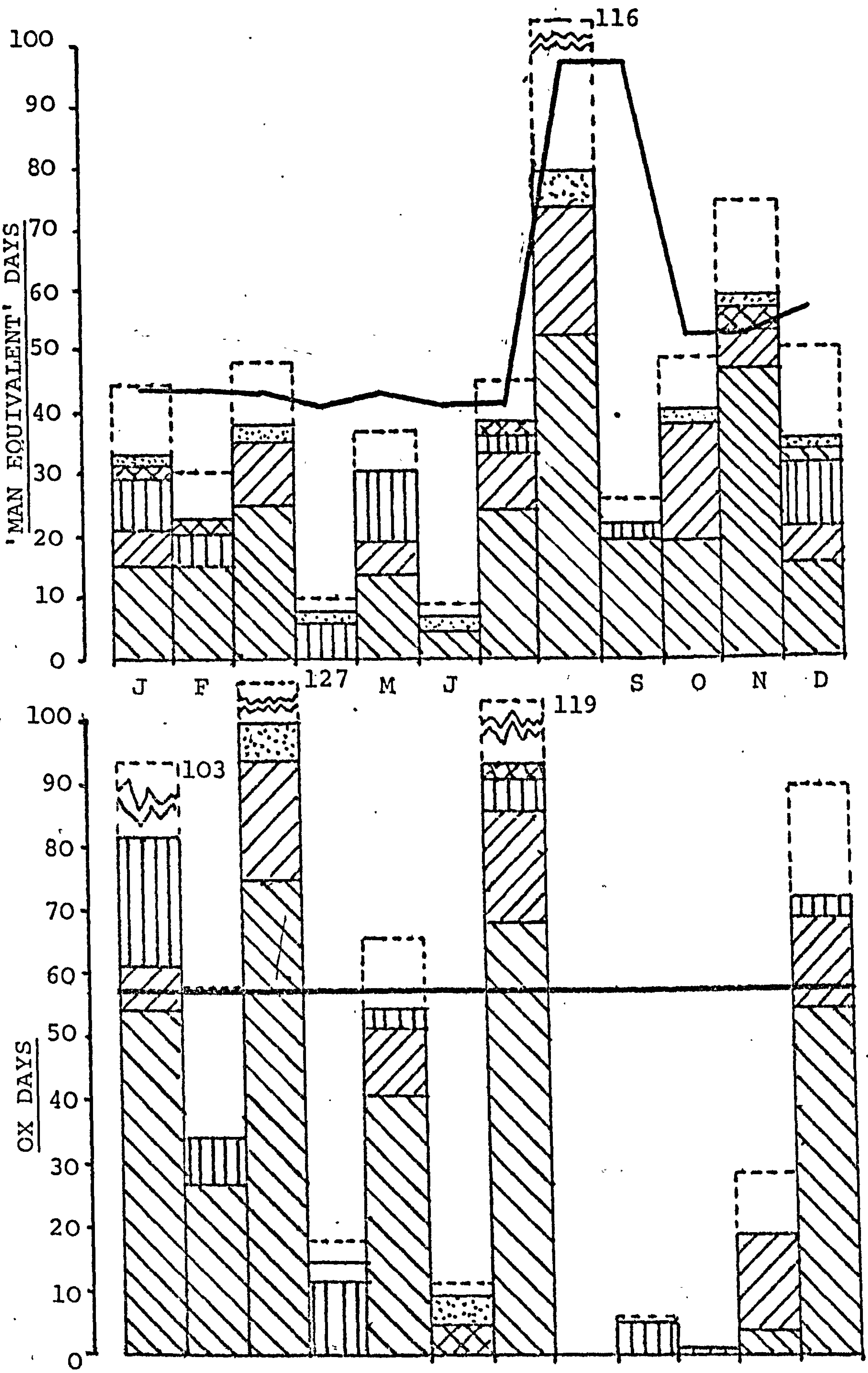
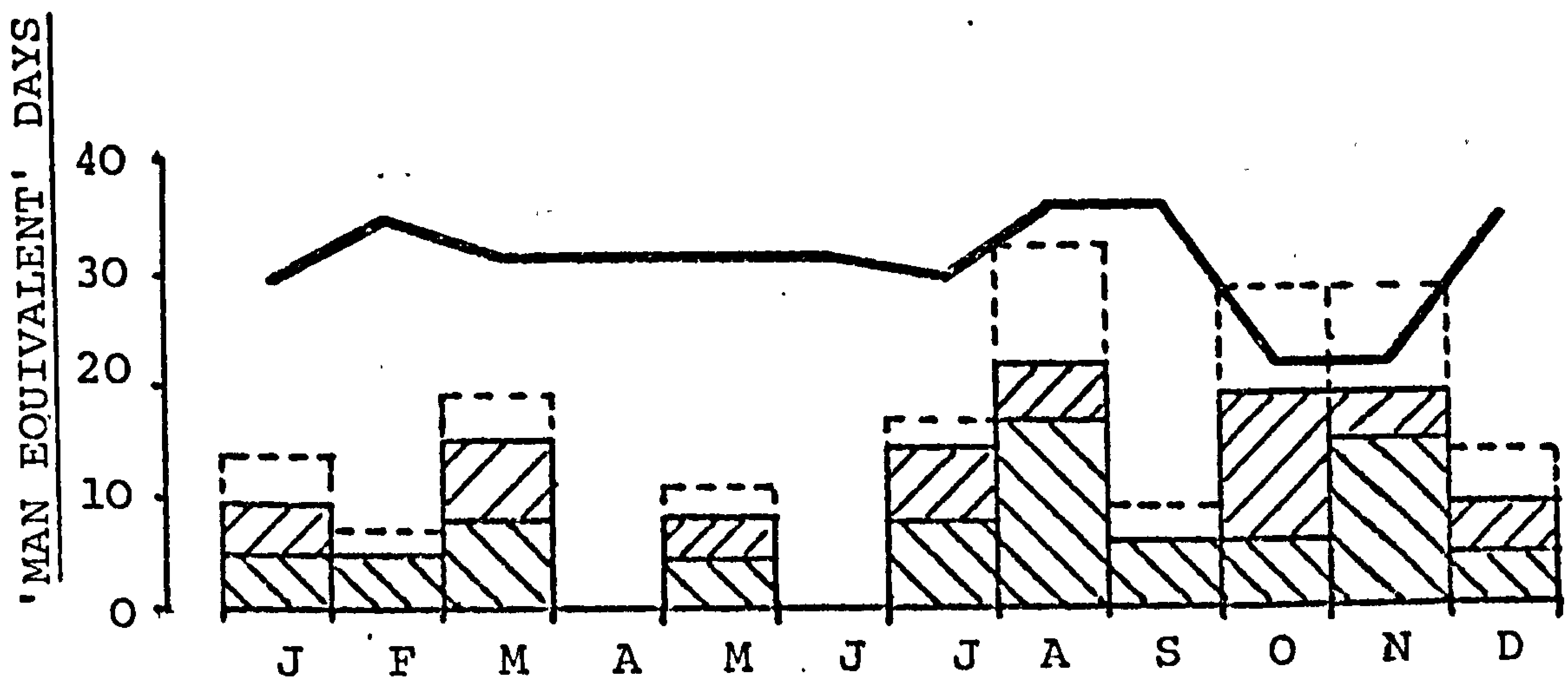


Diagram 5.3.9: Zone B, Crop Mix III

FIGURE 5.3 (contd)



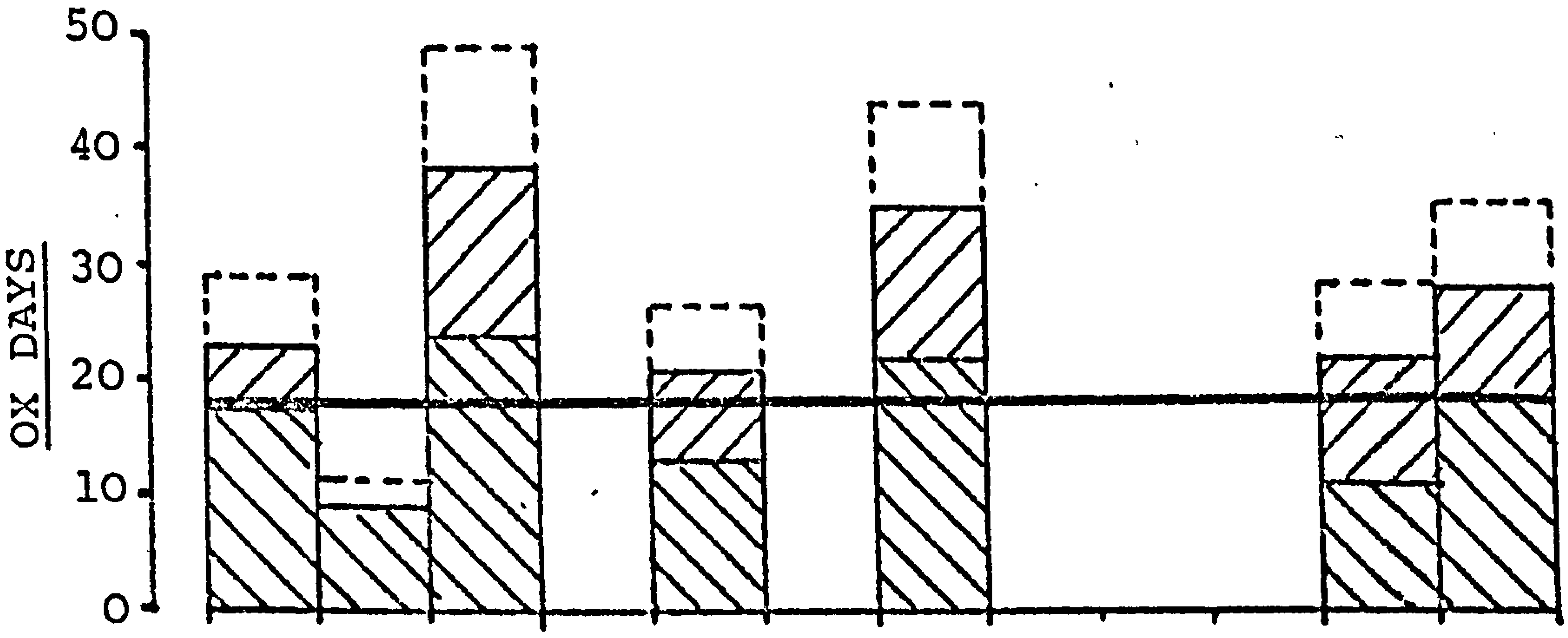


Diagram 5.3.10: Zone B, Crop Mix IV

FIGURE 5.3 (contd)

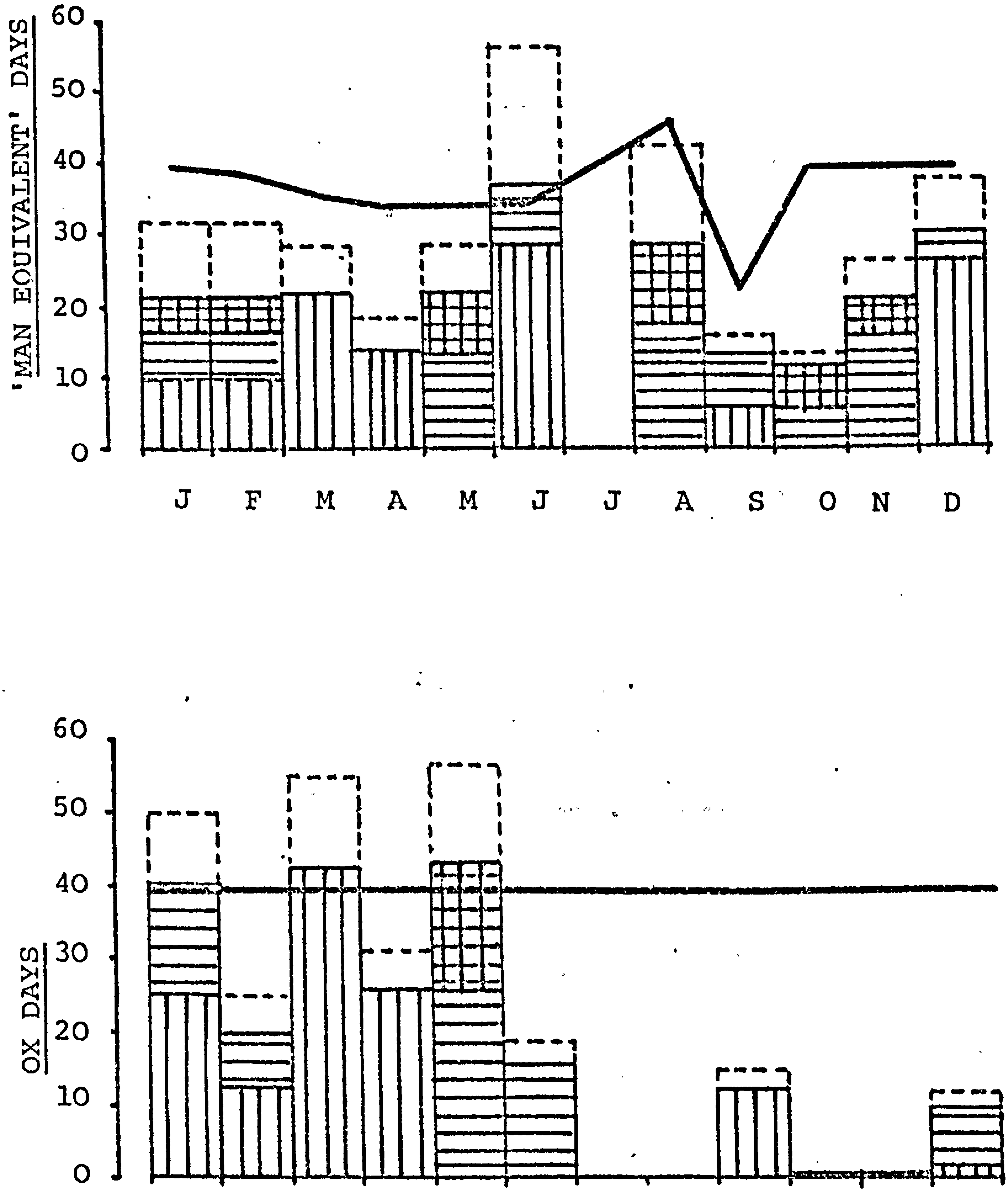
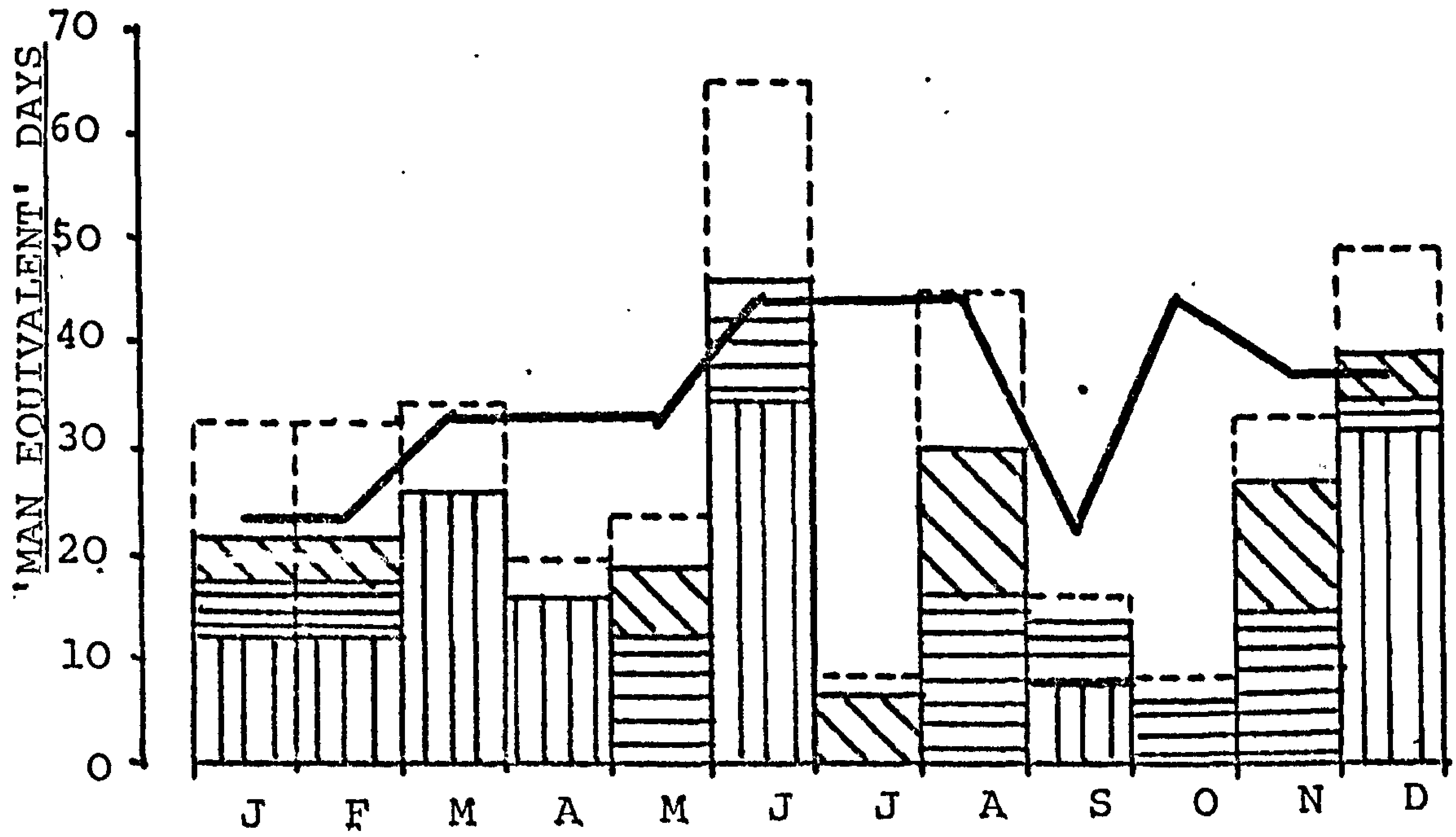


Diagram 5.3.11: Zone D, Crop Mix I

FIGURE 5.3 (contd)



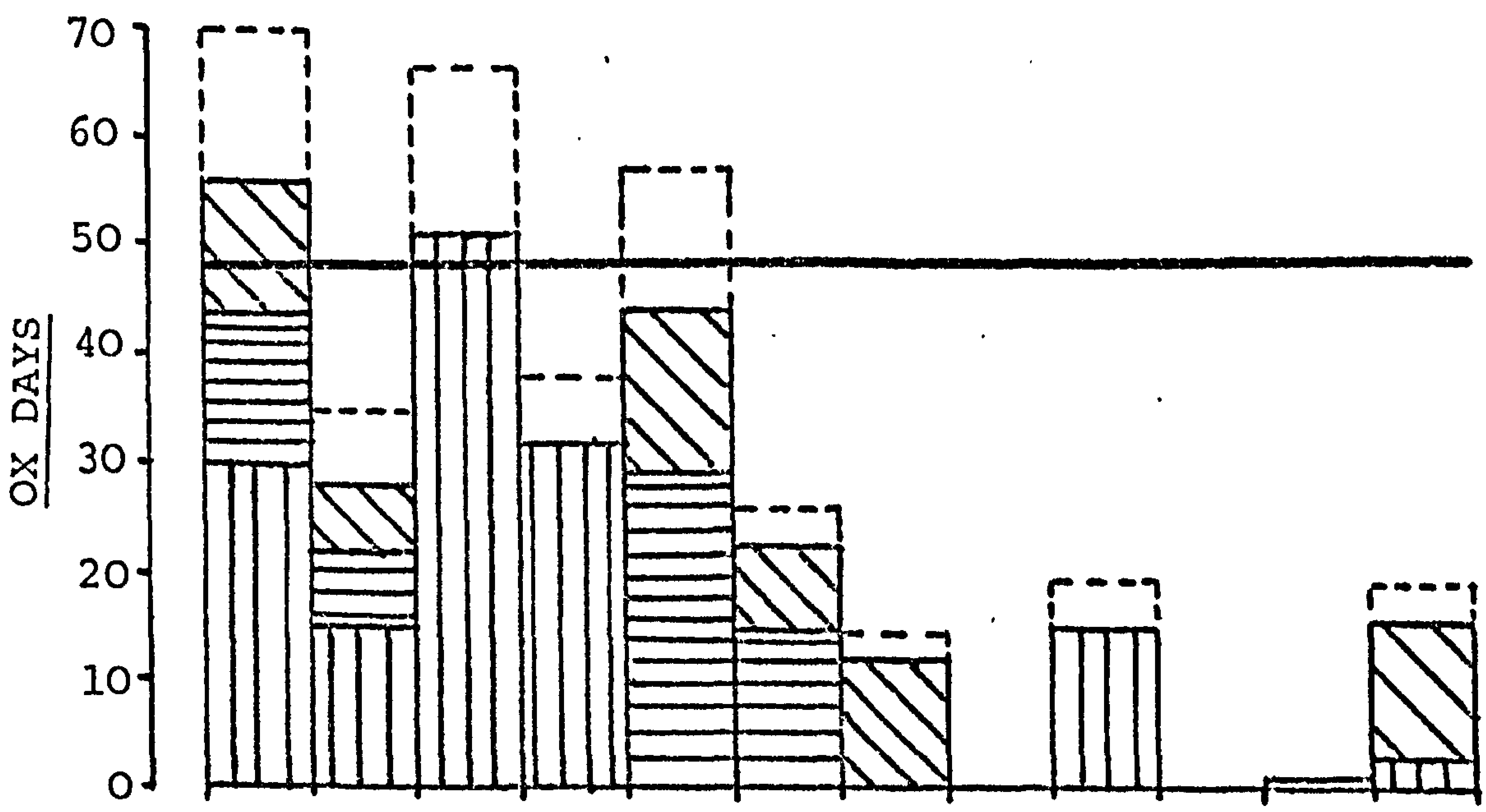


Diagram 5.3.12: Zone D, Crop Mix II

FIGURE 5.3 (contd)

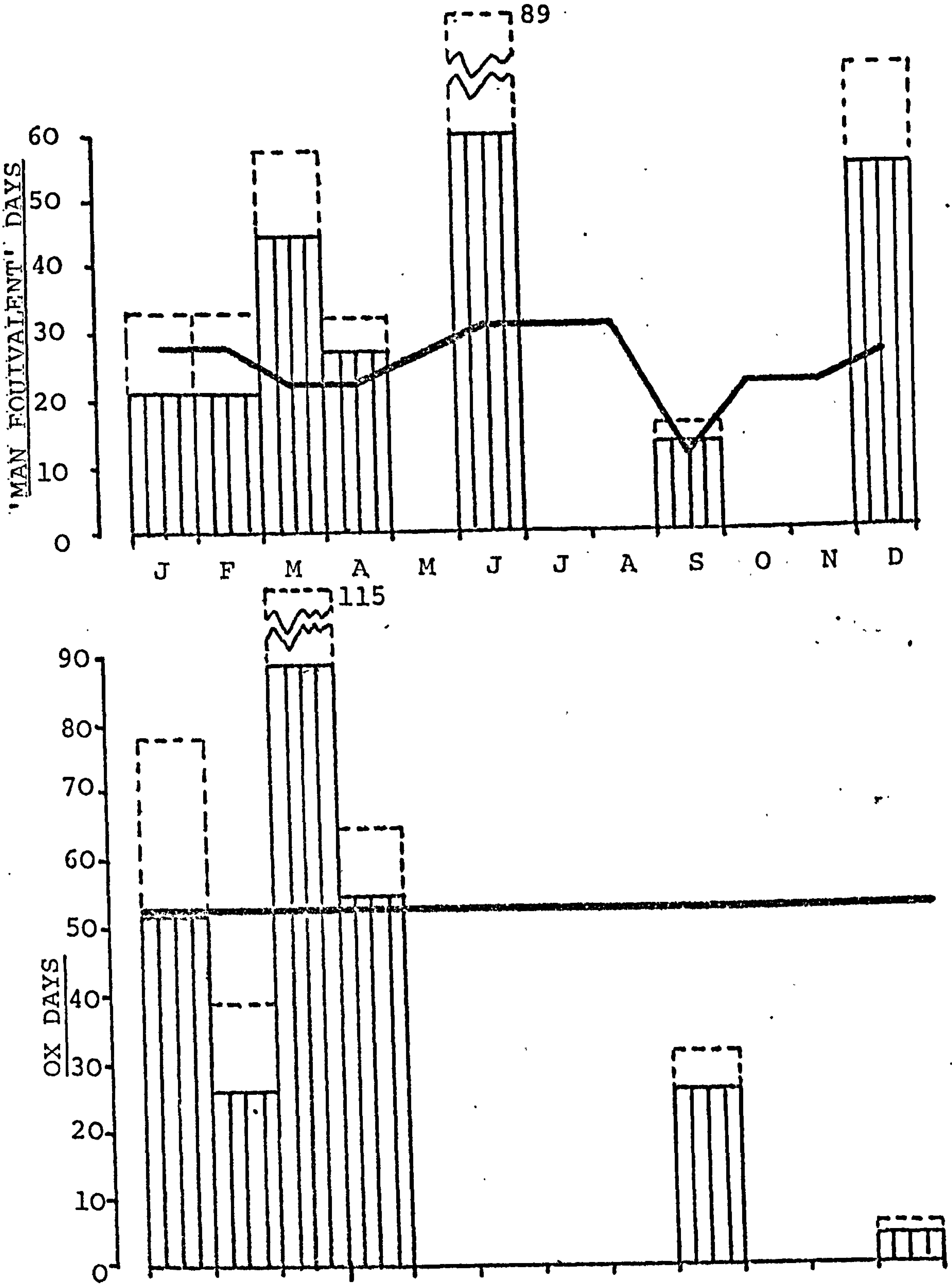
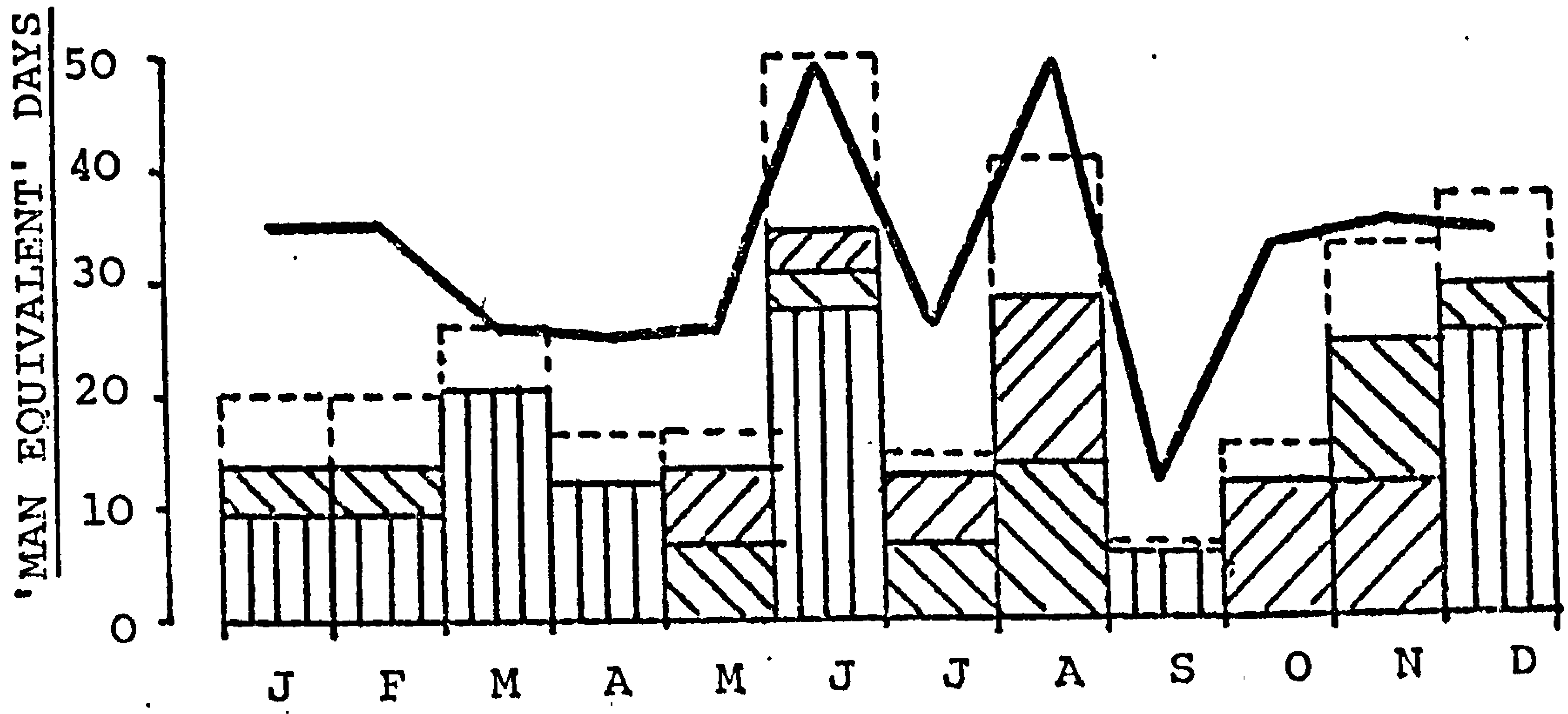


Diagram 5.3.13: Zone D, Crop Mix III

FIGURE 5.3 (contd)



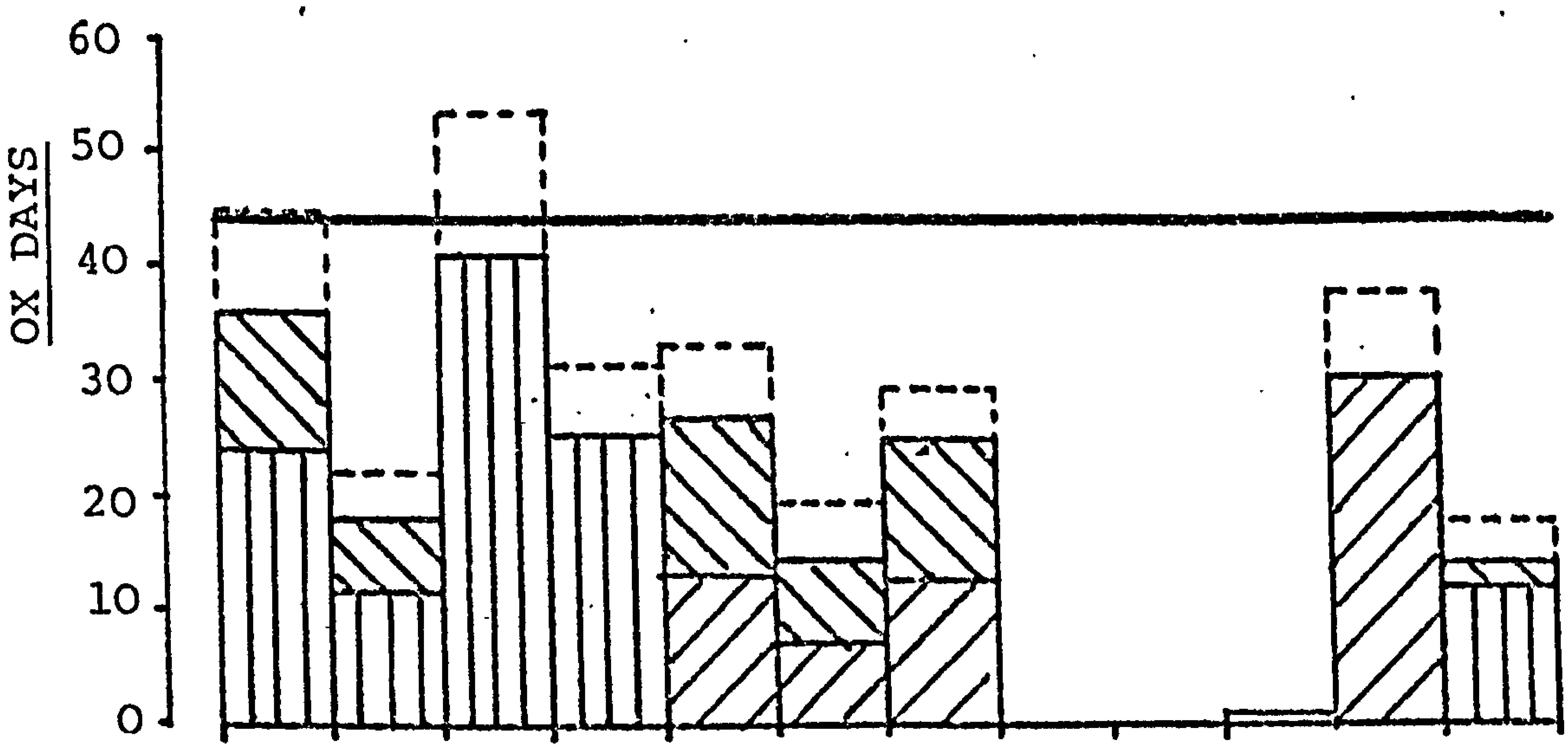


Diagram 5.3.14: Zone D, Crop Mix IV

FIGURE 5.3 (contd)

evenly spaced throughout the year. However, when energy requirement and availability are examined on a month-by-month basis,a situation of imbalance does in fact emerge.

A suitably disaggregated picture is provided in Figure 5.3. Although not of course entirely definitive, this series of histograms does provide some very enlight--ening insights into the seasonal pattern of potential on-farm energy supply and the energy requirements of the 'standard' crop mixes of the four zones. The first ,and probably the most obvious, feature of these diagrams is the seasonal variation in energy requirements, a feature which is seen more clearly when a single crop is viewed in isolation.Thus in the case of maize monoculture in Zone D (Diagram 5.3.13)there are four months in which no labour and six months during which no ox-power, is requir--ed in the direct process of crop production. These and other slack periods are counterbalanced by three periods of one month in the case of labour, and one such period in the case of oxen,during which the need for energy greatly exceeds potential on-farm supply, even when only minimum estimates of time requirements are postulated.A similar, although generally less pronounced,pattern of seasonal imbalance can be inferred when other crop mixes of Figure 5.3 are scrutinised.

Another form of imbalance is demonstrated on examin--ation of the proportions in which two traditional sourc--es of energy are combined. Obviously oxen cannot be used without labour, but there are times of often severe labour shortage when farm oxen are completely unemploy--ed. The first hadweeding, generally in August, and the harvest time are the two most pronounced of these periods.

Obviously in practice energy input cannot exceed maximum available supply, and as a last resort the farmer must simply reduce his standards of husbandry by for example ploughing or weeding less often or less intensively or at different times than he would other--wise consider to be optimal and paying the price in the form of reduced yields. Undoubtedly some adjustment of this type has actually taken place , but in many instances traditional farming in Chilalo, as elsewhere, has evolved more positive means of adjustment. On the supply side two such devices, the mutual labour exchan--ge group and the hiring of casual labour, have already been mentioned in Chapter 4, and two others, the adopt--ion of improved implements and engine-powered machinery, will be examined in Chapter.7.

On the requirements side, Figure 5.3 indicates how variation in the seasonal energy needs of different crops make it possible to produce a crop mix in which each component imposes a different seasonal pattern of energy requirements with the overall effect, in comparison with a monoculture, of reducing seasonal peaks and 'filling in' seasonal troughs.13/ This pro--cess of levelling out is most graphically illust--rated when the maize monoculture of Zone D is com--pared with the three three-crop mixes of the same zone (Diagrams 5.3.11 to 5.3.14). Each of these four crop patterns occupies a similar total area, but the picture of seasonal energy needs is remarkably different, with the extremely peaked distribution of Diagram 5.3.13 being greatly smoothed out by the substitution of two other crops for some of the maize.14/ Maize is from this viewpoint an excellent crop to include in a mix, since, as was seen in the calendar of operations, it is cult--ivated and harvested for the most part at times which are slack periods for other crops. Where maize does not form part, or at least not a substantial part, of the crop mix, seasonal requirements tend to coincide very much more, although some degree of complementarity can still be achieved.

The smallest degree of compatibility in this sense

13/ These patterns are not of course the only determinants of a crop mix. Other such factors include climatic and soil suitability, individual tastes and preferences, relative market prices and the requirements of crop rotation.

14/ The gross value of a given area of maize tends to exceed that of the other crops in Table 5.7 with the (temporary) exception of haricot beans.

exists among wheat,barley and horse beans, whose labour and ox-power requirements coincide at all times except the harvest. In the highland zones where maize cannot be produced, only field peas avoid imposing energy de--mands at the two most pronounced peak periods,March ploughing and August weeding. This is not,however, be--cause of complementary phasing but because of the generally low standards of husbandry applied to this crop. This partly explains why the area under field peas on most farms where both crops are grown exceeds that under the other major highland pulse crop,horse beans.

The overall picture which emerges from Figure 5.3 is one of shortage either of farm ox-power or of family labour in at least one season and frequently in two or three. The only apparent exception to this generalis--ation is crop mix DIV for which both labour and ox--power supplies seem adequate provided the maximum estimates of time requirements are not used. Again as a generalisation, existing labour 'bottlenecks' appear, in overall order of importance, to be weeding followed by harvesting - this despite the extra labour which is almost always available for weeding. However the period for weeding is followed by a slack period so that some flexibility is possible here, whereas the harvest is im--mediately followed by the busy threshing/winnowing/ marketing period. This will mean that for many farmers the harvesting bottleneck is the more restrictive of the two. Ploughing is not such an important bottleneck as farras labour is concerned, but it is very much so as regards ox-power.15/ The two most serious bottleneck processes for oxen are the first ploughing, when the early rains break, and the final ploughing-sowing-seedcovering process which begins at the onset of the main rainy season. In the two higher elevations,Zones A and C, the farmer is usually the more restrictive of the two processes, while in Zones B and D the order is reversed.

The degree of imbalance between labour and ox-power availability and requirements tends,as would be expect--ed, to bear a positive relationship to total cropped area. The imbalance is least noticeable in Zone D where farms are generally smaller, and most pronounced in Zone A where mean cropped area is largest of the four zones.16/ Again speaking generally, it will be observed

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15/It will be recalled that the working day for an ox in Chilalo is shorter-by some 30-50 per cent than that for a man. Thus any apparent labour bottlenecks in ploughing will usually be no more than that.

16/The availability-requirement figures for Zone D are put forward with rather less confidence as to their representativeness than is the case with the other three zones. The diversity of crop mixes in this zone is such that few standard mixes could be identified. In the event, as can be seen from Table 5.8, the four 'standard' crop mixes given for Zone D represent a total of just over one third of reporting farmers in that zone, which compares with a total of ninety per cent for the three standard mixes listed for Zone A.

that the more demanding crop mixes tend to be assoc-iated with greater availability of family labour and farm oxen. The most obvious example of this can be seen if mixes III and IV of Zone B are compared. Rather more formally, correlation analysis of the relationships be-tween the energy requirements of a given crop mix and its associated availability of farm energy resources shows a statistically significant positive relationship, as can be seen from Table 5.16.

TABLE 5.16: Correlations Between Available Farm Energy and Required Energy Input for Fourteen Crop Mixes.

Variables	Coefficient of Determination. r^2	Level of Significance. %
Labour Requirements (Min), Available Family Labour	0.574	0.1
Labour Requirements (max), Available Family Labour	0.475	0.3
Oxen Requirements , Available On-Farm Ox-days	0.512	0.2

Source: Computed from Table 5.15

Before leaving this topic, a few further observations will make it quite clear that if the picture of seasonal imbalance between farm energy resources and requirements is shown in Figure 5.3 as extending over a period of several months, since this is the time during which these operations can be completed. However a team of around ten oxen is required for threshing and such a team will be available for only a limited period of time, with the result that threshing will in fact impose more of a peak than Figure 5.3 suggests. It should be noted that a farmer with two oxen will have to lend these out for four days for every day he requires a team of ten, since mutual exchange in Chilalo operates on a strictly recip--rocal basis. In the case of winnowing it is customary to await a favourable wind, and this can cause delays and therefore further (but in fact much less important) peaks. In any case, farmers normally wish to thresh their crops as soon as possible after the harvest [18] in order to store their grain under cover and minimise both losses to birds,rodents and other creatures and the risk that untimely rains will damage the crop while it is stacked in the open. In conclusion it can be said that seasonal periods of peak labour demand not only exist in agriculture in Chilalo, but that thesealso constitute genuine bottlenecks which if they are not

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18/ Grain is stacked in the open for approximately a week to ten days after harvesting to allow it to dry out sufficiently for the traditional threshing process.

presented in Figure 5.3 is not completely accurate, then the true picture is almost certainly one of even greater imbalance than that portrayed. First on the subject of data reliability, it has already been noted that figures on cultivated areas are more likely than those on labour availability to have been under-reported, so that over--all labour requirements relative to resources could well be greater than is indicated by the figures. Second, it will be recalled that mean, rather than modal, figures were used as estimates of labour and oxen availability in the construction of Figure 5.3 and that the former are the larger of the two.

Finally the data in this figure have of necessity been recorded on a monthly basis,[17/] a factor which can obscure some sharp peaks of short duration. For example farmers try to complete their final ploughing, sowing and seedcovering in as short a period as possible in order to give the crop the best conditions for vigor--ous growth. The harvest must be completed as quickly as possible after the crop matures since otherwise losses from shattering may thenceforth increase steadily, as will the depredations of animal (and, say the farmers, human) predators. The period of threshing and winnowing

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17/Farmers were asked to report the usual time at which a given farm operation takes place and this will of course vary from one year to another with climatic changes. No very precise dates are therefore available.

eased or eliminated by energy sources from outside the farm will tend to reduce the level of yields.There is certainly nothing here that supports the thesis that the marginal productivity of labourers in traditional agri-culture in Chilalo is zero. The marginal product of labour on the other hand,can be zero (as far as crop production is concerned) at certain times of the year.19/

5.7 FARMERS' PERCEPTIONS OF WORKLOADS.

Farmers were asked (Appendix A, question A9.2) to name the farm operation or operations requiring the hardest work. Their replies are summarized in Table 5.17. These figures are useful not so much for the actual mag-nitudes involved, but for the valuable impression they provide of the relative drudgery of the various tasks - a feature whose importance was noted earlier. The picture presented in this table also conforms closely to that presented in Section 5.6 and therefore constitutes very useful confirmatory evidence concerning relative bottle-necks. Harvesting would appear to be the period of greatest drudgery for most farmers, followed, very closely in some instances, by weeding. One interesting exception is Zone B where weeding was listed slightly more often than harvesting. It will be recalled (Table 5.9) that

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19/ The distinction between labour and labourers in this context is discussed in Section 1.3 of Chapter 1.

weeding tends to be repeated more often in Zone B than elsewhere. At the other end of the scale, winnowing is listed by very few farmers - a factor which is of great importance in deciding whether or not threshing machines should incorporate this function, as will be demonstrated later. Ploughing is another interesting case. It is certainly a very arduous task, and yet is listed by comparatively few farmers, presumably because the limitations discussed earlier on the strength of the oxen have made the working day for ploughing very short.

The picture presented in Table 5.17 is not,however, completely satisfactory. Some farmers listed only one task,[20] some listed several and a few listed all seven. In Table 5.17, therefore, the opinion fo a farmer who had specified two tasks assumes twice the importance of a farmer who mentioned only one, and so on.

TABLE 5.17: Farm Operation(s) Reported as Requiring Greatest Effort (Percentage Frequencies).

Operation	ZONE A	ZONE C	ZONE B	ZONE D	Total
Ploughing	46.3	30.2	32.6	20.7	33.2
Sowing	6.0	32.6	9.3	20.7	16.1
Weeding	41.8	72.1	65.1	50.0	55.0
Harvesting	89.6	74.4	60.5	63.8	73.5
Threshing	40.3	37.2	23.3	27.6	37.7
Winnowing	9.0	9.3	4.7	0.0	5.7
Transport	17.8	16.3	23.3	22.4	19.8

20/ Where only one task is specified it is almost invar--iably harvesting. Winnowing, on the other hand,was never mentioned alone.

TABLE 5.18: Weighted and Unweighted Indices of Farm Operations Requiring Greatest Effort (Threshing = 100)

Operation	ZONE A		ZONE C		ZONE B		ZONE D		TOTAL	
	UNW	WTD	UNW	WTD	UNW	WTD	UNW	WTD	UNW	WTD
Ploughing	115	134	81	80	140	159	75	98	102	118
Sowing	15	11	88	89	40	69	75	86	49	57
Weeding	104	137	194	290	279	263	181	288	183	248
Harvesting	222	458	200	317	260	343	231	367	225	385
Threshing	100	100	100	100	100	100	100	100	100	100
Winnowing	22	18	25	14	20	10	0	0	17	11
Transport	44	61	44	34	100	112	81	70	61	67

UNW: Unweighted indices derived from Table 5.17.
WTD: Weighted for number of operations listed.

In order to correct this deficiency, the following weighting system has been devised. For each respondent, r, each of the seven farm operations(of Table 5.17) is given a value of 1 if listed by that respondent and 0 otherwise. The weighting factor,w, is then calculated as follows:

$$w_r = \frac{7}{\text{No of tasks listed by r}}$$

and each of the dichotomous task values is then multip--lied by this weight. The sum of the listed values for every respondent is thus seven, so that the inequality of Table 5.17 is eliminated. The values for each farm operation are then totalled. In order to make them more meaningful,these figures have been converted to index form, with threshing, which is generally the middle-rank--ing task, equated to 100. These indices are presented in Table 5.18 alongside the figures from Table 5.17 which for compatibility have also be converted to indices with the same base.

The weighted figures presented in Table 5.18 further emphasise the relative importance of the operations which have been identified as 'bottlenecks'. Comparing the weighted with the unweighted figures, the former tend to eliminate the inter-zonal differences of Table 5.17. Harvesting emerges as first in rank and weeding ranks second in importance in all four zones

CHAPTER 6

TECHNOLOGICAL CHANGE I:
FERTILIZER AND IMPROVED SEED

6.1 PERIOD OF ADOPTION.

The sample , it will be recalled , was drawn from farmers who had used fertilizer, improved seed or both, and Table 6.1 shows its distribution among these three categories.Obviously fertilizer is used by virtually all of the sample farmers, but the use of improved seed tends to be rather more concentrated in the two major wheat producing areas, Zones C and B. Zone D is the least suitable for wheat, being generally too hot for its efficient production. Wheat is of course the main crop in which varietal improvements have been achieved in Chilalo (see Tables 4.3 to 4.6)

TABLE 6.1: The Use of Fertilizer and Improved Seed by Sample farmers (Percentage)

Input(s) Used	ZONE A	ZONE C	ZONE B	ZONE D	TOTAL
Fertilizer only	13.4	2.3	7.0	50.0	19.9
Improved Seed Only	0.0	0.0	0.0	3.4	0.9
Both	86.6	97.7	93.0	46.6	79.1

When the years in which famers first used fertilizer and improved seed were examined, some interesting factors

TABLE 6.2: Year Fertilizer and Improved Seed First Used (Percentage)

YEAR FIRST USED	ZONE								TOTAL	
	A		C		B		D			
	F	IS	F	IS	F	IS	F	IS	F	IS
1964	0.0	0.0	0.0	0.0	2.3	2.3	2.3	0.0	0.5	0.5
1965	0.0	0.0	0.0	0.0	2.3	2.3	0.0	0.0	0.5	0.5
1966	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0.0
1967	0.0	0.0	0.0	0.0	0.0	2.3	o.0	1.7	0.9	0.9
1968	2.5	3.0	2.3	2.3	9.3	4.7	0.0	0.0	3.8	2.4
1969	16.4	6.0	4.7	0.0	20.9	11.6	3.4	1.7	11.4	4.7
1970	20.9	13.4	20.9	16.3	14.0	11.6	3.4	1.7	14.7	10.4
1971	11.9	9.0	25.6	9.3	99.3	11.6	12.1	8.6	14.2	9.5
1972	10.4	4.5	20.9	14.0	20.9	18.6	17.2	6.9	16.6	10.0
1973	16.4	13.4	11.6	20.9	2.3	2.3	34.5	15.5	17.5	13.3
1974	19.4	22.4	114.0	16.3	14.0	0.0	24.1	5.2	18.5	11.8
Not stated[a/]	100.0	14.9	0.0	I8.6	4.7	25.6	1.7	8.6	1.4	16.1
TOTAL	100.0	86.6	100.0	97.7	100.0	93.0	96.6	50.0	99.1	80.1

a/ The high proportions under 'seed' in this category arise from the fact that some improved wheats are apparently regarded as indigenous by the farmers.
F = fertilizer; IS = Improved Seed.

emerge. First it can be seen that there was very little use of these inputs before the establishment of CADU in 1967. Second, comparing the four zones, the cumulative figures (Table 6.3) show earlier adoption in Zone B than elsewhere, followed in order of importance (at least until recently) by Zones A,C and D, an order which exactly reflects the spatial and temporal extension of CADU's activities across the District.

Finally, comparing the two inputs there would seem to be a tendency for adoption of fertilizer to precede that of improved seed,although on closer examination (Table 6.4) it is clear that most farmers tend to adopt both inputs in the same year. There is,however, a sub--stantial minority of farmers in each zone who began to use fertilizer earlier.1/

TABLE 6.4; Leads and Lags in the Adoption of Fertilizer and Improved Seed (Percentages)

Ys	ZONE A	C	B	D	Total
Yf - 7 years	0.0	0.0	3.4	0.0	0.8
YF - 2 years	0.0	0.0	0.0	4.8	0.8
Yf - 1 year	6.5	2.8	0.0	0.0	3.0
Yf	47.8	63.9	75.9	61.9	60.6
Yf + 1 year	19.6	22.2	13.8	28.6	20.5
Yf + 2 years	13.0	5.6	3.4	0.0	6.8
Yf + 3 years	4.3	5.6	3.4	4.8	4.5
Yf + 4 years	8.7	0.0	0.0	0.0	3.0

1/ O.L.S. Linnear regression analysis indicates the follow--ing relationship: $Y_S = 11.1 + 0.853 Y_F$: (standard error of estimate = 1.143: $r^2 = 0.636$; level of significance = 0.001%; no of observations=134 Y_F and Y_S are calendar year - 1900

TABLE 6.3: Year Fertilizer and Improved Seed First Used

(Cumulative Percentages)[a/]

YEAR FIRST USED	ZONE								TOTAL	
	A		C		B		D			
	F	IS	F	IS	F	IS	F	IS	F	IS
1965	0.0	0.0	0.0	0.0	2.4	3.1	0.0	0.0	0.5	0.6
1966	0.0	0.0	0.0	0.0	4.8	6.2	0.0	0.0	1.0	1.2
1967	0.0	0.0	0.0	0.0	4.8	622	0.0	0.0	1.0	1.2
1968	0.0	0.0	0.0	0.0	4.8	9.3	0.0	1.9	1.0	2.3
1969	4.5	3.5	2.3	2.8	14.6	15.6	0.0	1.9	4.9	5.1
1970	20.9	10.6	7.0	2.8	36.5	31.2	3.5	3.7	16.4	10.7
1971	41.8	26.3	27.9	22.9	51.2	46.8	6.9	5.6	31.3	23.1
1972	53.7	36.9	53.5	34.3	61.0	62.4	19.2	15.0	45.9	34.4
1973	64.1	42.2	74.4	51.5	82.9	78.3	36.7	22.5	62.6	46.4
1974	80.5	57.9	86.0	77.2	85.3	90.4	71.8	39.5	80.3	62.2
1975	100.0	84.3	100.0	97.2	100.0	90.4	96.3	45.2	99.1	96.3

a/ Adjusted for those 'not stated'.

TABLE 6.4: Leads and Lags in the Adoption of Fertilizer and Improved Seed (Percentages)

Ys	ZONE				TOTAL
	A	C	B	D	
Yf - 7 years	0.0	0.0	3.4	0.0	0.8
Yf - 2 years	0.0	0.0	0.0	4.8	0.8
Yf - 1 years	6.5	2.8	0.0	0.0	3.0
Yf	47.8	63.9	75.9	61.9	60.6
Yf + 1 year	19.6	22.2	13.8	28.6	20.5
Yf + 2 years	13.0	5.6	3.4	0.0	6.8
Yf + 3 years	4.3	5.6	3.4	4.8	4.5
Yf + 4 years	8.7	0.0	0.0	0.0	3.0

Ys = Year improved seed was first used.
Yf = " " fertilizer " "

Ys = Year improved seed was first used

Yf = " " fertilizer " "

6.2 CHANGES IN BASIC CROP OPERATIONS.

Since by definition one of the main reasons for using fertilizer and high yielding varieties is to increase yields, the extent to which this aim is successfully realised will be reflected in increased workloads in harvesting and post harvest operations. This is true simply because of the increased volume of material to be reaped, threshed, winnowed and transported. However, changes other than these can be envisaged and an important purpose of the Survey was to establish if any of these had taken place.

The basic schedule (Appendix A) contains a large number of questions relating to changes in cultivation practices subsequent to the introduction of improved seed and/or fertilizer. Questions as to the direction of any change had to be pitched at the ordinal level only since any attempt to attain a quantitatively higher level would have been inordinately time consuming in a study of this type.[2/] Some additional information is,

2/ The classification of levels of measurement used here is based on Stevens(1946). Stevens identified four levels or 'scales' of measurement, all of which have been used in this study. In increasing order of quantification these are: (a) the nominal scale, in which numbers are assigned to specific categories are no more than labels -as, for example, when specific crop varieties are represented by numerical codes: (b) the ordinal

(continued on next page)

however, available from the small sub-sample previously mentioned. When the changes were reported by farmers in the full sample a supplementary 'open ended' question sought the reason for these alterations.

In general the changes of timing, duration and frequa--ncy in basic farming practices and the reasons given for these changes show the sample farmers to be well aware of the relationship between improved standards of husbandry and the better realisation of the potential of expensive new inputs. This,together with the fact that they had adopted such inputs in the first place show them to be far removed from the type of inflexible,unresponsive, tradition-bound individuals once portrayed(caricatured ?) by writerslike Boeke (1953). Their reactions, observations and conclusions are therefore well worth recording.

(2/continued) scale of measurement requires that categor--ies be capable of meaningful ranking - as for example when a farmer was asked whether he thought his work had become easier, become more difficult or reamained the same since he he had adopted fertilizer use:(c) the interval scale is "quantitave in the ordinary sense of the word", but its zero is fixed only by convention - as for example in the case of dates. One special case of the interval scale is the dichotomy - e.g. whether or not a farmer has ever hired a tractor:(d) the ratio scale of measurement has all the properties of a real numbering system and is used, for example when crop areas are recorded.

6.2.1 Seedbed Preparation

Table 6.5 and 6.6 show the number of farmers who reported changing respectively the timing and freque--ncy of ploughing since adopting new inputs. With one exception there are no major differences among the zones in regard to changes in either timing or frequency. In Zone C, however, a relatively large number of farmers have begun to plough both earlier and more frequently since the introduction of the new inputs. This except--ion can be explained by reference to three other tables in the text. First in the case of ploughing frequency, it can be seen from Table 5.8 that this tends even now to be lower in Zone C than elsewhere, so that it is probable that there has been more spare ploughing capacity there.3/ Second, as regards the date of ploughing, Table 4.4 shows that the most important improved variety in Zone C is 'romany' wheat which was not reported as having been grown in any of the other zones and which, as will be seen in Table 6.9, is sown earlier than indigenous wheats.

Comparing Tables 6.5 and 6.6 it is obvious that the trend towards more frequent ploughing is much more prono--unced than that towards earlier ploughing. The former

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3/ The other possibilities - larger areas under crops, less labour or fewer oxen do not hold.

Table 6.5: Changes in Time of Ploughing (Percentages)

	ZONE				TOTAL
	A	C	B	D	
Plough Earlier	20.9	41.9	20.9	29.3	27.5
" Later	6.0	2.3	0.0	8.6	4.7
No Change	73.1	55.8	79.1	62.1	67.8

Table 6.6 Changes in Frequency of Ploughing (Percentages)

	ZONE				TOTAL
	A	C	B	D	
Plough More Often	49.3	65.1	52.4	50.0	53.3
" Less "	3.0	2.3	2.4	6.9	3.8
No Change	47.8	32.6	45.2	43.1	42.9

TABLE 6.7: Changes in Time and Frequency of Ploughing (Percentages)

Ploughing		ZONE				TOTAL
Time	Frequency	A	C	B	D	
Earlier,	Increased	17.9	34.9	17.1	27.6	23.9
"	Same	3.0	7.0	2.4	1.7	3.3
"	Reduced	0.0	0.0	2.4	1.7	1.0
Same	Increased	28.4	34.9	36.6	17.2	28.2
"	Same	41.8	18.6	41.5	39.7	36.4
"	Reduced	3.0	2.3	0.0	3.5	2.4
Later,	Increased	1.5	0.0	0.0	3.5	1.4
"	Same	4.5	2.3	0.0	3.5	2.9
"	Reduced	0.0	0.0	0.0	1.7	0.5

change would probably be easier to make, since the earl--er the ploughing the harder the ground will tend to be. Table 6.7 shows the sample classified according to both criteria simultaneously and provides the not very surpr--ising information that farmers who now plough earlier than previously also tend to plough more frequently.4/ If it is assumed that earlier or more frequent plough--ing entail more work and vica versa, the changes in work-loads, if any, are as shown in Table 6.8 which de--rives directly from Table 6.7. Most farmers in the sample have had to work harder at ploughing since intro--ducing fertilizer and/or improved seed.

The reasons given for the above changes in ploughing operations link them directly to the introduction of the new inputs. Eighty per cent of those who now plough earl--ier stress the need for a smooth,clean seedbed in order to provide the fertilizer and/or improved varieties with the best possible environment in which to operate. The remaining handful of farmers mentioned weather conditions as the major reason for change. The few farmers who plough--ed later than previously tended to ascribe this to fast crop maturation resulting from either a specific variety

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4/Since these data are ordinal in scale,rank-order, rather than product-moment,correlation coefficients must be used.In view of the large number of tied ranks result--ing from the categorization, Kendall's 'tau' coeffic--ient is most appropriate.Correlating ploughing time with ploughing frequency yields Kendall's 'tau' = 0.381, level of significance 0.1% or better.

(wheat: 'laketch' 8156) or from fertilizer use. In the case of the number of times the land was ploughed, the same type of reason - fine tilth, and the elimination of weeds - was put forward by virtually all the respond--ents. Most of those few who plough less frequently state that otherwise the crop tends to 'lodge' 5/ which suggests that they are using either the wrong variety or too much fertilizer.

TABLE 6.8:Changes in Ploughing Workloads(Percentages)

	ZONE				
	A	C	B	D	Total.
More Work	49.3	76.8	56.1	46.5	55.4
Less "	7.5	4.6	0.0	8.7	5.8
No Change	41.8	18.6	41.5	39.7	36.4
Other a/	1.5	0.0	2.4	5.2	2.4

a/ i.e. Ploughing earlier but less frequently or later but more frequently.

One important point which deserves consideration is the comparison of those who have changed either the tim--ing or the frequency of their ploughing with those who have not. For example, do those who now report ploughing

5/ That is, the head of grain becomes too heavy for the stalk,which then collapses. Dwarf wheats were bred partly in order to overcome this problem.

earlier than before tend also to plough earlier than those who report no such change? Similar questions can be put in the case of ploughing frequency.Analysis of variance was used to investigate these questions both over the sample as a whole and within each of the four zones,[6] but in no case were the observed differences found to be statistically significance,in either the case of ploughing date or that of ploughing frequency. This suggests that what may happened is that the changes which have taken place have been more in the nature of all farmers now tending towards a common,generally higher, standard of husbandry since their adoption of new inputs, rather than a case of some farmers forging ahead, and others falling behind, a traditional norm. This interpretation is certainly supported by the difference, discussed earlier in the present section.between Zone C and the other three zones in this respect.

6.2.2 Sowing:

More than half of the sample farmers have changed the dates on which they sow at least one of their crops since adopting new varieties (i.e. they sow the introduced variety earlier or later than they sowed

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6/Using as the dependent variable in each case the calendar and frequency data from Question B4, Appendix A.

traditional varieties of the same crop). Table 6.9 (and Tables 6.14 to 6.17 inclusively) presents the findings for only five varieties, all of them improved wheats. Instances of change in respect to other crops were reported in a very few cases , much to few for any meaningful conclusion to be drawn - except perhaps that chage affects a good many more crops than those reported in the tables.

In comparison with European varieties, indigen--ous Ethiopian wheat ripens at lower temperatures, mature earlier and are short-strawed - although not of course, in comparison with dwarf wheat varieties (SRI, 1969,Ch III). This last characteristic presents an in--teresting contrasts to wheats which are native to many other parts of the tropics,where the process of natural selection has produced " a tall,thin-strawed plant that can keep its head above water when there is flooding and can compete successfully with weeds for its share of sunlight" (Brown, 1970,p16.)

The reasons given for earlier or later sowing of crops tend to relate to weather conditions and the length of time the crop takes to mature. Thus,'Kanga', 'Kentana'. Frontana' and 'Romany' are all slow maturing varieties and are sown early in order to avoid the frost which can occur in the higher areas especially during late September to early November. 'Supremo',on the other hand, is not slow ripening compared with

TABLE 6.9 Changes in Times of Sowing Major Improved Wheats of Local Wheat (No of Farmers Reporting Change)

Variety	ZONE								TOTAL	
	A		C		B		D			
	E	L	E	L	E	L	E	L	E	L
Kanga	1	-	1	-	-	-	1	-	3	-
Kentana F.	4	-	1	-	2	-	-	-	7	-
Laketch 8156	8	16	2	9	4	15	1	9	15	49
Romany	4	-	27	-	-	-	-	-	31	-
Supremo	8	1	7	1	26	-	3	6	44	8

E = earlier sowing ; L = later sowing.

indigenous wheats, but farmers report that this variety yields particularly well if it is sown early.[7] Only in the case of 'Supremo' does a very noticeable interzonal difference arise, with farmers in Zone B tending to sow this variety later than traditional wheats. Zone D is by far the lowest-lying (see Figure 5.1) of the four zones and crops mature there relatively quickly. There is also no danger of frosts in Zone D.

'Laketch 8156' presents the most interesting case of all, and continued reference will be made to this variety in this and subsequent chapters, since its agronomic characteristics differ very markedly from those of indigenous wheats and its therefore imposes very different demands on farm energy resources. 'Laketch' is a short-strawd wheat, developed origin--ally from Mexican stock, and is the only such variety to have been popularised in Chilalo. It is also by far the most popular of the improved strains (Table 4.2) occupying half of the total reported area under wheat and grown by slightly more than half of all farmers in the sample.

7/ Some indication of the orders of magnitude involved can be gauged from the report of one particularly helpful farmer in Zone B who reported that the sow-date the previous year in his area had generally been around 28th July for local wheats and 13th July to 18th for early-sown varieties like 'Supremo'.

Compared to traditional wheats, laketch is a fast-maturing variety and it is for this reason that it is often sown later than other crops, a fact ~~a fact~~ which enables the sowing-seed covering bottleneck described earlier to be somewhat eased.[8/] Alternatively laketch is sometimes sown and harvested early so as to provide a supply of food in the normally hungry period before the main harvest. Table 6.10 shows the relationship between the relative time of sowing and that of harvesting, and indicates that a substantial number of farmers are able to sow 'laketch' later and harvest it earlier than local wheats. The majority, however, report such time changes in one direction only.

TABLE 6.10 Times of Sowing and Harvesting 'Laketch' c.f. Local Wheat (no of farmers all zones).

TIME OF SOWING	Time of Harvesting		
	Earlier	Later	Total
Earlier	10	0	10
Later	18	2	20
Total	28	2	30

6.2.3 Weeding:

In any farming situation there are three distinct

8/ In the next section it will be shown that late sowing also affects the potential for reducing weed infestation.

sources of weeds :(i) weeds which are in the ground or whose seeds are in the ground at the time the crop is sown,(ii) weeds which are sown along with the crop be--cause weed seeds are mixed with the crop seed and (iii) weeds which become established after the crop has been sown. The use of fertilizer and improved varieties can have considerable impact on weed infestation.Fertilizer can of course encourage weed growth, for the same reason it nourishes crops, but if the soil is (at least relativ--ely) free of weeds and weed seeds before sowing and if the crop seed is uncontaminated, then fertilizer may give such an early boost to the crop that it will be able to compete successfully for water,sunlight and soil nut--rients with any weeds which later attempt to establish themselves.

The first of the above requirements is by far the more difficult to meet. While effective ploughing will deal with perennial weeds and with those seeds which have already sprouted, it will not greatly affect seeds which have not yet germinated. Delays in ploughing after the onset of the rains will ensure the maximum germinat--ion of the weeds, but at the cost of probable yield reductions or even putting the entire crop at risk if its period of maturation is long. There is in fact a curious little 'vicious circle' here: if a field is not proper--ly weeded one year, the weeds will survive to go to seed and thus conduce a recurrence of the same problem the following year.

The effect of improved varieties on weed contamin--ation is also important, if less obvious than that of fertiliser.First it was noted above that varieties which are slow maturing are especially vulnerable because of early sowing, but the opposite is not unfort--unately always true of fast-maturing strains. Dwarf wheats like'laketch'are fast maturing but require to be kept especially free from weeds since these could other--wise overshadow the crop and deprive it of essential sun--light. Second the use of clean certified seed, which is of course the state in which improved varieties are initially marketed, will ensure that no weeds are seed--ed with the crop. Unfortunately most farmers in devel--oping countries do not often use such seed except when it is first introduced into the area.[9]

Table 6.11 shows that a large majority of farmers in the sample reported that weed infestation had in--creased since their introduction of new inputs .Just over twenty per cent felt unable to say why, but the majority (76 per cent) blamed the increased soil fert--ility resulting from fertilizer use. This suggests one or both of two possibilities. First despite the

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9/ One additional point of at least indirect relevance concerns the influence of neighbouring farmers. An individual farmer has little chance of successfully tackling weeds if his neighbours' fields are choked with them.

TABLE 6.11: Changes in Wedd Infestation Since the Introduction of Fertilizer and/or Improved Seed (percentages)

	ZONE				TOTAL
	A	C	B	D	
Fewer Weeds	3.0	4.7	0.0	8.6	4.3
More Weeds	61.2	81.4	83.7	74.1	73.5
No Change	35.8	11.6	1.6	13.8	19.9
Don't Know	0.0	2.3	4.7	3.4	2.4

general increase in the number of ploughingsm the farmers' success in killing weeds may not have been sufficiently great - indeed three farmers specifically mentioned the fact that they sow the crops earlier,rather than have the use of fertilizer, as the reason for the increase in weed infestation of their fields.[10/] Second, farmers may be accidently sowing weeds. If farmers used clean, certified seed, the problem of weed contamination would be greatly reduced, but very few farmers infact do so: only nineteen farmers (9 per cent) reported buy--ing seed from CADU. The remainder either grew their seed themselves or bought it from relations or from oth--er farmers. However, the majority of all farmers (64 per cent) reported that they cleaned their seed in order to remove weed seed before sowing. It is not possible to say how effectively this was done, but the increase in weed infestation of fields suggests that it may not be very effective. Only one farmer reported row-planting his crop, although this practice would make it possible to weed the crop mechanically (e.g. with a plough). This not normally possible if the seed is broadcast.

10/ It is unusually perceptive insights such as this, at least as much as the general run of answers, which makes the opened-ended question so useful in this type of survey.

Four of the nine farmers who reported reduced weed contamination were unable to say why, but three report--ed that the rate of growth of the crop was such that it smothered the weeds. This however is unlikely to be entirely due to fertilizer use, since all three of these farmers also reported using herbicides, so that weed contamination is still clearly regarded by them as an important problem.[11/] The fact that the crop is able to smother the weeds is almost certainly due at least in part to the retardant effect that the herbicides have on weed growth. Of the other two farmers who reported fewer weeds, one simply stated that he used herbicides and the other that he had changed over to a less weedy field.

Table 6.12 shows that the majority of farmers now feel obliged to weed more frequently since the intro--duction of fertilizer and/or improved seed although a substantial minority weed less often. Again the gen--eral standards of husbandry seem to have increased most in Zone B. The reasons given for weeding more often are quite predictable: more weeds, repeated crops of weeds or simply the desire to achieve higher yields. One farmer did however mention the short straw of 'laketch'

11/ The subject of herbicides will be dealt with in much greater detail in Chapter 7.

and the consequent overshadowing effect of weeds as a reason for repeated hand weeding. The main reason giv--en for weeding less frequently is the introduction of herbicides, but again there was one important except--ion in the case of a farmer who gave virtually the 'textbook' reply: although there were more weeds, fert--ilizer gave such a boost to the crop that it was able to smother them and so he weeded less frequently than before - just one early (and this is very important) weeding. This farmer did not use herbicides.

TABLE 6.12: Changes in Frequency of Weeding.

(Percentages)

	ZONE				TOTAL
	A	C	B	D	
More often	43.3	53.5	74.4	46.6	52.6
Less Often	6.0	4.7	2.3	25.9	10.4
No change	50.7	34.9	18.6	27.6	34.6
"Depends on weed growth"	-	7. 0	2.3	-	1.9
Not stated	-	-	2.3	-	0.5

It should be noted that many of the farmers in--cluded in the sample mentioned a tendency for the problem of weed infestation to worsen the longer a given field remains under continuous cultivation.12/

12/The same tendency was noted in other African countries by Cleave (1974,Ch.5.).

This would suggest that with growing population pressures leading to increasingly intensive land use, the problem of weed infestation is likely to become increasingly serious in the future.

Before leaving the topic of weeds and weeding, it is worth investigating the differences, if any, between those who report having changed the frequency of weeding with those who do not, as was done in the case of ploughing at the conclusion of Section 6.2.1. Again analysis of variance is used, but in this instance the observed differences were statistically significant over the Survey Area as a whole. The mean frequency of weeding by those who reported an increase was 1.6 compared with a mean of 1.0 both for those who reported either fewer weedings or no change.[13/] When the data were disaggregated to a zonal level, however, only in the case of Zone A were the differences in means found to be significantly different.[14/] In this case the mean number of weedings was 1.4 for those who had increased them,1.0 for those who weeded less often and 0.8 for those who reported no change. It should be noted that Zone A is one in which fewer farmers than elsewhere report increased weed infestation since the introduction of new inputs (Table 6.11).

13/F-ratio = 11.264, significance level 0.1 per cent or better.

14/F-ratio = 11.181, significance level 0.1 per cent or better

TABLE 6.13: Changes in Weed Infestation and Frequency of Weeding

(Percentages)[a]

Weed Infestation	Weeding Frequency	ZONE A	ZONE C	ZONE B	ZONE D	TOTAL
Greater	Increased	41.8	55.8	72.1	43.1	51.2
"	Same	16.4	23.3	7.0	13.8	15.2
"	Reduced	3.0	2.3	2.3	13.8	5.7
Same	Increased	1.5	0.0	2.3	0.0	0.9
"	Same	32.8	11.6	9.3	8.6	17.1
"	Reduced	1.5	0.0	0.0	3.4	1.4
Less	Increased	0.0	0.0	0.0	1.7	0.5
"	Same	0.0	0.0	2.3	0.0	0.5
"	Reduced	3.0	0.0	2.3	10.3	4.3
OTHER[b]		0.0	7.0	2.3	5.2	3.3

a/ Kendall's *tau* = 0.524, level of significance 0.1% or better;
b/ "Dont Know", "not stated", "depends on weed growth".

6.2.4 Harvesting;

Where farmers report changes in the time required for harvesting they usually report that the new var--ieties take less time to harvest than traditional ones.(Table 6.14). Again the exception is 'laketch 8156.'In this aase 91 per cent of farmers who said that 'laketch' takes longer to harvest ascribed this fact to the short,brittle straw, which they find diff--icult to grasp, cut and bind. In addition 93 per cent of those who found other improved wheats easier to harvest attributed this to the relatively long straw.

The traditional harvesting technique in Chilalo is for the reaper to grasp a bunch of stalks near the heads with one hand and to cut them through with a single stroke of a (saw-toothed) sickle held in the other. Then, without either dropping sickle or grain, he pulls a straw at random from the bunch and with a dexterous movement of both hands uses it to bind the sheaf, which he then drops behind him, ready to re--peat the operation. With 'laketch', however, the short, brittle straw tends to break, thus interrupting the smooth flow of the entire sequence, since the reaper then has to spend time searching for a suitable straw

Other reasons given for relative ease or diffic--ulty of harvesting relate either to the density of

TABLE 6.14 : Changes in Time Required to Harvest Major Improved Wheats of Local Wheat

(No of Farmers Reporting Change)

VARIETY	Zone								TOTAL	
	A		C		B		D			
	M	L	M	L	M	L	M	L	M	L
Kanga	-	2	-	-	-	-	-	1	-	3
Kentana F	-	7	-	-	1	2	-	1	-	10
Laketch 8156	45	3	30	1	31	-	14	-	120	4
Romany	1	3	-	22	-	-	-	-	1	22
Supremo	-	18	3	11	3	21	2	11	88	61

M = more time required ; L = less time required.

growth or to any tendency of the crop to shed its ears or 'shatter' when it is ripe. Obviously the time required to harvest a crop will vary directly with the density of growth, while a crop which shatters early will require great care if high losses are to be avoided. Problems with shedding will also mean that the period available for harvesting the crop will be much shorter than would otherwise be the case. 'Laketch' in fact causes harvesting problems for all three of the above reasons, and yet the major cause of problems, the short, thick straw, is a result of deliberate breeding, since this makes the crop resistant to lodging and therefore suitable for use with heavy dressings of fertilizer. The straw characteristics also result in fast maturation and a relatively high ratio of grain to straw, both of which are additional desirable features.

Three farmers gave figures for the time required to harvest 'laketch' compared with local wheat. Two stated that 'laketch' required 30 per cent more labour input, the third that it needed twice as much. A fourth farmer reported hiring labour for several types of wheat and having paid Eth$28 per hectare for 'laketch' and Eth$24 for all other wheats. It will be recalled that local wheat was postulated in the labour/oxen profiles of Figure 5.3 and that even then harvesting was seen as a bottleneck process in most cases. Since

TABLE 6.15 : CHANGES IN TIME OF HARVEST FOR MAJOR INPROVED WHEATS c.f.LOCAL WHEAT.

(No of farmers reporting change).

VARIETY	ZONE									
	A		C		B		D		TOTAL	
	E	L	E	L	E	L	E	L	E	L
Kanga	-	5	1	-	-	3	-	4	1	12
Kentana F	-	5	-	1	-	1	1	-	1	7
Laketch 8156	23	2	18	-	8	4	7	1	56	7
Romany	-	8	-	22	-	-	-	-	-	30
Supremo	9	2	17	-	27	1	11	1	64	4

E = earlier harvest : L = later harvest.

the area under 'laketch' now exceeds that under indig--enous wheats (by 350 per cent), this bottleneck will have become even more restrictive than previously.

One final point in Table 6.14 which requires clar--ification is the fact that while most farmers report change in one direction for a given variety, a few report change in the opposite direction. Obviously where only one or two respondents are concerned this could easily arise by mistake, but in the cases of 'Supremo' and'laketch' there are too many observations for this explanation to be really plausible. In the case of 'supremo' those who report requiring more time for the harvest blame this on the crop's tend--ency to shatter, a factor which for them evidently outweighs the advantages of long straw. In the case of 'laketch' the explanation given for the reportedly less time-consuming harvest was the fact that the crop rip--ens early. Presumably what is meant is that these farmers harvest 'laketch' in the slack season before the main harvest when more family and other labour is available for the purpose.

Table 6.15 shows a tendency for 'laketch' and 'supremo' to be harvested earlier and the other HYV's to be harvested later than local wheats. A substantial minority (one-third) of those reporting change in the time of harvest did not know the reason for it -

except to say that it was a characteristic of the crop. Half of those who ventured to give a reason related early harvesting to varieties which are prone to shatter and vica versa. Others related the time of harvest to the time of sowing or earlier harvesting to faster maturation resulting from fertilizer use.

6.2.5 Threshing:

Table 6.16 shows relative changes in the perceived difficulty of (time required for) threshing associated with improved varieties. Here, as elsewhere, the directions of the reported changes are for the most part fairly unanimously agreed upon, with the singel exception of 'laketch', where a sizeable minority,especially in Zone A, report that the crop takes longer to thresh. The reasons given by this minority are not very helpful, but in each case the farmer had also reported harvesting earlier, or at the same time as,local wheat which could mean that threshing has to be completed during a busy period for harvesting other crops, so that the threshing process for 'laketch' thereby becomes more protracted.

Table 6.16 shows that the two most popular of the improved wheats,'supremo' and 'laketch' are also believed to be easier to thresh than traditional wheats. As was shown in subhead 6.2.4, farmers report that these

TABLE 6.16: Changes in Time required to Thresh Major Improved Wheats c.f. Local Wheat

(No of Farmers Reporting Change)

VARIETY	ZONE								TOTAL	
	A		C		B		D			
	M	L	M	L	M	L	M	L	M	L
Kanga	10	-	-	-	5	-	7	-	22	-
Kentana F	8	1	3	-	6	-	-	-	11	1
Laketch 8156.	10	22	-	24	2	16	-	9	12	71
Romany	19	1	35	1	9	-	-	-	63	2
Supremo	-	11	-	22	-	24	-	11	-	68

M = more time required ; L = less time required.

two wheats are also prone to shattering. The reasons
farmers gave in explanation of the difficulty or other-
-wise of threshing were not usually very enlightening
(most replies simply relating to whether it is easier
or more difficult to remove the kernal from the husk).
Where replies were more meaningful, however, the reas-
-ons given related to whether or not a particular wheat
had multiple coverings of chaff or husk over the grain.
One third of the farmers reporting more difficult thre-
-shing of 'kanga','kentana frontana' and 'romany' asso-
-ciated the threshing-resistance of these wheats with
this particular characteristic, while a quarter of those
who reported'supremo'and 'laketch' as being easily
threshed noted the absence of this feature. This point
about multiple layers of husk or chaff is an interest-
-one, since it is obviously this feature which determ-
-ines whether or not a particular variety will be
susceptible to shattering.

The same feature has very important implications for
the inter-seasonal energy requirement - availability
balance for any given crop mix and any given pattern of
access to labour, oxen and other sources of energy.If
a particular grain is liable to shed its ears easily,
there will be a relatively short optimum period over
which harvesting may take place, and in addition extra

care will have to be taken in reaping in order to avoid shaking the grain free. Thus with grain of this type, harvesting will tend to impose relatively restrictive demands while for the same reason threshing will be com--paratively easy. Grains like 'romany', on the other hand, which do not shake free very easily, will be relatively less difficult to reap, but relatively more so to thresh.

It should be noted, however, that with traditional technology in Chilalo, the length and thickness of the straw is the more importantndeterminant of the degree to which different grains are difficult to reap. This will be seen from a comparison of Tables 6.14 and 6.16 which shows that although in most cases a crop which is listed as being relatively easy to reap is also listed as being relatively difficult to thresh, and vice versa, there is one exception in 'supremo'. This wheat is shown as being relatively easy under both headings thus suggest--ing that the advantage in reaping conferred by 'supremo's' long straw outweighs in the minds of most farmers any harvesting difficulties imposed by its tendency to shed its kernels.

6.2.6 WINNOWING :

Table 6.17 shows that a relatively small number of

Table 6.17. Changes in Time required to Winnow Major Improved Wheats c.f. Local Wheat.

(No of Farmers Report Change)

VARIETY	ZONE A		ZONE C		ZONE B		ZONE D		TOTAL	
	M	L	M	L	M	L	M	L	M	L
Kanga	1	-	-	-	3	-	3	-	7	-
Kentana F	3	-	1	-	2	1	-	-	6	1
Laketch 8156.	2	13	-	14	2	14	-	5	4	46
Romany	6	-	19	-	4	1	-	-	29	1
Supremo	3	4	-	11	-	11	-	3	3	29

M = more time required ; L = less time required farmers report changes in the time required to winnow improved varieties of wheat compared with indigenous strains. In almost every case, relative ease of winnow--ing tends to be associated with relative ease of thre--shing and vice versa. The majority of farmers who re--port changes in time requirements for this operation stated that a crop which is well threshed is easy to winnow and that the multiple layers of chaff associated with threshing-resistant strains also result in a higher proportion of trash to be separated from the grain.

6.3 COMPLEMENTARITY AMONG WHEATS

It is clear from the above results that yield increases are not the only changes which have resulted from the introduction of new wheat varieties in Chilalo. Inter-varietal differences in agronomic characteristics, comparing the HYV's both with local wheats and with each other, have had important effects on both the timing of farm operations and in the length of time required to complete them. It is also apparent that farmers are to some extent able to vary the timing of the crop operations to suit their convenience - as in the case of the sowing and harvest dates for 'laketch', discussed in subhead 6.2.2 above. This,however, is not the only possibility open to the farmer : just as he can select a mix of crops which spreads out inter-seasonal demands on farm energy resources, he can also for the same reason select a mix of varieties of the same crop.

Table 6.18 provides in convenient summary form the views of the majority of reporting farmers on the tim--ing of, and time required for, major crop operations on the five main improved wheats relative to indigenous Ethiopian Strains. The potential complementarity of some of these varieties, particularly 'laketch', can be clearly seen in the tables, although of course factors such as environmental suitability, the availabity of seed and the farmers' knowledge of peculiar crop char--acteristics will also help determine whether a given variety can be included in a given farmer's crop mix.

Table 6.19 shows that twenty-eight per cent of all wheat farmers in the sample reported growing more than one variety of wheat as part of their crop mixes. This could be partly due to the desire for insurance against failure of a particular variety - due for example to disease attach - but the possibility of a deliberate attempt to spread workloads should certainly not be ruled out. It will be seen from Table 6.19 that most of the reported mixes - and especially those including 'laketch' - are sometimes to a very considerable extent complementary in their seasonal demands for energy. In the case of the most popular mix,'supremo' plus 'laketch', The early harvest plus easier threshing and winnowing

TABLE 6.18: Summary of Changes of Timing and of Time Required For Major Crop Operations on Improved Varieties c.f. Local Wheat

VARIETY	Time of Sowing	Time Reqd. to Harvest	Time of Harvest	Time Reqd. to Thresh	Time Reqd. to Winnow
Kanga	Early	Less	Late	More	More
Kentant F	Early	Less	Late	More	More
Laketch 8156	Late	More	Early	Less	Less
Romany	Early	Less	Late	More	More
Supremo	Early	Less	Early	Less	Less

TABLE 6.19: Combinations of Different Wheat Varieties Grown by Sample Farmers (No of Farmers)

COMBINATION	ZONE A	ZONE C	ZONE B	ZONE D	TOTAL
Laketch + *Supremo*	1	3	14	1	19
Laketch + Local Wheat	2	-	6	-	8
Laketch + *Romany*	-	3	-	-	3
Laketch + *Kanga*	1	-	-	1	2
Laketch + *Kentana F.*	2	-	-	-	2
Supremo + Local Wheat	1	-	1	-	2
Supremo + *Romany*	-	3	-	-	3
Romany + *Kentana F.*	-	1	-	-	1
Kanga + *Romany* + *Supremo*	-	1	-	-	1
Laketch + *Romany* + *Kentana F.*	-	1	-	-	1
Laketch + *Kanga* + Local W.	-	1	-	-	1
Laketch + *Supremo*++ Local W.	-	-	3	-	3
(Percentages)a/	(11.7)	(29.5)	(64.9)	(8.7)	(28.0)

a/ i.e. Percentage of all wheat growers reporting more than one variety.

makes earlier marketing possible, with marked advant--ages which will be described in Section 6.4. This mix also makes it possible for farmers to spread the workload in ploughing. It will be noted once more that the most market-oriented area, Zone b, is outstanding in having the highest number of farms producing this particular mix as well as having a majority of sample farmers including more than one wheat in their crop mixes.

6.4 CHANGES IN MARKETING

The majority of farmers in the Survey report that they have become more market-oriented since adopting improved seed and/or fertilizer (Table 6.20) The reas--ons for the increase are for the most part fairly ob--vious : yield increases have resulted from increased use of purchased inputs and have resulted in an increase in consumption of non-farm goods. The farmers who report--ed marketing the same or even less, did not, unfort--unately, provide much insdght into the reason for this, but this factor was probably related to the widely-reported poor performance of fertilizer in the previous season, which will be discussed in Chapter 8.

Farmers were also asked if, as a result of using fertilizer and improved seed, they now marketed their

TABLE 6.20 Changes in Amount Marketed Since Introducing Fertilizer/Improved Seed

(Percentages)

	ZONE				TOTAL
	A	C	B	D	
Market more	62.7	67.4	55.8	67.4	62.1
Market less	4.5	4.7	9.3	4.7	5.2
No change	29.9	18.6	25.6	18.6	27.0
Don't know	1.5	-	2.3	-	0.9
Other[a]	1.5	9.3	7.0	9.3	4.8

a/ These were farmers who said the amount marketed varied with household needs, yields, prices,etc.

their crop earlier or later in the year. The replies to this question are summarized in Table 6.21 , which shows that the majority of farmers now market their crops earlier than they did in the past [15/]. The great majority (82 per cent) of those who report that they market their crops earlier say they do so in order to avoid the additional interest charges imposed by CADU on overdue loans (a "collection fee" of two per cent per month on the outstanding balance). The other major reason given (by 11.5 per cent) was the earlier harvest. A few farmers mentioned the need to buy non-farm goods such as clothing. The great majority of those who re--ported marketing later (11 farmers) did so in order to take advantage of higher prices later in the season.

The question of timing of marketing is of crucial importance to farmers everywhere, since seasonal var--iations in the price of farm produce can be very large indeed. The most important terminal grain market in Ethiopian is that of the capital and largest city,Addis Ababa, and agricultural commodity prices in all other markets in the country vary directly with addis Ababa prices (see Gill 1975,Section 2.5) This is especially

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15/ The relationship between changes in the quantity marketed and changes in the time of marketing is significant : Kendall's 'tau' = 0.337, level of significance 0.1% better.

TABLE 6.21: Changes in Time of Marketing Since Introducing Fertilizer/Improved Seed

(Percentage)

	Zone				TOTAL
	A	C	B	D	
Market Earlier	59.7	41.9	67.4	62.1	57.7
Market Later	-	14.0	4.7	10.3	6.6
No Change	29.9	25.6	14.0	25.9	26.4
Don't Know	1.5	-	2.3	-	10.9
Other a/	9.0	18.6	11.7	1.7	10.5

a/These were farmers who said the time of selling depended on household needs, prices ,etc.

true of Chilalo, since the District's main crop-producing areas are only a few hours drive from the capital along excellent all-weather roads. In any case the prices paid by CADU are calculated directly from the current Addis Ababa market prices and CADU has by now become the price leader among Chilalo grain buyers. Seasonal variations in Addis Ababa prices are therefore a convenient surrogate for those facing Chilalo small-holders.16/ These are presented in Table 6.22 which shows that there is a tendency for commodity prices to remain relatively low and even continue to decline for some months after the harvest as grain deliveries continue to reach the terminal marketf from the interior. Thus the prices of the main cereals do not begin to move upwards until around April and do not reach their peak until August-September.

16/ The system of grain marketing in Ethiopia is at the moment in a state of disarray - to put the point mildly - since the arrest and even execution of many private grain merchants on charges of hoarding. Nevertheless, since inter-seasonal var--iations in grain prices are not entirely the result of speculation for private gain, but do at least partly reflect real storage and associated costs, it is conceivable that even a future state-owned grain marketing organization would set prices which at least in part reflect these costs.

TABLE 6.22: Indices of Seasonal Price Variation for Grains, Pulses and Oilseeds (1962-74)

(Percentage Coefficients of Variation in Parentheses)

CROP (Harvest)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
RED TEFF	89.2	94.0	96.0	99.0	98.3	102.2	107.9	110.6	106.7	104.6	99.4	91.9	100.0
(Nov-Jan)	(1.7)	(2.7)	(2.8)	(2.1)	(2.1)	(2.0)	(1.3)	(1.4)	(1.2)	(1.9)	(1.7)	(1.1)	(6.6)
BROWN TEFF	94.9	93.1	94.0	97.9	96.9	101.5	105.5	107.3	105.7	103.8	100.6	98.6	100.0
(Nov-Jan)	(2.4)	(2.8)	(2.5)	(1.9)	(2.2)	(1.2)	(1.5)	(1.8)	(1.5)	(1.0)	(0.8)	(1.5)	(4.9)
WHITE WHEAT	94.5	94.8	93.9	99.5	100.6	100.2	104.0	106.6	107.6	104.0	98.3	96.5	100.0
(Nov-Dec)	(2.6)	(2.9)	(3.1)	(2.9)	(2.4)	(1.9)	(2.3)	(3.2)	(4.4)	(1.5)	(4.0)	(2.9)	(4.7)
BROWN WHEAT	92.8	94.4	94.9	100.3	101.8	100.7	104.8	107.5	106.6	104.2	98.0	94.7	100.0
(Nov-Dec)	(2.8)	(2.9)	(1.6)	(2.6)	(1.8)	(0.9)	(2.3)	(3.1)	(2.4)	(2.4)	(3.7)	(1.5)	(5.1)
MAIZE	91.4	93.0	96.7	99.2	100.0	103.6	109.7	111.8	112.1	101.8	94.4	87.3	100.0
(Oct-Nov)	(3.6)	(3.3)	(2.7)	(3.8)	(1.5)	(1.5)	(2.5)	(2.1)	(2.8)	(3.2)	(5.4)	(2.7)	(8.1)
BARLEY	97.3	93.2	94.8	98.3	97.5	100.1	103.2	107.5	108.0	104.0	96.3	100.7	100.0
(Oct-Dec)	(2.8)	(3.8)	(4.3)	(3.1)	(2.7)	(2.3)	(3.6)	(3.6)	(2.1)	(3.4)	(2.2)	(2.8)	(4.8)
SORGHUM	90.5	95.3	96.2	98.0	97.9	100.2	104.0	107.6	107.2	104.2	104.8	94.8	100.0
(Oct-Dec)	(3.9)	(2.7)	(3.1)	(1.9)	(2.6)	(1.8)	(2.1)	(1.4)	(2.0)	(3.2)	(4.9)	(4.0)	(5.5)
LENTILS	94.5	103.6	96.0	95.3	98.0	100.3	103.0	108.2	107.7	103.7	93.5	94.3	100.0
(Oct-Nov)	(2.9)	(6.8)	(3.5)	(3.5)	(3.5)	(1.9)	(2.4)	(2.1)	(1.7)	(3.4)	(4.3)	(3.9)	(5.2)
GREEN PEAS	89.8	97.6	101.0	99.6	104.9	104.9	105.1	105.4	104.4	104.5	93.7	89.4	100.0
(Oct-Nov)	(2.2)	(2.0)	(2.1)	(2.0)	(2.4)	(1.1)	(2.3)	(1.9)	(2.6)	(2.4)	(2.7)	(4.7)	(6.1)
HORSE BEANS	90.8	97.1	103.8	97.9	99.6	100.2	106.8	109.1	106.9	103.0	94.6	91.8	100.0
(Oct-Nov)	(4.1)	(2.9)	(7.0)	(9.3)	(2.3)	(2.4)	(2.9)	(3.0)	(2.7)	(3.4)	(1.7)	(2.6)	(6.0)
CHICK PEAS	106.2	100.4	93.4	92.8	94.9	98.8	101.6	105.2	104.2	99.1	97.3	104.6	100.0
(Feb-Mar)	(7.6)	(4.3)	(3.9)	(3.4)	(2.8)	(3.5)	(3.7)	(3.4)	(2.6)	(2.0)	(5.2)	(6.0)	(4.7)
LINSEED	93.6	96.9	98.9	97.5	99.9	104.8	105.5	108.2	107.4	102.0	92.2	94.1	100.0
(Nov-Dec)	(2.3)	(2.9)	(1.9)	(3.0)	(1.6)	(2.2)	(1.7)	(2.6)	(4.3)	(2.3)	(3.0)	(2.7)	(5.5)
RAPESEED	92.3	97.7	98.9	98.5	101.0	105.7	106.3	109.0	105.3	101.7	94.4	89.7	100.0
(Nov-Dec)	(3.5)	(2.3)	(2.5)	(1.3)	(1.7)	(2.4)	(2.1)	(3.1)	(1.3)	(3.0)	(3.6)	(3.8)	(6.0)
NIGER SEED	90.7	98.3	97.8	96.2	97.9	101.9	105.8	107.8	107.6	105.2	97.0	93.6	100.0
(Nov-Jan)	(1.6)	(2.1)	(2.2)	(2.4)	(2.5)	(2.8)	(2.0)	(1.9)	(1.8)	(1.6)	(3.6)	(3.1)	(5.6)

Source: Computed from unpublished data from the Ethiopian Grain Corporation.

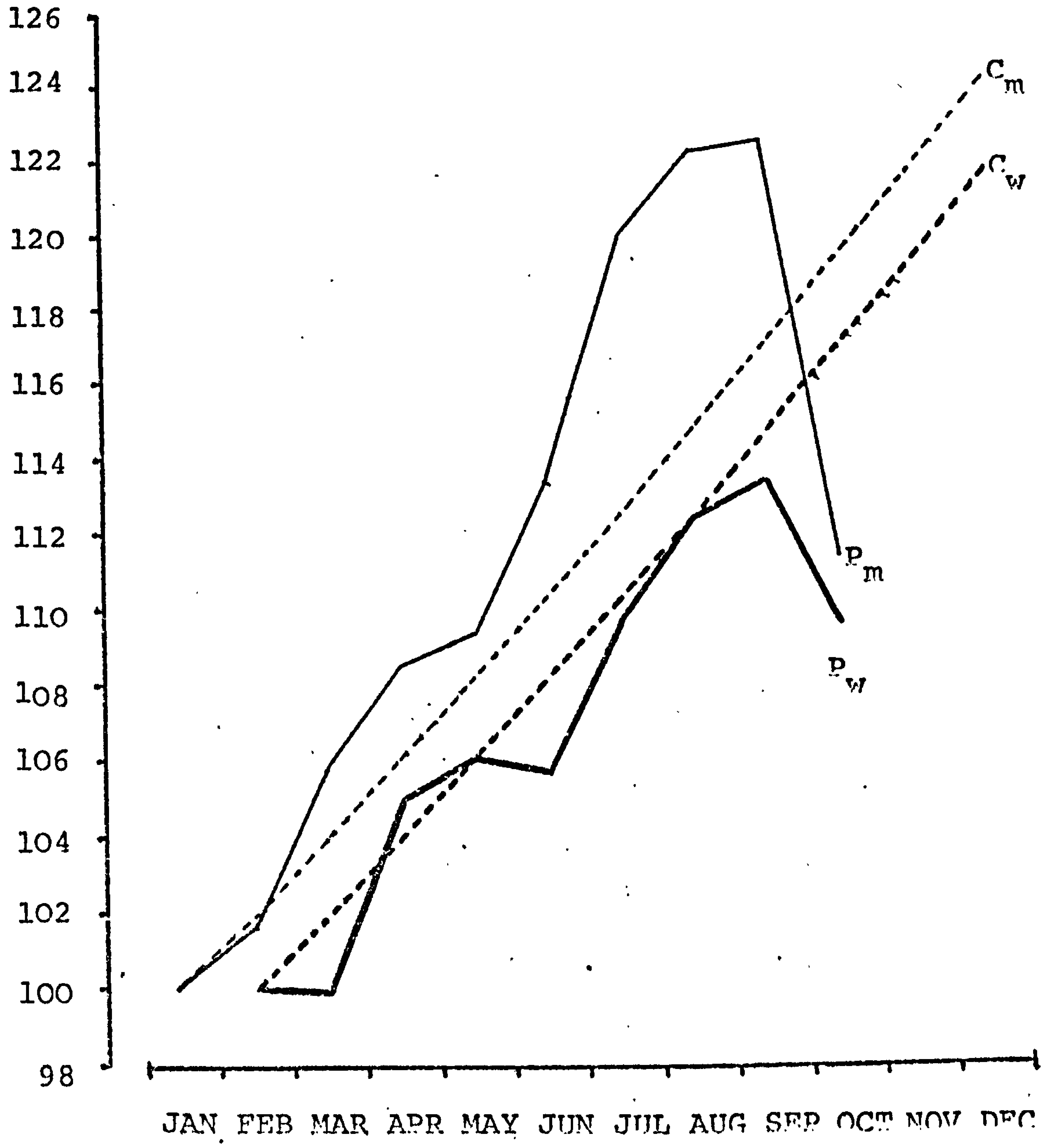

FIGURE 6.1: MONTHLY INDICES OF CROP PRICES AND CREDIT COST

C_m = Monthly credit cost index for maize (Jan 15=100)
C_w = " " " " " wheat (" " ")
P_m = " price index for maize (Jan 15=100)
P_w = " " " " wheat (" " ")

The question of timing of marketing obviously has very important implications for any study of seasonal energy requirement-availability balances, since both increased market-orientation and earlier marketing will make earlier harvesting desirable and/or require speedier completion of post-harvest operations. The question is therefore worth pursuing further.

CADU has two periods for credit repayment : 15th December to 15th January for Zones B and D and 15th January to 15th February for Zones A and C.[17] The choice facing any individual farmer who has borrowed from CADU, therefore, would appear to lie on the one hand between marketing his crop shortly after the harvest at relatively low prices in order to repay the CADU loan on time, or, on the other hand, storing his produce in the expectation that higher prices later in the season will more than compensate him for the penalty charges imposed by CADU.

The above choice is illustrated in Figure 6.1 for two hypothetical farmers in the Survey area, one a lowland farmer whose main cash crop is maize and who faces the 15th January deadline and the other from the highlands marketing wheat and having to meet the later deadline. The curves c_m(aize) and c_w(heat) represent in index form the steadily increasing cost of CADU's

17/ These dates are taken from internal CADU policy documents. The later repayment period at the higher elevations reflects the generally later harvest.

two per cent "collection Fee" with compound interest, after the respective deadline dates are passed. The base dates are 15th January and 15th February for maize and wheat respectively. Curves Pm and Pw represent the monthly wholesale prices of the two crops, taken from Table 6.22. In each case the base date of the series has been adjusted to equal that of the relevant cost series for the sake of ease of interpretation.

The maize farmer is apparently in a relatively fortunate position, largely because the harvest date for this crop in Chilalo is later than that in most other parts of Ethiopia. Provided this farmer can re--tain his crop at least until March, it would appear from Figure 6.1 that the benefits of the operation would substantially exceed the costs. The wheat farmer on the other hand seems to be able to store his crop profitably only if he sells in April, and even then the improvement would be marginal. Some words of caution must be added, however, to show that the picture pres--ented in Figure 6.1 is very much biased in favour of a decision to store the crop.

First there is obviously considerable uncertainty about future prices, since the seasonal pattern of Addis Ababa wholesale prices can vary markedly from year to year, as is shown in Figure 6.2. Given that Thrid World smallholders are notoriously - and entirely rationally - averse to risk, even those who, like thesample examined

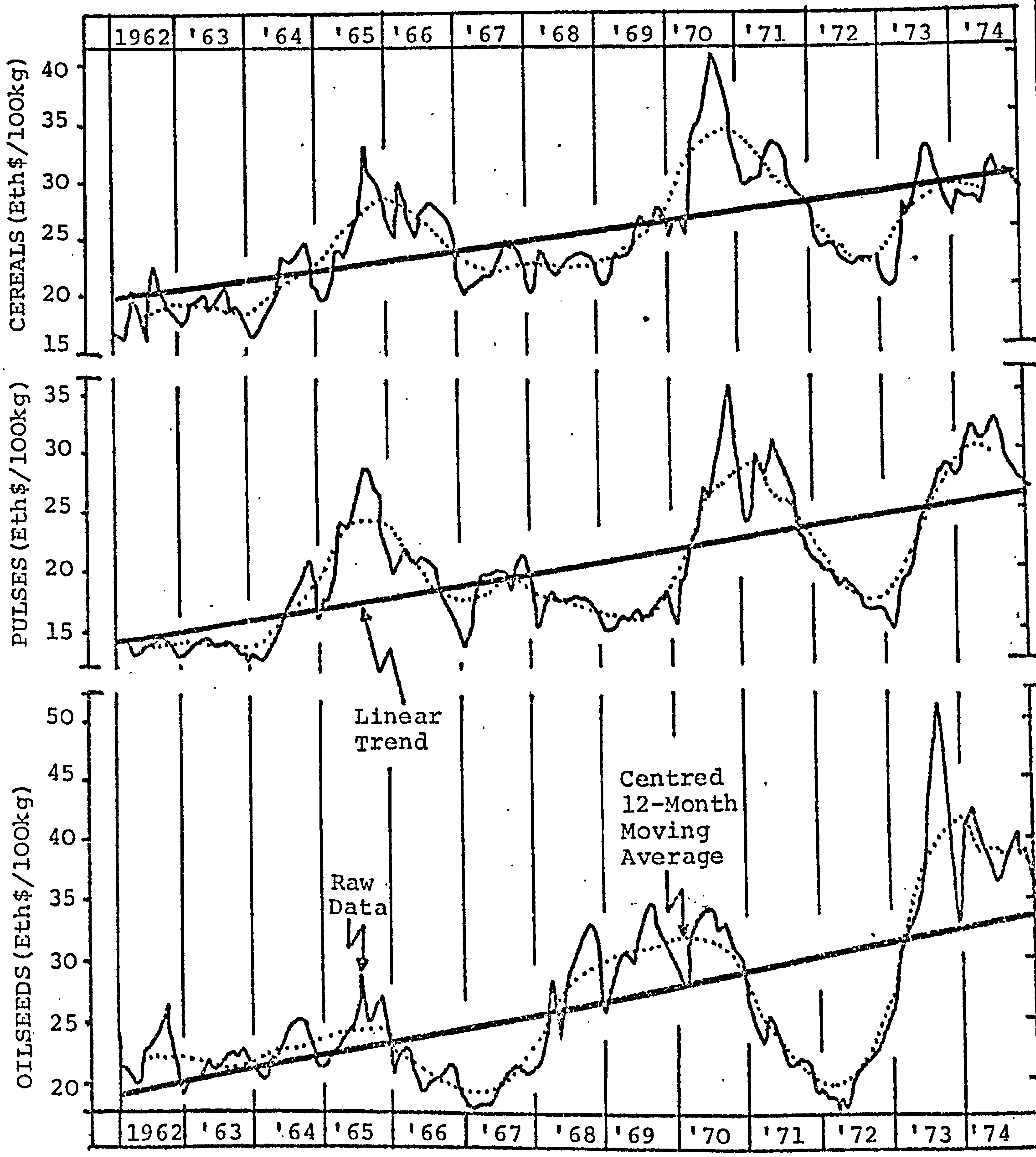

FIGURE 6.2: MONTHLY WHOLESALE CROP PRICES IN ADDIS ABABA, 1962-74

Drawn from monthly data from the Ethiopian Grain Corporation.

in this survey, have become relatively more market-oriented, are likely to be deterred by this factor. Second, CADU's "collection fee" is not the only additional cost associated with late repayments, since no further credit will be granted [18], nor will CADU's marketing or other facilities be made available until the outstanding balance has been repaid. Third, an implicit assumption of the model is that storage costs other than interest charges are zero, whereas there may in fact be some, albeit small, loss or spoilage of produce in store (see Chapter 2, pp38-39). Finally another implicit assumption is that the farmer is a price-taker in this situation. This is probably valid in the case of maize, since Chilalo produces only a tiny fraction of Ethiopia's total marketed output, but in the case of wheat, and to a lesser extent barley, the opposite is true. Thus any decision by a substantial number of Chilalo's wheat farmers to market their crop later in the year, could be expected to have noticeable effect on inter-seasonal price movements.

In conclusion, therefore, it can be said that the decision of the bulk of the sample farmers to market their crop in time to meet CADU's deadline for credit repayments is economically justifiable (provided of course that non-marketing costs are not thereby increased). The result

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18/ Jonsson(1975, Ch.4) has shown that a substantial number of those who use CADU's credit facilities for inputs continue to do so in successive years.

will, in some instances however, be a tendency for any existing bottleneck in harvesting and post harvest oper--ations to be intensified or new ones created. The trend towards earlier marketing, it should be noted,almost certainly helps explain the great popularity of 'laketch 8156' and supremo, both of which, as was shown in Table 6.15, are generally harvested earlier than traditional wheats. Wher earlier harvesting is not possible, as in the case of other wheats listed in Table 6.15, the time available for post-harvest operations is likely to be sub--stantially reduced.

6.5 OTHER CHANGES

A number of other possible changes resulting from the use of new inputs was investigated. These results are summarised only briefly in this section, since none of them seems to be as important as these discussed in the previous two sections.

6.5.1 STORAGE:

An increase in storage capacity would suggest, but not necessarily imply, either delayed marketing in order to await seasonal price increases or enhanced food sup--plies for subsistance, or both. Table 6.23 shows that only one third of the responents had increased their stora--ge space and in fact none of these reported that this

Table 6.23: Changes in Storage Space Since Introducing Fertilizer and/or Improved Seed (percentages)

	ZONE				
	A	C	B	D	TOTAL
More Storage	28.4	25.6	32.6	24.5	30.3
Less Storage	3.0	-	-	1.7	1.4
No Change	62.7	69.8	60.5	58.6	62.6
Other[a]	1.5	2.3	-	-	0.9
Don't Know	4.5	2.3	7.0	5.2	4.7

a/ ie "depends on the yield".

was in order to await higher prices: all of them stated that it was because of higher yields, which in turn suggests and increase in supplies of food for subsistence. The three farmers who reported a reduction in storage space gave increased sales as the reason for this.[19]

6.5.2 OXEN

Restrictions on a traditional Farmer's access to oxen have been shown to be a major potential source of imbalance between energy requirements for crop product--ion and the availability of on-farm energy supplies. First, in Section 5.4 of the previous chapter it was established that the working day for a team of oxen is considerably shorter than that for a man. Second in Section 5.6 and especially in Figure 5.3, it was shown that even when due allowance is made for the shorter working day, the non-availability of a sufficient number of oxen could still be a more important constraint than shortage of labour. Finally Section 5.2 of the present chapter indicates that in a number of cases the intro--duction of improved seed and/or fertilizer has increased rather than diminished the energy requirements associated with certain farm operations in which ox-power is a major input.Ploughing, and with some varieties,threshing

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19/ Rank order correlation shows no significant correl--ation between changes in the timing of marketing and changes in storage requirements. There is,however, a significant positive relationship between Storage requirements and quantity marketed : Kendall's'tau'= 0.319,level of significance =0.1% or better.

TABLE 6.24: Changes in Number of Oxen Since Introducing Fertilizer/Improved Seed

(Percentages)

	ZONE				TOTAL
	A	C	B	D	
More Oxen	17.9	18.6	27.9	32.8	24.2
Fewer Oxen	3.0	-	7.0	-	2.4
No Change	74.6	81.4	55.8	63.8	69.2
Other a/	-	-	2.3	1.7	0.9
Don't Know/Not Stated	4.5	-	7.0	1.7	3.3

a/e.g. "depends on resources available".

fall under this heading.

One traditional response[20] to the above situation would obviously be to increase the number of oxen on the farm, resource availability permitting, but in fact only a quarter of the sample farmers reported doing so (Table 5.24). Of those who did report using more oxen, most attributed this to the needs imposed by new inputs: better seedbed preparation (53 per cent) or more diffic--ult threshing (18 per cent). In the remaining cases answers related to the need to complete the work on time, but did not specify operations.

The replies given by the farmers who reported having fewer oxen than previously, although few in number (four), are neverthe less illuminating. Two farmers reported a reduction in fallowing, one adding that a field that is in continuous cultivation for a longer period is easier to till. A third farmer mentioned a reduction in avail--able grazing, which could in part stem from a reduction in fallowing, since fallow land is normally available for rough grazing. Finally, one farmer reported having to sell his oxen in order to repay a CADU loan after a crop failure. Although replies of this sort should always be treated with some caution (since a survey of this type provides a useful opportunity to air grievances by way of an over-stated case), they do provide a useful remind--er of the increased risks faced by a farmer who begins

20/ The substitution of non-traditional energy sources will be discussed in the next chapter.

to use purchased inputs, particularly if these are pur--chased on credit.

6.5.3 RELATIVE CROP AREAS:

It was shown in Figure 5.3 how by varying the indiv--idual components of a crop mix a farmer could quite successfully adjust the inter-seasonal incidence of energy requirements to match available on-farm supplies more closely and how a number of existing crop mixes in Chilalo exhibit this type of complementarity. In an att--empt to investiage changes of this type subsequent to the introduction of new inputs, farmers were asked to report relative changes in the areas under five major crops in the Survey Area : wheat,barley,maize,field peas and beans (question A12,Apprendix A). Unfortunately this question does not appear to have been fully understood by all the farmers interviewed and the enumerrators re--ported having gained the impression that some farmers tended not to distinguish between cyclical changes in crop areas resulting from crop rotation and those which followed the introduction of new inputs. The results of this part of the survey will not therefore be presented in tabular form, to avoid giving a spurious impression of precision.

For all of these crops almost all farmers report either no change in the areas under these crops or sli--ghtly less frequently, that the area has been increased.

This suggests at first glance either that the average farm size of sample farmers has tended to increase or that the areas under these major crops have tended to increase at the expense of minor ones, or perhaps both, Either of these answers is plausible. First, the farmers selected for interview come for the most progressive segment of the farming community, namely those who had adopted fertilizers and/or improved seed, and such farm--ers would be likely to be in a good position to buy or rent land from less progressive neighbours or from land--lords. Second, the switch towards larger areas under major crops could accompany a reduction in the total number of different crops grown, reflecting a shift away from subsistence farming in the direction of the more specialized, market-oriented agriculture.

Positive relationships between the relative areas under the various crops are not of very great interest in this type of study, whereas negative relationships (indicating the possibility of substitution of one crop for another) are. Only in one case was a statistically significant negative relationship established between two crops;maize and field peas.[21/] The possibility of substitution between these particular crops is espec--ially interesting in view of their complementarity as shown in Figure 5.3, but in view of the caveat expressed earlier, no further speculation on this possibility is really worth undertaking.

21/Kendall's tau=0.288(with 33 observations);level of significance = 3.6 per cent.

6.5.4 SOIL BURNING :

The reasons for this practice, its advantages and disadvantages, were described in Chapter 2, Section 2.3. Table 6.25 shows that the practice was never common in the two lower zones and that it has by now largely been abandoned in the highlands - at least by farmers who have begun to use chemical fertilizer. The advantages of soil burning according to the farmers are that it increases yields and/or kills weeds.

A surprisingly large proportion (18 per cent) of respondents who had xxx at some time burned the soil stated that the practice had no disadvantages, although in view of the fact that the majority of them have now abandoned the practice makes this very difficult to believe.[22] The majority of those who had abandoned the practice of soil burning did, however state its disad--vantages and chief among them was the arduous,dusty and unhealthy labour which this technique entails. A sizeable minority (27 percent) of those who reported

[22] This is an example of an intriguing phenomenon which was encountered more than once in the course of the present study. Farmers were very prone to defend their traditional techniques and technology verbally, although evidently quite prepared in practice to aban--don them in favour of more modern methods. This could result partly from self-respect and partly from the adoption of a bargaining stance by playing down the relative advantages of modern technology in the hope that this will affect the asking price!

TABLE 6.25: Changes in the Practice of Soil Burning (Percentages)

Burnt Soil in Past	Burns Soil Now	ZONE				TOTAL
		A	C	B	D	
Yes	Yes	6.0	9.3	2.3	-	4.3
Yes	No	52.2	55.8	2.3	1.7	28.9
No	Yes	1.5	-	9.3	1.7	2.8
No	No	40.3	34.9	86.0	96.6	64.0

any disadvantages took the view that soil burning would increase yields for two,or at most three, years but at the expense of infertility in the longer term, while three others observed that increased water erosion of the soil resulted from this pratcice.

The abandonment of soil buring is one of the very few examples uncovered by this study of workloads act--ually being reduced as a consequence of the introduct--ion of chemical fertilizer.

However, the time and effort saved is only during what in Zone's A and C is an otherwise slack period after the first ploughing (see Diagrams 5.3.1 to 5.3.6 of Figure 5.3).Against this must be set the fact that soil burning does destroy weeds, and more important, weed seeds, so that the abandonment of this practice can be blamed at least in part for the increased problems with weeds noted earlier in the present Chapter. This is not, of course, to defend what was, after all, a highly destructive tech--nique, but simply to point out a less-than- desirable side-effect of its falling into disuse.

6.5.5 WORKLOADS :

Farmers were asked for their impressions as to whether their work had generally become either easier or more difficult as a result of their using the new inputs. This question was deliberately placed at the end of the schedule section dealing with changes in crop operations(Section A,Appendix A), since by that point in the interview the respondent would have been, verbally "taken through" the farming year and would have been giving the subject his attention for some time. The results are summarized in Table 6.26.

Obviously the majority of farmers feel that they had to work harder since the introduction of new inputs. Two-thirds of these blame increases in weed contaminat--ion for the increase in their workloads.Difficulties associated with the harvest were noted by a further 21 per cent and problems caused by extra or earlier plough--ing by 14 per cent. The remainder noted only that the general standard of husbandry had had to improve. One especially interesting reply was given by three farmers in Zone A who blamed problems with harvesting on the fact that all of their crops now tended to ripen at the same time, which is a fairly clearcut case of tradition--al arrangement for easing bottlenecks having been upset by the advent of modern technology.

It is interesting to compare the above results with those of Tables 5.17 and 5.18 which indicated that the most frequently noted period of heaviest work is har--vesting,whereas Table 6.26 shows that work on weeding has become a major new problem. Harvesting has always been a period of heavy workloads because of the back-

TABLE 6.26. Changes in Farmers' Perceptions of Overall Workloads Since Introducing Fertilizer/Improved Seed (Percentages)

	ZONE				
	A	C	B	D	TOTAL
Work More Difficult	64.2	53.5	58.1	55.2	58.3
Work Easier	4.5	9.3	7.0	19.0	10.0
No Change	29.9	32.5	25.6	24.1	27.9
Other a/	-	2.4	-	-	0.5
Don't Know/Not Stated	1.5	2.3	9.3	1.7	3.3

a/ "Easier except for weeding."

straining labour of reaping with a sickle.Weeding has evidently now moved into secon place ; it is worth noting that these tasks must be performed by hand lab--our only. Tasks were work animals are used tend to be regarded as major problems areas by relatively few farmers.

6.6 FARMERS' VIEWS OF THE NEW INPUTS

Farmers who had used fertilizers and/or improved seed were asked to give their views on the advantages and disadvantages of using these inputs. These views are detailed in Tables 6.27 to 6.30. In each of these four tables percentage figures relate only to those farmers who have actually used the inputs in question. It should be noted that since farmers were asked to re--port more than one advantage or disadvantage, the per--centages given in these four tables will often total more than 100.

As would be expected the vast majority of farmers felt that increasing crop yields was the chief advantage of using fertilizer, although one farmer observed that if too much fertilizer were applied, yields showed a tend--ency to decline. The second most frequently reported advantage, namely that fertilizer increases the fertility of the soil, could in some cases mean the same thing as increased yield, but the very large number of farmers

TABLE 6.27: Farmers views of the Disadvantages of Using Fertilizer (Percentages)

	ZONE				TOTAL
	A	C	B	D	
1. Expensive	70.1	79.1	51.2	75.0	69.4
2. Price Keeps Increasing	4.5	7.0	2.3	12.5	6.7
3. Fertilizer not Successful Now	19.4	-	14.0	7.1	11.0
4. Increases Weed Growth	13.4	25.6	18.6	28.6	21.1
5. High Interest Rates	3.0	-	2.3	-	1.4
6. Causes Crop to Lodge	-	2.3	2.3	10.7	3.8
7. Increases Insecurity	-	2.3	2.3	-	1.0
8. Not Successful if Rainy	1.5	-	4.7	1.8	1.9
9. Requires Hard Work	3.0	-	-	3.6	1.9
10. More Damage if Drought	-	-	-	7.1	1.9
11. Reduces Yield	-	-	-	5.4	1.4
12. Helps Leaf Growth Only	-	-	-	1.8	0.5
13. Can Damage Crops unless used properly	-	-	-	1.8	0.5
14. Needs increased crop sales when price is low	-	-	-	1.8	0.5
15. No Disadvantages	9.0	14.0	18.6	10.7	12.4
(Number Reporting)	(67)	(43)	(43)	(56)	(209)

TABLE 6.28: Farmers' Views of the Advantages of Using Fertilizer (Percentages)

	ZONE				TOTAL
	A	C	B	D	
Increases Yield	100.0	100.0	93.0	91.1	96.7
Better Crop Stand	7.5	4.7	-	7.1	5.3
Produces Good Seed	1.5	2.3	-	-	1.0
Taller Crop	-	7.0	-	1.8	1.9
Increases Soil Fertility	23.9	20.9	37.2	39.3	30.6
Crop Ripens More Quickly	-	7.0	4.7	5.4	3.8
Earlier Harvest	-	2.3	-	-	0.5
Makes Ploughing Easier	3.0	4.7	-	5.4	3.3
Fewer Weeds	3.0	-	-	-	1.0
Prevents Rust	-	-	-	1.8	0.5
Effects Still Felt in Second Year	-	-	-	3.6	0.[illegible]
No Advantages	1.5	-	4.7	10.7	4.3
(Number Reporting)	(67)	(43)	(43)	(56)	(209)

TABLE 6.29: Farmers' Views of the Disadvantages of Using Improved Seed (Percentages)

	ZONE				TOTAL
	A	C	B	D	
1. High cost of credit	-	-	5.0	6.9	2.4
2. Some varieties need harder work	20.7	11.9	25.0	17.2	18.9
3. Lower yield (*Kanga*)	-	-	2.5	3.4	1.2
4. Expensive seed	13.8	16.7	5.0	13.8	12.4
5. Increase insecurity	-	-	2.5	-	0.6
6. Need fertilizer to produce higher yield	3.4	-	7.5	-	3.0
7. Do not resist disease	3.4	4.8	2.5	10.3	4.7
8. Shattering	1.7	-	-	-	0.6
9. More Weeds	1.7	-	-	-	0.6
10. Grain too soft	1.7	-	-	-	0.6
11. Do not resist Frost or Cold	5.2	-	-	-	1.8
12. Difficult to bind	-	-	-	3.4	0.6
13. Poor market	-	-	-	3.4	0.6
14. Affected by lodging	-	7.1	-	-	1.8
15. No Disadvantages	60.3	57.1	65.0	55.2	58.0
(No Reporting)	(59)	(42)	(40)	(29)	(170)

TABLE 6.30: Farmers' Views of the Advantages of Using Improved Seed (Percentages)

	ZONE				TOTAL
	A	C	B	D	
1. Complement fertilizer	10.3	2.4	2.5	-	4.7
2. Clean Seed	5.2	11.9	10.0	13.8	9.5
3. High Yield	62.1	85.7	75.0	89.7	75.7
4. Easier to harvest	-	-	10.0	10.3	4.1
5. Improved flavour	12.1	7.1	15.0	17.2	12.4
6. Germinate easily	-	-	2.5	-	0.6
7. Frost resistant (Laketch, Romany)	3.4	4.8	5.0	-	3.6
8. Earlier harvest	-	-	2.5	48.3	8.9
9. Smother weeds	-	-	2.5	3.4	1.2
10. Availability of credit	1.7	2.4	-	-	1.2
11. Only wheat that will grow in lowlands	-	-	-	3.4	0.6
12. Good price	25.9	31.0	40.0	27.6	30.8
13. No advantages	31.0	4.8	2.5	6.9	13.6
(Number reporting)	(59)	(42)	(40)	(29)	(170)

gave both reasons.So they must perceive some difference. Some farmers added that fertilizer could make poor or exhausted land fertile or that it would prevent the land from becoming barren, so that in most cases this is what was probably intended. The import of most of the advantages listed for fertilizer in Table 6.28 are either self-evident or will hopefully have been made clear earlier in the present chapter. However some of the stated advantages may seem rather puzzling. The following explanations are plausible.

1. Produces Good Seed; because of less weed contam--ination ?
2. Taller crop:this would promote easier reaping.
3. Makes Ploughing easier: this probably results from the reduction or elimination of fallowing after fertilizer is adopted (see Subhead 6.4.2), with the result that the problem of highly compacted overgrown fields after the fallow is avoided.
4. Fewer Weeds: if fertilizer gives a good early boost to the crop, the crop can become strong enough to choke any weeds which later appear. (See Section 6.2.3).

As regards inter-zonal differences, the only really noticeable difference was seen in Zone D, where a size--able minority of farmers claimed that fertilizer brought no advantages. This will be discussed in Chapter 8.

Farmers' views on the disadvantages of fertilizer use can be seen in Table 6.27. The fact that the great maj--ority offarmers stated that fertilizer is too expensive or that interest rates are too high, should not of course be taken at face value. Rather more significant, however, is the fact that a substantial number of farmers object--ed to the fact that the price of fertilizers keeps in-creasing from year to year.

It is of course the complaints other than those regarding cost which are of most interest to a study of this type. Of these the fact that fertilizers boost weed growth was one the most frequently voiced. This was espec--ally true in Zone D where, as noted earlier, weed comp--etition is regarded as an important problem. There are also a few complaints that the use of fertilizer made for harder work in seedbed preparation. A fairly large number of farmers complained that, whereas fertilizer had increased yields in the past, it had not increased them, and in some cases had actually reduced them, in the current crop season. This was probably the result of climatic factors, but it unfortunately coincided with a change in the type of fertilizer supplied by CADU and this has caused considerable ill-feeling among farmers.[23/]

23/This factor will be discussed further in Chapter 8.

As in the case of fertilizer, the main perceived advantage of improved seed is its yield-increasing properties (Table 6.31). A few farmers also specifically mentioned the relationship between the use of fertil--izer and that of high yielding varieties. The relat--ively high price which improved varieties fetch is also widely noted, although just as there was probably some over-statement of the disadvantage of high fert--tilizer prices, there may have been some understatement of the advantages of relatively high prices for improv--ed grain.

These reports about improved varieties having a better flavour and fetching higher prices than tradit--ional strains is very interesting indeed. The second point was checked with CADU's Marketing Division but Cadu apparently pays the same price for all wheats of a given standard of purity, so that it must be private traders who pay higher prices for HYV's. This situation compares very favourably with that obtaining in many parts of asia where Falcon(1970) reported that because of problems of poor flavour and therefore low consum--er acceptance, the grains of high yielding varieties sold at discounts up to twenty per cent, at least initially.

As far as this survey is concerned, the most imp--ortant among the perceived advantages and disadvantages of HYV's are those concerning workloads . Although a small proportion of farmers felt that the use of such varieties made their work easier, the majority (82 per cent) of those who felt that HYV's affected their work--load felt they made it more difficult. Only three farm--ers felt that the use of HYV's affected the question of weed infestation, two of whom felt that it was lessened. This is interesting, because if farmers were to use clean, certified seed instead of growing their own, the weed prob--lem would almost certainly be greatly reduced.

Farmers who used fertilizer and/or improved seed were asked whether or not they intended to use them in the future. Their replies to these questions are summarized in Table 6.31 and 6.32. These show that the great maj--ority of farmers do intend to continue using such pur--chased inputs. In the case of fertilizer, it is interest--ing to note the proportion of farmers who intend to use it again declines towards the more lowland areas. This is almost certainly because of the change in fertilizer type supplied by CADU in the lowlands in the previous year and (coincidently ?) poor yields in the same year.[24] In the case of improved seed, the farmers who state that they do not intend using it again are probably referring to seed purchased from CADU.Seed produced by the farmers themselves

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24/ This point is further discussed in Chapter 8, Section 8.1.

TABLE 6.31: Stated Intentions Regarding Future Use of Fertilizer

(Percentages)

	ZONE				TOTAL
	A	C	B	D	
1. Intend to use fertilizer again	97.0	95.3	86.0	70.7	87.2
2. Do not intend to use fertilizer again	-	2.3	4.7	15.5	5.7
3. Undecided	1.5	-	-	6.9	2.4
4. Provided price does not increase	-	-	2.3	-	0.5
5. Provided quality is improved	1.5	-	-	-	0.5
6. Provided price is Reduced	-	-	-	1.7	0.5
7. Provided price is reduced and quality improved	-	2.3	-	5.2	1.9
8. Not stated	-	-	7.0	-	1.4

TABLE 6.32: Stated Intentions Regarding Future Use of Improved Seed (Percentages).

	ZONE				TOTAL
	A	C	B	D	
1. Intend to use improved seed again	67.2	86.0	81.4	67.2	73.9
2. Do not intend to use improved seed again	19.4	4.7	-	22.4	13.3
3. Undecided	7.5	7.0	4.7	8.6	7.1
4. Not stated	6.0	2.3	14.0	1.7	5.7

will almost certainly continue to be used.

CHAPTER 7; TECHNOLOGICAL CHANGE II:

HERBICIDES AND FARM MACHINERY

Chapter 5 was mainly concerned with examining the organization of traditional farming in Chilalo, partic--ularly insofar as this affects the balance between on-farm supplies of energy and the energy requirements of particular crop mixes season by season. The concern of Chapter 6 was with alterations to traditional inter-seasonal energy requirements which have resulted from the introduction of fertilizer and/or improved seeds. The present chapter will therefore aim at completing the picture by examining the steps taken by Chilalo farmers to adjust energy supplies to cope with either traditional or newly created bottlenecks.

It is for this reason that herbicides have been included in this rather than in the previous chapter, although in their physical characteristics at least, they more closely resemble working capital like fert--ilizers than items of fixed capital such as tractors and combine harvesters. Further attention will also be paid to the question of hired labour (see also pp105-111), since this can play an important altern--ative or even complementary role to that of machin--ery and herbicides. It is perhaps worth noting that

that there is an important distinction to be drawn here between hired labour and labour which is avail--able under a traditional mutual exchange agreement. because in Chilalo labour is exchanged under such arrangements on a basis of strict reiprocity, the total supply of labour to any given member is not thereby increased, but instead the system permits him (to a limited extent) to trade surplus labour in a relative--ly slack period for additional labour in a relatively busy period. Any hiring of labour, on the other hand constitutes for the individual farming enterprise at least, an addition to total labour supply, and its potential magnitude is limited only by the number of man-hours which are offered at any given wage rate.[1]

7.1 THE USE OF HERBICIDES

The proportion of sample farmers who use herbic--ides shows a very clear relationship with the agro--nomic zone, as can be seen from the final row of Table 7.1. The reason for this relationship is that the incidence of broad-leaved weeds is inversely pro--portional to altitude in Chilalo : at higher elevations

1/Although the hiring of labour is now illegal for most Ethiopian farmers (see Chapter 2), the past existence and extensiveness of the practice is neverthe less very instructive, since it indicates a willingness to invest in saving or supplementing farm family labour supply.

the weeds tend to be a grassy type which cannot be treated with selective weedkiller in plots of wheat, barley and other narrow-leaved crops.

Comparing Table 7.1 with Table 6.2 it is clear that herbicides have 'arrived' in Chilalo rather more recently than fertilizer and improved seed. The relationship be--tween the year of first use of the above three inputs was investigated and was found, as could be expected, to be positive and statistically significant (Table 7.2).

TABLE 7.1: Year Herbicides Were First Used (Percentage)

Year First Used	ZONE				TOTAL
	A	C	B	D	
1965	-	-	2.3	-	0.5
1969	1.5	-	-	1.7	0.9
1971	-	2.3	2.3	-	0.9
1972	4.5	-	4.7	5.2	3.8
1973	1.5	7.0	7.0	6.9	5.2
1974	1.5	4.7	7.0	20.6	8.5
1975	-	-	5.7	15.5	5.2
TOTAL	9.0	14.0	27.9	50.0	25.1

TABLE 7.2: Matrix of Correlation Coefficient Between Year of First Use of Three Inputs (39 observations)

	Fertilizer	Improved Seed	Herbicides
Fertilizer	1.000	0.700	0.735
Improved Seed	0.799	1.000	0.631
Herbicides	0.735	0.631	1.000

The stepwise multiple regression analysis was then used to investigate the relationship between the year of first adoption of herbicides (as the dependent var--iable) and the year of first use of fertilizer and improved seed as the explanatory variables for those farmers who had used all three inputs (39 observations). However the degree of multicolinearity between the explanatory variables was such that only fertilizer could be said to have a significant effect. The following bivariate regression equation was therefore calculated for all farmers who reported using both fertilizer and herbicides:

$$Y_h = 25.13 + 0.629\ Y_f \quad (7.1).$$

(Standard error of estimate = 1.005; $r^2 = 0.551$; level of significance = 0.001%; number of observations=52; Y_h = Year herbicides were first used; Y_f = year fertil--izer was first used:Year' = Gregorian Calendar year minus 1900).

For the period under consideration, the above results indicate a distinct lag between the year of introduction of fertilizer and that of herbicides. In fact only one farmer introduced herbicides first, while another re--ported using herbicides(in 1975) but not fertilizer. of those using both inputs, 62 per cent reported the introduction of fertilizer first, while 37 per cent had adopted both inputs in the same year.

There is also a distinct tendency, which can be seen more clearly in Figure 7.1 than in equation (7.1), for

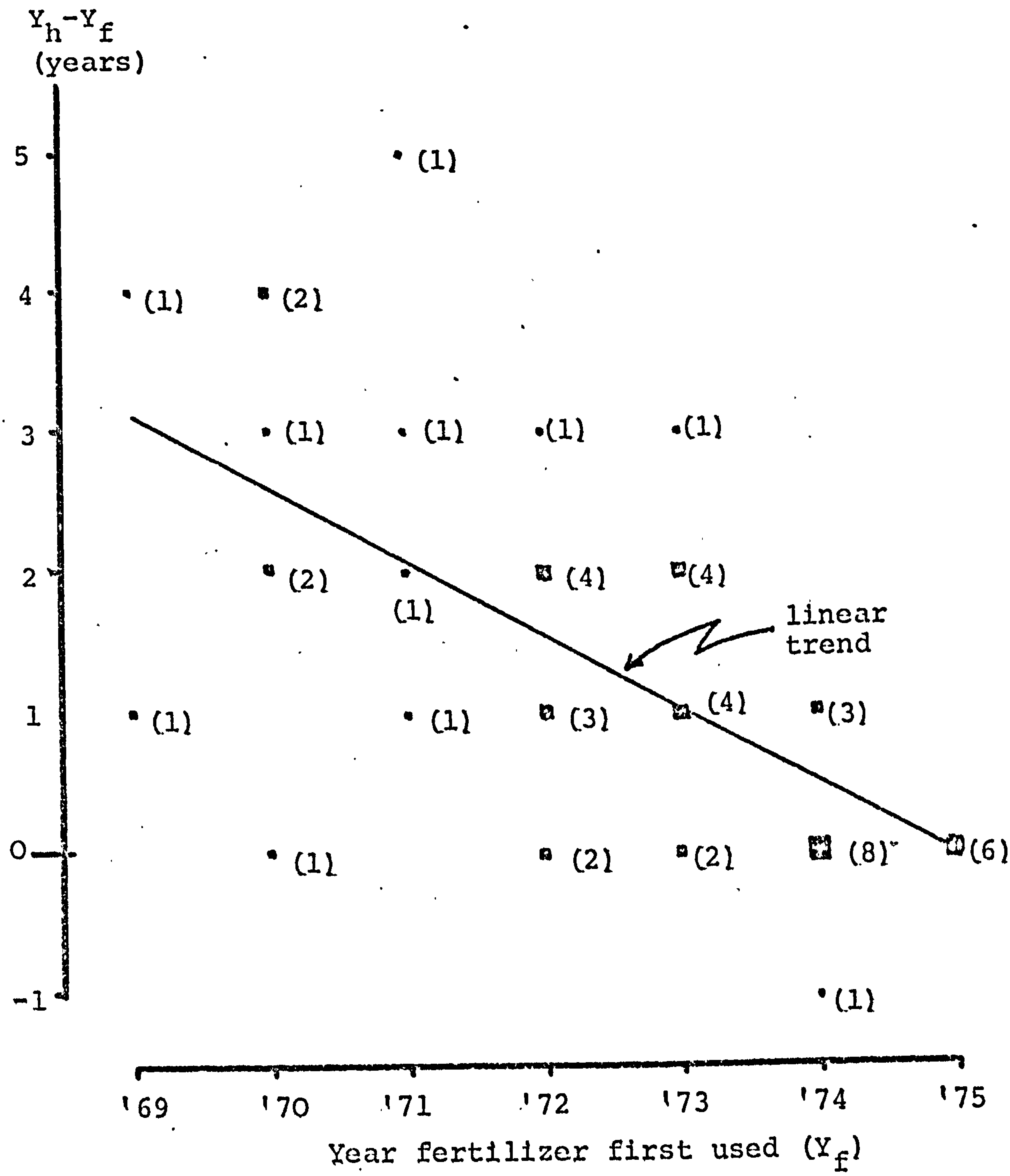

FIGURE 7.1: LAGS BETWEEN THE INTRODUCTION OF FERTILIZER AND HERBICIDES (No of observations in parentheses)

the lag between the date of fertilizer adoption and that of herbicides to diminish over time. The O.L.S regression equation is :

$$(Y_h - Y_f) = 36.34 - 0.533\ Y_f \qquad (7.2)$$

(Standard error of estimate = 1.018; $r^2 = 0.439$ level of significance = 0.001%; variable names are as in equation (7.1).) 2/

Although correlations of this type do not of course constitute proof of causality, they do tend to confirm what *a priori* reasoning would suggest on the basis of the farmers' stated belief that fertil--izer boosts the growth of weeds, namely that fertil--izer causes such a tightening of an existing bottle--neck that purchased inputs have in many cases had to be introduced to cope with this. The explanation for the reduction in the 'lag' before the adoption of the second input is probably to be found in any given loc--ality in the gradually increasing awareness on the part of farmers of the potential of herbicides to eliminate an unwelcome side-effect of fertilizer use.

2/ Two other types of regression curve, the parabola and the semi-logarithmic, were fitted to the data in an attempt to test whether the familiar curvilinear (convex-to-origin) path was being followed, but in neither case did these curves produce a significantly better 'fit' than the straight line. One 'outlier' who used both inputs before the advent of CADU was omit--ted in the calculation of equation (7.2).

Evidently the majority of sample farmers are favourably impressed with the performance of herbicides (Table 7.3). Only two farmers who had used this input stated that they would not use it again, while a substantial number who had not tried it were apparently willing to do so. This fact underscores the willingness of farmers to use purchased inputs for weed eradication, which in turn emphasises their increased concern with this problem.

TABLE 7.3;Past Use of Herbicides and Future Intentions

(Percentages)

USED IN PAST	WILL USE AGAIN	ZONE				TOTAL
		A	C	B	D	
Yes	Yes	9.0	14.0	25.6	46.6	23.8
Yes	No	-	-	2.3	1.7	0.9
Yes	D.K	-	-	-	1.7	0.5
No	Yes	23.9	58.1	27.9	37.9	35.5
No	No	26.9	2.3	4.7	1.7	10.4
No	D.K	40.3	23.3	34.9	10.3	27.5
Not Stated		-	2.3	4.7	-	1.4

D.K. = Don't Know.

7.2 Tractors and Combine Harvesters.

None of the farmers in the sample reported owning such equipment, but 10 per cent of them did report having hired it, as is shown in Table 7.4.

In explanation of the very marked inter-zonal differ--ences here, it should be pointed out that these

TABLE 7.4 Tractors and Combines hired by Sample Farmers (Percentages).

Equipment Hired	ZONE				TOTAL
	A	C	B	D	
Tractor only	-	-	-	1.7	0.5
Combine only	-	9.3	7.0	5.2	4.7
Both	-	2.3	18.6	3.4	5.2
Neither	100.0	88.4	74.4	89.7	89.6

probably reflect the availability of machinery at least as much as farmers' willingness to use it. In Zones B and D, particularly the former, there has in the past been a great deal of mechanization, so that farmers in these areas are familiar with the equipment concerned and could also hire it without excessive charges for travelling time. In Zone A on the other hand there were no nearby commercial farms.

The use of farm machinery is concentrated on the pro--duction of wheat, and in fact all but one of the farmers who had hired tractors reported using these machines to prepare the land for wheat. The exception was a farmer in Zone D who reported tractor-ploughing the land for 'teff'. The same holds true for combines: two farmers in Zone D reported stationary-threshing 'teff' by combine and one in Zone C had combine-harvested barley, but in all other cases the combine was used for wheat.

What, from the viewpoint of the present study, is even more interesting about the data in Table 7.4 is the fact that almost twice as many farmers have used combines as have used tractors (21 to 12) despite the fact that per unit area the combine is around twice as expensive to hire (Table 7.5). Thus yet another piece of evidence suggests - the point should be put no more strongly for the moment - that the harvest/threshing/winnowing period (i.e. any one or combination of these tasks) is viewed as a more restrictive period of peak energy demand than is land preparation.

The cost of hiring agricultural machinery shows a considerable degree of variation (Table 7.5), although in the case of combines there is an obvious mode.The price differences could arise from a number of factors, such as differences in travelling time or in the type of tractor, plough, combine etc. that was in use. The fact that one farmer was able to borrow a tractor free of charge also shows that there can in some cases be a considerable element of subsidy in the figures. Discussion of this question will be resumed in Chapter 9.

The advantages and disadvantages which farmers see in the use of farm machinery are most instructive for

TABLE 7.5: Hire Charges For Agricultural Machinery

HIRE CHARGES (Eth$)	ZONE C	ZONE B	ZONE D	TOTAL
(1) TRACTORS				
Free[a]	-	1	-	1
12.00/hour	-	1	-	1
12.00/hectare	-	1	-	1
20.00 "	-	1	-	1
24.00 "	-	-	1	1
25.00 "	1	2	-	3
30.00 "	-	1	2	3
Not stated	-	1	-	1
Mean Charge (Eth$/hectare)	25.00	22.40	28.00	24.50
(2) COMBINES				
(1.50/quintal)[b]	-	-	(3)	(3)
2.00 "	-	-	2	2
2.50 "	5	8	-	13
3.00	-	1	-	1
50.00/hectare	-	1	-	1
52.00 "	-	1	-	1
Mean Charge (Eth$/quintal)	2.50	2.55	2.00	2.47
" " (Eth$/hectare)	-	51.00	-	51.00

a/ Loaned by a relative; b/ Stationary threshing only.

the insights they provide into the motives for mechanization. For example the fact that only one farmer reported increased yields as an advantage of tractor-ploughing (Table 7.6) would seem to provide a useful commentary on the controversy surrounding this point (see Chapter 1,Section 1.4). However a number of the other advantages listed for tractors may also refer indirectly to a perceived beneficial effect on yields. "Better seedbed preparation","the elimination of weeds" and "deeper ploughing" could possibly be subsumed under this heading. The farmer who noted that tractor ploughing facilitates subsequent ox-ploughing (for the three following years,he said) had a very interesting point. Such occasional loosening up of the soil and the destruction of the root systems of especially tenacious weeds would indeed have this effect and should at least indirectly (but perhaps only in the short term - see Section 2.3) increase yields.

The distinction between the time- and labour saving characteristics of the tractor is an important one : many farmers listed both advantages separately, so that they cannot be considered to be alternative ways of expressing the same point."Time saving" can therefore be assumed to relate to the need for timely cultivation. Just as many of the stated advantages (of Table 7.5) might relate indirectly to an increase in yields, so could many similarly relate to timeliness of cultivation : for example the (rapid?) elimination of weeds and the (rapid?) achievement of a good seedbed.

TABLE 7.6: Farmers' Views of the Advantage of Using Tractors (No. Reporting)[a]

	ZONE			TOTAL
	B	C	D	
1,No Advantage	1	-	1	2
2.Better Seedbed Prep.	4	-	1	5
3.Eliminates Weeds	3	-	2	5
4.Time-Saving	7	1	1	9
5.Labour-Saving	3	-	1	4
6.Increases Yields	1	-	-	1
7.Cuts Tree Roots	-	-	1	1
8.Deeper Ploughing	1	1	-	2
9.Subsequent Ox-Ploughing	-	-	1	1

a/no only farmers who had used tractors were asked for their opinions; many gave more than one advantage.

The only disadvantage stated for the tractor was its "expensiveness". Half the farmers who used a tra--ctor menioned this point, while the others stated that no disadvantages attached to tractor use. These views are perhaps not too easily interpretable. At the risk of seeming unduly sceptical it may be pointed out that either of these above relies could represent a bargain--ing stance;"no disadvantages" perhaps represents an appeal for the continuation of tractor-hire services after the expropriation of the large commercial farmers who used to provide such facilities (but perhaps at cheaper rates in future? !). On reflection, however, this view probably is over sceptical, since some of the farmers who stated that tractors had no disadvantages felt differently in the case of combines, where the same reasoning could otherwise have been expected to apply. In any case, it is probably true that the use of the trac--tors creates no perceived disadvantages at the individ--ual, as distinct from the national, level. Peasant farmers could hardly be expected to notive immediately any long-term ill-effects such as increased soil eros--ion.

The perceived advantages of combine harvesters are summarized in Table 7.7. Once again several of the answers could mean the same thing - for exapple reply No.3 is probably a more explicite, and certainly more informative, version of No 2, while Nos 7,8, and 9 all evidently relate to the same basic point. It is interesting to note that farmers are aware of the wastage that results from traditional methods of threshing, but once again it is the timeliness of operation that is mentioned most frequently as the advantage of an egine-powered machine.

Again as in the case of the tractor many farmers (52 per cent) who had used the combine felt that it had no disadvantages while most of the remainder felt that it was too expensive (38 per cent). Three other disadvant--ages were noted, but each by one farmer only: these were the wastage of straw, the combine's inability to harvest wet crops and the fact that the combine leaves some heads unthreshed. This last point may appear to contradict reply No 8 in Table 7.7, but in fact the efficiency of any threshing machine in this respect depends on whether it have set correctly for the particular crop being threshed 3/.

TABLE 7.7 Farmers' views of the Advantages of Using Combine Harvesters (No. Reporting)[a]

	ZONE			TOTAL
	C	B	D	
1. No Advantages	-	1	1	2
2. Time-Saving	2	7	3	12
3. Completes Work on Time	-	-	2	2
4. Harvests, Threshes and Winnows together	1	3	-	4
5. Labour-Saving	4	2	3	9
6. No Need to Hire Labour	-	1	-	1
7. Reduces Wastage	3	2	-	5
8 Leaves no Heads Unthreshed	-	-	1	1
9. Produces Clean Grain.	1	-	-	1

a/ See footnote to Table 7.6

3/ A 'trade-off) operates here : the closer the setting of the concave to the cylinder the smaller will be the proportion of the unthreshed grain but at the expense of a higher proportion of broken kernels.

The impression that farmers who have used such farm machinery are generally well satisfield with it, is confirmed by their stated intentions about using such equipment in the future Table 7.8) Obviously the great majority would be willing to use such equipment again, while those who "don't know" would probably wish to make reservations concerning the level of hire charges. The single farmer who did not intend to use either a combine or a tractor in the future listed their expen--siveness as the only disadvantage of both machines.

7.3 CADU's FARM IMPLEMENTS

The three implements which CADU has produced for sale will be discussed in this section, while the threshing service will be dealt with in Section 7.4 Table 7.9 shows credit sales(at least 95 per cent of total sales) of the three implements on a zonal basis. Obviously the plough has been by far the least, and the harrow by far the most,successful of the three pieces of equipment. A very clear inter-zonal pattern is also apparent with sales of harrows positively, and sales of ox-carts negatively, related to the alt--itude of a given zone. These points will be examined below.

TABLE 7.8: FARMERS' INTENTIONS REGARDING FUTURE USE OF FARM MACHINERY (No Reporting)[a/]

	ZONE			TOTAL
	C	B	D	
TRACTORS:				
Will Use	1	6	3	10
Will Not Use	-	1	-	1
Don't Know	-	1	-	1
COMBINES:				
Will Use	5	7	4	16
Will Not Use	-	1	-	1
Don't Know	-	1	-	1
Not Stated	-	2	-	2

a/ See footnote to Table 7.6.

TABLE 7.9: Credit Sales of CADU Implements, 1971/72 to 1974/75

EQUIPMENT	ZONE				TOTAL
	A	C	B	D	
Ploughs	20	26	13	29	88
Harrows	212	210	144	78	644
Ox-Carts	6	12	12	122	152
TOTAL	238	248	169	229	884

Source: Computed from unpublished data, CADU Credit Unit.

7.3.1: Use of CADU Implements.

Obviously only a very small proportion, in fact in the region of 1.5 per cent, of Chilalo's farmers have bought CADU implements. For such a relatively small sample as was practicable to include in this study, the reflection of total sales of implements in ownership by sample farmers was surprisingly good (Table 7.10). Only in the case of harrows does the sample under-reflect the true position and even in that case the representative--ness in Zone C is good.

Table 7.10 shows that, very roughly and based admittedly on a small proportion of all owners, each implement appears to be used by about three times as many farmers as actually buy it. This is a very import--ant point, since it shows how misleading it can be to rely purely on sales figures as indicators of the over-all diffusion of such equipment, especially if such figures are to be compared with sales of fertilizers and improved seeds as they were in Table 3.1. (It is in any case misleading to compare total sales of dur--able items of fixed capital with those of consumables like fertilizer without drawing the obvious distinction.)

7.3.2 Renting of CADU Implements.

Of those who did not own the implements they had

TABLE 7.10: Ownership and Use of CADU Implements by Sample Farmers.(No. Reporting)

	ZONE A	C	B	D	TOTAL
Plough, Owned	1	-	1	-	2
" Borrowed	-	-	-	1	1
" Total Use	1	-	1	1	3
Harrow, Owned	1	3	1	-	5
" Borrowed	1	7	-	3	11
" Total Use	2	10	1	3	16
Ox-Cart, Owned	-	-	1	12	13
" Borrowed	-	-	-	21	21
Total Use	-	-	1	33	34

used, a fairly large number had borrowed them free of charge from a friend, relative or landlord. No implements were reported as having been rented in Zone A, and no ploughs were rented in any zone. Tental charges for ox-carts and harrows (Table 7.11) have clear modes :Eth$1.00 per day for the harrow and Eth$3.00 for the ox-cart. These rates when compared with the wages paid to a casual-labour--er (Eth$1.00-1-50 per day plus food) seem fairly high and some farmers do clearly place considerable value on such equipment. The great majority,however, hired it for one day only, so that the total burden of expense would not be too heavy

TABLE 7.11; Rents Paid for CADU Implements (No.Reporting)

DAILY RENTAL (Eth $)	ZONE				TOTAL
	A	C	B	D	
Harrow Free	1	3	-	2	6
0.50	-	-	-	1	1
1.00	-	4	-	-	4
1.50	-	1	-	-	1
Mean Rate (Eth$/day a/	-	1.10	-	0.50	1.00
Ox-cart Free	-	-	-	3	3
1.00	-	-	1	-	1
2.00	-	-	-	3	3
2.50	-	-	-	2	2
3.00	-	-	-	19	19
Mean Rate (Eth $/day) a/	-	-	1.00	2.83	2.76

a/excluding those loaned free of charge.

7.3.3. Breakage of Equipment :

Farmers who owned CADU implements or equipment were asked to report on any breakdowns and subsequent repairs which they had experienced. Neither of the two farmers who owned ploughs had had any such mis--fortune. In the case of the harrow, only two break--ages were reported, both of them in Zone C. In one of these cases it was reported that the towing hook had snapped (apparently a common fault with the older harrow design, which has since been rectified). This farmer reported that his harrow was out of use for only three days and that he had repaired it himself. The second farmer reported simply that the oxen had broken his harrow, that it had been out of action for ten months and had not yet been repaired.

The ox-cart, being a much more sophisticated piece of equipment, presents rather a different picture in this respect. The one farmer in Zone B who had one, reported that it had broken down two years previously and had not been repaired. In Zone D, ten of the twelve farmers who owned ox-carts reported breakdowns, and of these, five had not yet had them repaired.Of the remain--ing five, three carts had been repaired free of charge by Cadu, one by a neighbouring farmer at the cost of Eth$4.00, while the fifth had been repaired by the farmer himself at a cost of Eth$3.00. The length of time the carts had been out of use ranged from one to twelve months and averaged about four months.

It is interesting to note that the newer ox-carts seem to break down more frequently than the older ones. One of the four carts purchased in 1971 had broken down, as had three of the four 1972 carts but all three pur--chased in 1973 and all three purchased in 1974 had met with this fate.

CAUSE OF BREAKDOWN	NUMBER REPORTED
"Using on rough ground ..	1
"Parts became worn.out"..	1
Nuts and Bolts Missing...	5
"Struck Against Tree"....	2
Not Stated.............	1

The above answers are not all very illuminating , but one clear cause for complaint is the the nuts and bolts of the cart tend to shake free very easily. This could very easily be remedied by a simple locking dev--ice such as a locknut or split pin. Perhaps too a simple repair kit - spanner, nuts ,bolts and nails, - could be provided with each cart without much increase in cost.

7.3.4 Advantages and Disadvantages:

The advantages and disadvantages of CADU's plough, as perceived by farmers who have used it, are shown in Table 7.12. The apparent disagreement as to whether or not this implement ploughs deeply is probably due to differences in soil type. This was certainly a point made by CADU extension agents,namely that the CADU plough is only effective in light soils and that in the heavy clay soils which typify much of the District the oxen simply cannot pull it. Allthree farmers felt that the plough required too much draft power, but the farmer in Zone B had some interesting additional points to make. It is certainly true that the handle of CADU plough is higher than that of the traditional implement. It is also true that the traditional plough has an - admitted--ly crude, but fairly effective - means of adjustment for depth of ploughing which the CADU mouldboard plough does not.

Other complaints, which were reported by the exten--sion agents rather than by farmers in the sample,are that the handle tends to snap off easily and that the beam has a tendency to break at the point where it is bolted to the body of the plough. Erosion of the plough share is also a problem in sandy soils. Another problem relates to the technique of using the Cadu plough.Since it has a single mouldboard, the farmer using the CADU plough must follow a slightly complicated ploughing pattern in order to have all the furrows turned over in the same direction. Such a problem obviously does not arise when using a symmetrical plough like the trad--itional ard, and farmers seem to find it difficult at first to adjust to the new ploughing technique.

TABLE 7.12: Farmers' Views of the Advantages and Disadvantages of the CADU Plough a/

	ZONE			TOTAL
	A	B	D	
ADVANTAGES				
1.Tills Land Well	-	1	-	1
2.Ploughs Grass Easily	1	-	1	2
3.Ploughs Deeply	1	-	1	2
DISADVANTAGES				
1.Does not Plough Deeply	-	1	-	1
2.Cannot be Adjusted	-	1	-	1
3.Handle too High	-	1	-	1
4.Oxen have difficulty in pulling it	1	1	1	3

a/See footnote to Table 7.6.

In the case of the CADU spike-toother harrow, a great many advantages are listed (Table 7.13), almost all of them relating either to the fact that the harrow does a better job of seedbed preparation and seed covering, thus resulting in increased yield, or to the fact that it saves time in what can be regarded as a bottleneck period -sowing and seed-covering. Again it should be noted that

TABLE 7.13: Farmers' Views of the Advantages and Disadvantages of the CADU Spike-Tooth Harrow (No. Reporting)[a/]

ADVANTAGES	ZONE				TOTAL
	A[b/]	C	B	D	
Shallower seed covering, good stand of grain	1(1)	3	1	2	8
Time-Saving	1	2	-	1	4
Labour-saving	1	3	-	1	5
Covers greater area in shorter time	(1)	4	-	-	5
Breaks up large clods	(1)	4	-	-	5
Rakes away grass and weeds	(1)	2	-	-	3
Prevents Soil Erosion	(1)	-	-	-	1
Makes smooth seed bed	1	5	-	-	6
Two oxen can do the the work of eight	(1)	-	-	-	1
Seed Grows more Quickly	-	-	-	1	1
DISADVANTAGES					
A little heavy	2	-	-	-	7
Cannot be used on stoney land	1	-	-	-	1
Does not work well when soil is satured	(1)	-	-	-	1
Expensive	-	4	-	1	5
Cannot easily be repaired	-	1	-	1	2

TABLE 7.13: (Cont'd.)

DISADVANTAGES (contd)	ZONE A[b/]	C	B	D	TOTAL
Does not cover all seed	-	1	-	1	2
NO Disadvantages	(1)	2	1	1	5

a/ See footnote to Table 7.5.

b/ Figures in parentheses under Zone A relate to two farmers who were not in the sample, but who were interviewed on these points because they both owned spike-tooth harrows. These farmers have been included only in this table.

that there is an important distinction to be drawn between tome- and labour-saving in this respect. The Ethiopian plough, which is traditional used for all land preparation and for seed covering does not produce such a smooth seedbed and necessitates more repeated ploughing. When used for seed covering, this plough tends to drive some seeds in too deeply for germination.

Apart from the familiar disadvantage of expense, the most frequently stated point was that the harrow is a little heavier for the oxen than the traditional plough. Again, however, the point about repair difficulties cropped up. The spike-tooth harrow is by far the most successful of CADU's implement innovations, and the only on which has been successful in the highland zone.

The advantages listed for the CADU ox-cart (Table 7.14) read for the most part like a bill of lading! Again there is the interesting apparent conflict between those claiming that the ox-cart means harder work for the oxen and those who claim that it makes the Oxen's work easier. One possible explanation is that the latter type of farmer did not use his oxen for transport in the past, whereas the former had used ox-sleds.Again it is significant that the question of repairs often appears under the heading of "disadvantages", and a good deal of attention ought to be devoted to this problem.

TABLE 7.14:Farmers Views of Advantages and Disadvantages of the CADU Ox-Cart (No. Reporting)

ADVANTAGES	ZONE		TOTAL
	B	D	
1. Labour-Saving	-	14	14
2. Time-Saving	-	13	13
3. Needs Only Two Men	-	1	1
4. Easier for Oxen Than Ox-sled	-	1	1
5. Robust	-	1	1
6. Can Assist (Rent to?) Neighbours	-	1	1
7. Other b/	1	33	34
DISADVANTAGES			
1. Expensive	-	13	13
2. Cannot be Repaired Locally	-	12	12
3. No Insurance	-	1	1
4. Heavy for Oxen	-	3	3
5. Easily Broken	-	1	1
6. Expensive to Repair	-	2	2
7. Poor Quality Nuts & Bolts	-	3	3
8. No Disadvantages	1	11	12

a/ See footnote to Table 7.5

b/ These were farmers who listed the goods they carried on the cart - crops, firewood etc.

Again CADU's extension agents have provided some further insight into the advantages and disadvantages of using this piece of equipment. First, as was noted earlier, the ox-cart is much more popular in the lowlands than in highland regions. The main cause for this is that the highland terrain is very rugged in places, and is often split by gorges, so that away from the roads there is no scope for wheeled transport. The lowland terrain however, is much more level. A secondary reason suggest--ed by the extension service is that it appears to be difficult to transport maize cobs by pack animal, so that the ox-cart is very useful in the maize producing low--lands. A third reason, which emerged for general discuss--ions withfarmers, is that pack animals seem to be com--patatively shortlived in the lowland regions.

7.4 THE CADU THRESHING SERVICE

As noted in the previous section,CADU has been prov--iding a stationary-threshing [4] service for smallholders. In the 1975/76 crop season, CADU switched over from a heavy full-cleaning thresher to a much lighter non-cleaning one. No farmer included in the main survey had used the newer machine, so that the advantages and disadvantages listed in Table 7.15 relate to the now superseded model. This machine had been used only by seven farmers in the sample

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4/So-called because this machine, unlike a combine harvester for example, remains stationary while it is actually threshing. It can of course be moved from place to place when not in use.

TABLE 7.15: Farmers' Views of the Advantages and Disadvantages Of Using CADU's Stationary Threshing Service [Full-Cleaning Model] (No. Reporting)[a/]

	ZONE				TOTAL
ADVANTAGES	A	C	B	D	
Threshes heads well	-	-	1	-	1
Saves time and energy	1	1	-	2	4
Cleans well	-	-	-	1	1
Cheaper than combine	-	-	-	1	1
Threshes Quickly before rains	-	-	-	1	1
No Advantages	-	-	-	1	1
DISADVANTAGES					
Saves less time than combines	-	-	1	-	1
Expensive	1	-	-	1	2
Wastes the straw	-	-	-	1	1
Very hard work to feed machine	-	2	-	-	2
Loss of grain	-	1	-	-	1.
No Disadvantages	-	-	-	1	1

a/ See footnote to Table 7.6.

- one each in Zones A and B, two in Zone C and three in Zone D. The saving of time and energy were obviously seen as the main advantages of the full-cleaning thresher, but the work required to feed the machine was still suff--icient to be regarded as an important drawback.

As noted earlier, CADU'S full-cleaning thresher was unable to cover costs and has been withdrawn from ser--vice and replaced by a simpler non-cleaning threshing machine. The major differences between the two machines are as follows :

a) Weight: The N-C thresher is very much lighter than its predecessor and can be transported on an ox-cart instead of requiring a Toyota Land Cruiser and trailer. This in turn means that the entire operation can be turned over to the farmers themselves, thus further re--ducing costs.

b) The non-cleaning thresher, as its name suggests, does not separate the grain from the chaff, as the prev--ious machine did. However the traditional winnowing process, unlike the traditional threshing process, does not cause loss of grain or impair its quality. On the credit side, the elimination of machine-cleaning roughly halves the cost of the operation.[5/]

5/ Costings of CADU implements and equipment will be considered further in Chapter 9.

Another change of policy in the 1975/76 crop season was to charge for the thresher on an hourly basis in = -stead of on a throughput basis, thus giving the farmers an increased incentive to use the machine efficiently. The initial (provisional) charge for the N-C thresher was Eth $2.00 per hour. In the case of wheat and barley the hourly throughput is around six quintals (24 bushels), giving an average cost to the farmers of Eth$0.30 per quintal. This compares with a charge of Eth$1.50 to Eth$2.00 per quintal for stationary threshing by combine and Eth$1.25 per quintal with the previous CADU thresher.

Since none of the sample farmers had used the new threshing service, another group of (eight) farmers who were using this service were contacted and questioned as to the machine's performance. These men were threshing 'supremo',which as was shown in Chapter 6 is widely re- -garded as being less threshing resistant than local wheats. These farmers reported that the thresher could process around 20 quintals of this wheat in a day but to thresh the same quantity of 'supremo' by traditional methods would require the services of three men and ten oxen for six days. The actual threshing time using oxen would be three days, but since threshing is a dry season activity, the oxen would have to be taken to be watered every second day.

The Etheya Area is one where is thought to be a severe shortage of oxen because of past mechanization, but of the eight farmers interviewed, four owned two oxen, three owned one ox and only one had none. These figures it should be noted conform to the general pict--ure of ownership of oxen by farmers in the main sample, which were shown in Table 4.24. If the NC stationary threshing service appeals to farmers with one or two oxen, and if it is used even for wheat which is not threshing-resistent, then it would probably appeal to farmers in many other parts of Chilalo. It should be added that the one farmer who reported having no oxen was able to borrow them from his parents, or to exch--ange his own labour for the use of the oxen for threshing. However hed had in the past faced the problem of having to wait 'at the end of the queue' to borrow oxen, always facing the threat that rain would spoil his crop. It was agreed that the great majority of people who had no oxen could not be farmers and would have to work as daily labourers.

Since this group of farmers was interviewed at the same time, they did not give individual opinions as to the merits and drawbacks of the CADU N-C thresher, but tended to arrive at a consensus. The advantages of the machine, in the stated order of importance, were:

1. Saving of time, thus avoiding the fear of rain spoiling the crops.
2. It is very advantagous for people who do not have oxen.

The perceived disadvantages, again in order of importance were :

1. Requires new skills on the part of the operator.
2. It needs many men (normally six compared with three for the traditional method of threshing)
3. Oxen are needed to move the machine around.

The general impression,however, was that the farmers were on balance very satisfied with the machine. For once even the complaint that the service was very expen- -sive was not heard !

7.5 FACTORS ASSOCIATED WITH 'ENERGY' PURCHASES

The type of innovation discussed in the present chapter is largely equivalent to the purchase of energy and energy substitutes. Such innovations may usefully be classified, in order of degree to which they repres- -ent a departure from traditional on-farm energy resour- -ces, under the following four headings:(i) hired labour:[6] (ii) factors which (at least to the extent that they are successful) permit more efficient use of exist- -ing farm energy resources, namely improved manual and animal-powered implements: (iii) factors which substitute directly for on-farm energy e.g.engine-powered machinery, and (iv) inputs like herbicides which represent not merely the introduction of a new source of energy for the

[6] The hiring of labour as such is certainly no innovat- -ion in Chilalo, but it may be so on a particular farm. The distinction between hired labour and exchange labour was discussed at the beginning of the present chapter.

performance of a specific task, but which in fact sub--stitutes for energy (narrowly defined) itself.

Clearly within the above scheme, the concept of energy has been stretched somewhat to embrace innovations which serve either to make more of the existing store of farm energy available for useful work or to reduce the need for energy by introducing a less energy-intensive means of achieving a given result. This shorthand notat--ion has obvious advantages provided this definition is kept in mind.

A great many factors are potentially capable of influe--ncing a farmer indedeiding whether or not to purchase supplementary energy. These may be logically - even chronologically - subsumed under three headings. The first relates to the percáived needs and preferences of the individual farming household,factors which are in turn determined for example by the quantity of farm energy available (number of oxen and man-equivalents per hectare), its quality (the state of health and strength of workers and workstock), the crop mix, the membership and practicability of mutual labour exchange arrangements and of course the relative utility of income and leisure. These causitive factors are in turn influenced by others - for example the last may be affected by expectations con--cerning changes in the terms of trade between farm and non-farm produce, including energy itself.

The second factor is ability to pay, which will clearly depend both on the cost of the energy in question and on the availability of cash resources after the deduct--ion of essential expenditure on for example rents, taxes and indispensible factors of production like seed. The availability of credit may play a vital role here in view of the 'gestation' period between investment in energy and realisation of any return. The length of this period is, it should be noted, a variable which is depend--ent on the actual operation concerned. Thus energy purchased for harvesting will produce a return so quickly that the 'energy-owner' - casual labour or combine harvester contractor - may be prepared to provide the very short term 'credit' required by postponing payment demands until after the crop is sold. On the other hand, energy pur--chased for seedbed preparation will have a 'gestation' period of six to ten months so that more formal,and most certainly more costly. credit arrangements could be required. This factor could be an extremely important one in explaining the relatively greater expenditure on energy for harvesting than for other farm tasks by the sample of farmers included in this study.

The question of risk must also be taken into account here. Crop failure through drought,flood disease or pestilence may prevent investment in preharvest energy from realising any return whatever, whereas with the advent of the harvest itself this danger disappears. Indeed a situation could easily arise in which fear of crop failure deterred a farmer from investing in energy for preharvest tasks, whereas fear of crop spoilage, through for example untimely rains or the depradations of predators, actually impel him to invest in energy for the harvest and for post harvest operations. Furthermore at the time of the harvest the farmer has a good deal of information at hand as to both the likely yield and current crop prices, which will enable him to make an informed judgement as to whether or not expend--iture on energy is economically justifiable. No such information is available when the seedbed is just being prepared.

Finally there is the question of the availability of suitable energy resources (or the suitability of available resources). Some relevant observations have already been made in this regard in the course of the present study. For example, it was noted that herbic--ides become increasingly inappropriate for use in plots of wheat and barley with increasing altitude, while farm machinery is not readily available for hire in Zone A. There is an important relationship, which should be mentioned here, between the availability of farm machinery and that of casual labour. In areas which have recently experienced large scale eviction of tenant farmers and their replacement by farm machinery, not only is such machinery likely to become increasingly available for hire to the remaining smallholders, but so too is casual labour, because of the evictees hav--ing to seek employment. Finally, even if farm machin--ery is available for hire in a given area, the prospects for using it on any particular farm will depend on certain physical features such as the accessibility of fields and their size,shape,slope and any obstructions (rocks, tree stumps, etc.) which they may contain. These particular restrictions do not of course apply to more readily divisible factors of production such as hired labour or herbicides.

It is of course obvious that even the most compre--hensive farm management study could not possibly pro--duce an exhaustive investigation of all the factors which might potentially influence a farmer's decision whether or not to purchase additional energy resources. Even greater limitations therefore apply to a study based largely on a single visit technique. Nevertheless statistical investigation of the available data does produce some interesting indications of the degree of correlation between the decision to purchase such re--sources and several other variables which might logic--ally be expected to influence such a decision.

Two important data constraints must be noted at this point in the discussion. First, questions in the main survey regarding the use of purchased energy did not relate this use to any specific time period, since meaningful interpretation of such information would have required a great deal of supplementary time-related data whose coll--ection was not possible given existing resource constr--aints. It will therefore of necessity have to be assumed that most of the relevant parameters did not change significantly between the time (a) at which the farmers purchased additional energy and the time at which the survey was conducted.[7/] One important exception, however, is the crop mix, which could be liable to annual change as a result of crop rotation.

The second data constraint, imposed by similar resource considerations, arises from the fact that farmers were asked to report whether they had used a particular form of purchased energy, but not the 'quantity' used or the total level of expenditure on its acquisition. Any statistical analysis of factors associated with energy purchases

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7/ It will be recalled that the Survey was conducted before the implementation of any envisaged land redistribution measures under the 1975 land reform, so that the above assumption is probably valid in respect of at least one important variable, total cultivated area. Unfortun--ately, as was noted at the end of Chapter 3 there are reasons for suspecting that there <u>may</u> have been some under-reporting here in any case.

measured on such a scale will therefore be concerned with a situation in which the dependent variable is dichotomous. If this variable is given a value 1 when it occurs and 0 when it does not (in this instance 1 if the farmer has used the input in question and 0 of he has not), we have a situation of which Johnston (1972, p.183) says:

> " If we run a multiple regression of such a depend- -ent variable Y on several explanatory variables X, then we may interpret the calculated value of Y, for any given X, as an estimate of the condit- -ional probability of Y, given X " (Johnson's emphasis) 8/

One very important difficulty, however, lies in the way of using regression analysis in this particular case. A normal assumption of this type of analysis is that the independent variables have been measured without error, but in view of the data constraints mentioned above, it must be acknowledged that this assumption cannot really be justified here. If data were available concerning

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8/ Much of the pioneering work in this field is reported in Orcutt et al (1960,Ch.12).Goldberger (1964,pp248-50 has suggested a two-stage method of estimation which confronts the problem of heteroscedastic disturbances which arises when classical least squares is applied in this type of situation.

the relative error variances of the variables, this diff--iculty might have been surmounted (see Wonnacott and and Wonnacott, 1970,pp.164 - 70), but unfortunately no such imprmation is available in this instance. It has not been possible, therefore, to produce reliable est--imates of the coefficients of the independent variables[9].

9/ For the purposes of illustration only, an example of the regression approach will be provides. The task for which'energy' (which here includes herbicides) was most frequently purchased was weed control (see Table 7.16), so that this is the example which will be used. The regression equation is :

$$P_W = 1.10313 - 0.0005B_1 + 0.00181B_2 + 0.05029B_3 \quad (7.3).$$

$$(0.0007) \quad (0.54460) \quad (0.1936)$$

Standard error of Estimate = 0.390; F ratio = 27.12;

$R^2$0.284 (Figures in parentheses are the standard errors of the B coefficients).

Where P_W = the conditional probability of energy being purchased for weed control; B_1 = mean altitude of the sample sites in the given zone; B_2 = in index of relat--ive yield; B_3 = total cultivated area. (Further dis--cussion of these explanatory variables is included in the text).

Thus the probability of using purchased energy for weed eradication increases with diminishing altitude and with increasing yields and cropped area. For example in the case of a farmer in Zone D(altitude 1676m) with a yield index of 120 and 5 hectares of cultivated land, we have:

$$P_W = 1.10313 - (0.0005 \times 1676) + (0.00181 \times 120) + (0.05029 \times 5)$$

$$= 0.734\tfrac{1}{2}$$

while for a farmer in Zone A (2627m) with a yield index of 80 and 2 hectares under crops $P_W \doteq 0.035$.

However, as Brookins points out (1975, pp.228-29), if only the best predictor is required, then least squares regression is still optimal, provided it is used only to produce coefficients of correlation and determination, and not the parameters of an estimating equation.

Of the variables on which information was gathered in the Survey, a fairly large number could help to ex--plain a given farmer's decision to purchase energy. Total areas cultivated is an obvious example, since this would help determine both the need for such inputs and the ability to pay for them. Farm resources of labour and ox-power are equally obvious potential factors, as is membership of a mutual labour exchange association for the task in question. The importance of agro--climatic zone is a factor whose importance has already been illustrated in this context.

A number of other potential influences may be less

Footnote 9/ continued.
One problem with this technique which has not yet been completely resolved lies in the fact that the above formulation permits the regress and to assume a value out-with the range 0-1, which is clearly inconsistent with its interpretation as a probability.

immediately apparent. For example it was hypothesised at the beginning of this study - and it has been well substantiated since - that the introduction of improved seed and fertilizer can either create new, or aggravate existing, seasonal peaks in energy requirements for crop production. Since these could become increasingly apparrent over time, the use of purchased energy might be expected to be positively correlated with the number of years since new inputs were first used.[10/] Moreover, the earlier adopters of any purchased input are likely to be the wealthier and (hence?) more innovative members of the farming community and are therefore the more likely to at least experiment with the use of other purchased inputs.

Another potential 'explanatory' variable, not unconnected with the previous one, is crop yield, since, like total cultivated area, this factor is likely to correlate positively with both the perceived need for additional (ie non-farm) energy and the availability of the resources required to pay for it. Representation of this concept is not completely straightforward, however, since what is ideally required is a single value for each farm which will represent the yields of a number of different crops

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10/ In Section 7.1 it was shown that this type of lagged causative relationship apparently exists between the introduction of fertilizer and that of herbicides.

weighted by their relative importance in that farm's crop mix. The method adopted here was to calculate an index for each farm based on the yields of crops reported for that farm, relative to the overall average of reported yields for the same crops for the entire sample. A list of eleven crops for which sufficient yield data were available were used for this purpose.[11/] Equation 7.4 (overleaf) shows the formula which was used in calculating the necessary yield indices.

The final variable which was included in the list of potential 'explanatory' variables was the area on a given farm under wheat. It was shown in Section 7.2 that where it has been possible to relate purchased energy to a particular crop - as in the case of tractors and combines - the crop in question generally transpired to have been wheat, so that the area under this crop - or at least the fact that it is grown on a particular farm - must be seen as an important potential explanatory variable. If this seems to contradict what was said earlier about crop mixes changing as a result of crpp rotation, it should perhaps be added that since wheat

11/ The eleven crops were kentana frontana, laketch 8156, romany and supremo high yielding wheats, and indigenous wheat, barley, maize, teff, field peas, horse beans and haricots. Yields are discussed in much more detail in Chapter 8.

$$Y_i = \frac{100 \sum_{j=1}^{11} \frac{y_{ij} \cdot p_{ij}}{\bar{y}_j}}{\sum_{j=1}^{11} p_{ij}} \qquad (7.4)$$

Where:

Y_i = the yield index for farm i;

y_{ij} = the reported yield of crop j on farm i;

p_{ij} = the proportion of total cultivated area of farm i under crop j, and

$\bar{y}_j$ = overall mean yield of crop j for all reporting farmers.

is the main cash crop in Chilalo, it is arguable that although farmers may alternate the plots on which this crop is grown they will tend to grow a relatively con--stant proportion of wheat, so that its relative imp--ortance will not fluctuate too much from year to year.

In the case of the depenent variable, energy pur--chases were considered for each of five major crop operations: seedbed preparation, weed control,harvest--ing, threshing and on-farm transport. Sowing and winn--owing are not included since it is evident that farmers do not generally hire energy specifically for these tasks. In each of the above five cases, a farmer was considered to have purchased energy if he reported having used any one of the forms available for the task (see Table 7.16). Thus a farmer was assigned a score of 1 for seedbed preparation if he had used a tractor, CADU plough or CADU harrow, or had hired labour for ploughing, and 0 otherwise. This somewhat aggregated scheme was adopted because of the impossibility,given data constraints, of measuring the intensity of energy use.

Table 7.17 shows the percentage frequency distribution of such energy purchases by sample farmers. Clearly such purchases vary greatly from zone to zone but with a clear tendency to be associated in most cases with the two lower zones, B and D, much more than with A and C.

TABLE 7.16: Forms of 'Purchased Energy' Available For Five Farm Operations

Seedbed Preparation	Weed Control	Harvesting	Threshing	On-farm Transport
Tractor[a/] CADU Plough CADU Harrow Hired Labour	Herbicides Hired Labour	Combine[b/] Hired Labour	Combine CADU thresher Hired Labour	O-Cart Hired Labour

a/ Tractors can of course be used for other farm tasks such as weed control and transportation, but the sample farmers had used them for seedbed preparation only.

b/ Only if used for harvesting and not purely for stationary threshing.

TABLE 7.17: Farmers Using Purchased 'Energy' for Five Farm Operations (Percentates)

Farm Operation	ZONE				TOTAL
	A	C	B	D	
Seedbed Preparation	4.5	20.9	20.9	10.3	13.7
Weed Control	9.0	14.0	39.5	58.6	29.9
Harvesting	7.5	14.0	51.2	39.7	26.5
Threshing	3.0	11.6	39.5	58.6	27.5
On-farm Transport	0.0	0.0	2.3	56.9	16.1

Some interesting features emerge when energy purchases for different tasks are compared on a zonal basis. The cases of weed control (herbicides) and transportation (ox-carts) have already been discussed. In seedbed preparation it will be noted that energy purchases tend to be greatest in the two main wheat producing zones,B and C. Harvest--ing provides an interesting case. Zone B is an area which experienced particularly extensive mechanization in the past (see Hancock, 1972 and Jonsson, 1975,Ch7),so that the availability of both combine harvesters and casual labour is likely to be greater, and their hire charges/ wages lower, than elsewhere.[12/] Finally farmers in Zone D report the highest proportionate purchase of energy for threshing; this is also the zone with the highest pro--portion of maize, which is a difficult crop to thresh by the traditional methods.

There is clearly a high degree of intercorrelation between the use of purchased energy for various farm tasks (Table 7.18). This, as will be shown in Table 7.19, largely arises from the fact that the same set of

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12/Combines are both more expensive to hire on an hourly basis and more slow-moving than tractor, so that travelling expenses are much higher - around seven times as high per kilometer - for combine. It is so much more difficult - and indeed dangerous, to drive a combine over rough terrain. Thus the geographical range of economic operation for a combine harvester is very much more limited than for a tractor.

TABLE 7.18: Correlation Coefficients Between Energy Purchases for Five Farm Operations[a/]

	Seedbed Prep.	Weed Control	Harvesting	Threshing	Transport
Seedbed Prep.	1.000	0.298	0.403	0.384	n.s.
Weed Control	0.298	1.000	0.445	0.416	0.338
Harvesting	0.403	0.445	1.000	0.600	0.237
Threshing	0.304	0.416	0.600	1.000	0.711
Transport	n.s.	0.338	0.237	0.711	1.000

a/ n.s. = not statistically significant at the 5 per cent level.
All other relationships are significant at the 0.1 per cent level or better.

'explanatory' variables tends to be associated with the purchase of energy for each of the five farm tasks.

Multiple correlation analysis was used to investig--ate the strength of the relationship between each of the five dependent variables proposed above and the various potential 'explanatory' variables. Each of the independent variables was introduced 'stepwise' into the analysis so that the increment in the coefficient of multiple determination (R^2) attributable to each such variable could be independently estimated and an F-ratio employed to assess whether or not the 'contrib--ution' of each of these variables was statistically significant at the conventionally accepted five per cent level or better. Variables which did not meet this criterion were then excluded from further analysis.

One problem which can arise with this approach is that of multicolinearity. Two potential explanatory variables might each correlate closely with the depend--ent variable, but because they themselves are highly intercorrelated one of them could be automatically excluded from the analysis on the basis of insuffic--ient incremental 'explanatory' power. Such variables can however sometimes be usefully transformed in order to counter this problem. For example in the present analysis it was found that although both total cultiv--ated areas and total area under wheat correlated -significantly with the purchase of energy for harvesting [13]

13/ The correlation coefficients were 0.329 and 0.286 respectively: the level of significance was better than 0.1 per cent in each case.

the degree of intercorrelation between the two independ--ent variable was such[14] that 'area under wheat' was rejected on the above criterion. However when 'percentage of cultivated area under wheat' was substituted, the cor--relation with total cultivated area disappeared[15] and the new variable, which correlated significantly with the dependent variable,[16] was accepted in addition to total cultivated area.

The results of this analysis are presented in Table 7.19 which shows a surprisingly (in view of the various caveats expressed earlier) close correlation in some cases. The independent variables in this table are listed in order of their 'contribution' to the overall coefficient of multiple determination, and it is clear from these results that agro-climatic zone (for which altitude[17] is used as a surrogate measure here) and total cropped area

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14/ $r^2 = 0.593$, level of significance better than 0.1 percent.

15/ $r^2 = -0.012$;not significant at the 10 per cent level.

16/ $r^2 = 0.130$; significant at the 3 per cent level

17/ Since it was not possible to measure the altitude at each farmstead, the altitude at the local CADU extension office was taken as representative of the area. The extension office tends to be centrally placed in the area it serves.

Table 7.19: Results of Multiple Correlation Analysis of Purchases of 'Energy' for Five Farm Operations

VARIABLES	(Sign.) a/	Change in R^2	F-Ratio
1. Seedbed Preparation			
INDEPENDENT VARIABLES			
(i) Total Cultivated Area	(+)	0.0769	19.81
(ii) Per cent Under Wheat	(+)	0.0385	6.25
(iii) Yield Index	(+)	0.0274	7.37
(iv) Family Labour b/	(+)	0.0225	5.50
OVERALL		0.1653	10.10
2. Weed Control			
INDEPENDENT VARIABLES			
(i) Altitude	(-)	0.2063	50.23
(ii) Relative Yield	(+)	0.0543	11.00
(iii) Total Cultivated Area	(+)	0.0236	6.75
OVERALL		0.2842	27.12
3. Harvesting			
INDEPENDENT VARIABLES			
(i) Altitude	(-)	0.1145	58.58
(ii) Total Cultivated Area	(+)	0.1083	40.15
(iii) Per cent Under Wheat	(+)	0.0977	29.46
OVERALL		0.3205	32.22
4. Threshing			
INDEPENDENT VARIABLES			
(i) Altitude	(-)	0.2640	75.58
(ii) Yield Index	(+)	0.0789	17.80
(iii) Total Cultivated Area	(+)	0.0454	15.21
OVERALL		0.3883	45.38
5. On-Farm Transport			
INDEPENDENT VARIABLES			
(i) Altitude	(-)	0.4007	85.23
(ii) Years of Fertilizer Use	(+)	0.0172	6.52
(iii) Area Under Wheat	(-)	0.0148	7.65
(iv) No of Oxen	(+)	0.0116	4.31
(v) Yield Index	(+)	0.0112	6.79
OVERALL		0.4555	33.96

a/ i.e. sign of the coefficient of multiple correlation.

b/ i.e. family labour available for ploughing.

are the most important of the explanatory variables. This is particularly true in the case of transportation, where altitude (zone) 'explains' forty per cent of the observed variation compared with 5.6 per cent 'explained' by all of the other independent variables combined.

CHAPTER 8: CROP YIELDS.

It was suggested earlier that the type of techno--logical change examined in Chapter 7 is most usefully viewed as an indication of the way in which smallholders have adopted non-traditional forms of'energy' in order to counter the type of traditional and newly created bottlenecks which were the subject of the previous two Chapters. The present chapter sets out to examine a closely related topic, namely the extent to which crop yields on smallholdings have attained their full potent--ial. The (postulated) relationship between these two topics holds because both phenomena are associated with seasonal bottlenecks : low crop yields because for example operations were not performed on time or are performed with insufficient thoroughness, while energy purchases can be seen as the farmers' response to seasonal shortfalls in energy availability.

One important relationship has already been estab--lished in this regard. It was shown in Table 7.18 that for the sample of smallholders studied here crop yields correlate positively and significantly with the decision to purchase non-traditional forms of 'energy' for various farm operations. In fact, the relationship appears rather closer than that indicated in Table 7.18 when only the bivariate relationships are examined.

Table 8.1 shows these latter correlations to be fairly strong and, statistically speaking, highly significant.

The statistical evidence thus lends support to the deduction that there is a causal relationship between energy purchases and cropyields, although it does not of course separate cause from effect. Either factor could actually be causitive: yield increases could ob--viously result from the easing or elimination of bottlenecks in the process of crop production, but so too could relatively high yields be required to generate sufficient income to pay for energy purchases, and thus be regarded as, indirectly, causing them. In addition higher yields of themselves increase energy requirements per unit area for the harvest and for post-harvest oper--ations. There is undoubtedly some element of 'circular causation' in operation here, but there is also little doubt that bottlenecks caused by seasonal energy 'defic--its' in the production process will, almost by defin--ition tend to have an adverse effect on yields. 1/

8.1 REPORTED LEVELS OF YIELD

It was not possible to measure crop yields directly

1/ One exception might be where a farmer responded to a seasonal 'deficit' in energy by reducing the area under cultivation, thus maintaining yields per unit area at the expense of total(potential output.

TABLE 8.1: Correlations Between 'Energy' Purchases and Yield Indices

Farm Operation	Coefficient of Determination (r^2)	Level of Significance
Seedbed Preparation	0.054	0.1
Weed Control	0.097	0.1
Harvesting	0.082	0.1
Threshing	0.136	0.1
On-Farm Transport	0.053	0.1

on the sample farms by means of crop cuttings. This was because the timing of the Survey (see Section 3.5, Chapter 3) was not appropriate for this purpose and resource limitations did not permit any additional (earlier) visits.[2/] In any case such measurements would have furnished data for only one year and would by themselves have provided no indication as to their representativeness.

In fact, the crop year in question (1975/76) was very far from being typical in respect of the relevant variables. First, deliveries of fertilizer to the distribution centres was later than usual. Second, the rains were unusually heavy during the sowing period, so that the fields in many areas were waterlogged and the soil very heavy, with the result that the land was poorly tilled and fertilizer, where it had been used, was poorly incorporated with the soil and tended to wash away in a downpour. Finally, these unfavourable conditions unfortunately coincided with the type of fertilizers supplied in Zones B and D. Previously

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2/. Yield figures deriving from crop sampling by CADU are examined in Section 8.2.

CADU had supplied diammonium phosphate 18-46 (DAP)[3/] in all areas, but experiments had indicated that soils at lower elevations tend to be relatively rich in phosphorus when compared with the higher elevations (Hammar,1974). It was therefore decided to substitute a fertilizer with lower phosphate content in the former areas. Since this new fertilizer was of a different colour from DAP the farmers of course realised that a change had been made and tended to blame the low yields of the 1975/76 Season on the new fertilizer. During the course of the Survey many angry complaints were voiced by farmers on this account.

In order to surmount the above difficulties, partic--ularly the latter, farmers were asked to report the 'normal' level of yields of their various crops (i.e. yield in a climatically 'normal' year) with and without fertilizer. Thus the yield data which have been obtained are rather more impressionistic than those deriving from say sample crop cuttings repeated over a five year period, but they are nonetheless more useful since they derive

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3/ The three main plant nutrients which are supplied in chemical fertilizers are nitrogen (n), phosphate (P_2O_5 or 'P') and potash (K_2O or 'K'). The numbers attached to a particular fertilizer describe in the above order its percentage by weight of pure nutrient. Thus 100 Kg, of DAP 18-46 contains 18 Kg nitrogen and 46 Kg phosphate. The new fertilizer supplied in the lowlands contained 20 per cent each of N and P.

from a highly informed source and, perhaps even more important, since the variables under investigation here are the farmers' impressions of change, at least as much as its more objectively determined magnitude.

An overall view of yields thus measured is provid--ed in Table 8.2 for the eleven crops which were used in the calculation of the yield indices (see Chapter 7, footnote 11). In each case the yield is that reported as being obtained with fertilizer, if used . Comments upon the actual levels reported will be postponed until Section 8.2, but it is worth noting that the variation in reported yields is rather large, as is indicated by the coefficients of variation. This is of course to be expected both in view of the nature of the data and on account of the very large number of factors which can affect the level of yield of a given crop even in a single year.

One important variable which has a profound effect on crop yields is of course soil fertility. This var--iable is itself the result of two others: the inherent fertility of the soil and any supplementary nutrients added by the farmer. In the former case no direct meas--ures are available, but the agro-climatic zone can serve as an (admittedly rough) surrogate, since as was noted earlier soil fertility as measured by phosphorus con--tent tends to be greater in the lower zones : 20-40

TABLE 8.2: Summary Yield Statistics for Eleven Crops

CROP OR VARIETY[a]	Number of Observations	Mean Yield (qtl/ha)[b]	Coefficient of variation	Standard Error	Confidence Interval[c]
Wheat	23	7.5	0.56	0.88	5.6 - 9.4
Kentana F.	8	8.5	0.42	1.26	5.4 -11.6
Laketch	89	9.4	0.60	0.60	8.2 -10.6
Romany	22	8.8	0.48	0.90	6.9 -10.7
Supremo	52	9.5	0.60	0.80	7.9 -11.1
Barley	124	9.5	0.60	0.51	8.5 -10.5
Maize	12	16.5	0.62	2.94	9.7 -23.3
Teff	35	6.2	0.60	0.63	4.9 - 7.5
Field Pea	26	6.3	0.51	0.62	5.0 - 7.6
Horse Bean	13	7.2	0.60	1.19	4.5 -10.0
Haricots	21	6.6	0.47	0.68	5.2 - 8.0

a/ Indigenous variety unless otherwise stated

b/ 1 quintal/hectare (wheat) = 1.62 bushels/acre

c/ i.e. 95 per cent confidence interval for means.

parts per million compared with 10-20 p.p.m in Zones A and C (Hammar, 1974, p.28). Added fertility can be measured in terms of fertilizer input .

The mean values of the yield indices are shown in Table 8.3, which certainly suggests that yields tend to be higher in the lower elevations. The differences in means are statistically significant.[4/] This point is of considerable practicable importance, since it confirms that farmers in Zones B and D tended to report 'normal' yields, as they were asked to do, instead of yields in in the current crop year which were cerainly much below average in these two areas.

Inter-zonal comparison of yields of individual crops confirms the general picture of Table 8.3. Yield figures for two crops, laketch wheat and local barley were report--ed by a substantial number of farmers in all four zones. These figures are presented in Table 8.4 which suggests that yields bear a negative relationship to altitude. However only in the case of Laketch were the observed differences in means found to be statistically significant.[5/]

4/ Analysis of variance : F-ratio = 3.093, level of significance = 2.8 per cent.

5/ Analysis of variance : F-ratio = 4.952, level of significance=0.3 per cent.

TABLE 8.3: Inter-Zonal Comparisons of Yield Indices

ZONE	MEAN YIELD INDEX	COEFF. OF VARIATION	STANDARD ERROR	CONFIDENCE INTERVAL[a]
A	85.1	0.49	5.11	74.9 - 95.3
C	98.1	0.50	7.51	82.9 - 113.3
B	109.9	0.54	9.25	91.2 - 128.6
D	109.0	0.50	7.14	94.7 - 123.3

a/ i.e. 95 per cent confidence interval for means.

4/ Analysis of variance : F-ratio = 3.093, level of significance = 2.8 per cent.

TABLE 8.4 Inter-Zonal Comparisons of Yields of Two-Crops

Crop/Zone		No. of Observ-ations	Meal Yield (qtls/ha)	Coeff. of Variation	Standard Error	Confidence Interval a/
Laketch	A	41	7.3	0.73	0.84	5.6 - 9.0
"	C	11	10.7	0.51	1.65	7.0 - 14.4
"	B	20	10.1	0.45	1.02	7.9 - 12.2
"	D	17	13.0	0.46	1.44	9.9 - 16.0
Barley	A	55	8.2	0.58	0.65	6.9 - 9.5
"	C	33	10.6	0.63	1.16	8.2 - 12.9
"	B	22	10.3	0.61	1.33	7.5 - 13.0
"	D	14	10.7	0.48	1.37	7.7 - 13.6

a/ i.e. 95 per cent confidence interval for means.

The relationship between crop yields and the level of fertilizer input is capable of rather more satis--factory analysis, since the data are more disaggregated and are more directly measured than was true in the prev--ious case. Dillon has observed that" the most satisfactory simple theory " of crop response to such inputs "under present conditions of knowledge" implies, among other things, that "there is a smooth casual relation between the X's (inputs and Y (output)" and that "diminishing returns prevail with respect to each input factor X_1" (Dillon 1968,p.3). Thus the response or production function in agriculture conforms to the familiar curv--ing shape conventionally postulated for other branches of production.6/

Many algebraic forms of agricultural response or production function have been formulated, no single one of which "can be used to charactize agricultural product--ion under all environmental conditions"(Heady and Dillon, (1961) p.73). However in certain cases some forms can certainly be regarded as inappropriate.7/ In the case

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6/ This view, however, has recently been challenged by Upton and Dalton(1976), in an interesting article which suggests that in some cases at least, the prod--uction - response relationships may assume a rectil--inear or "bent stick" shape in crop and livestock production.

7/ A very useful discussion of the/algebraic formulations of the production function in agriculture is provided by Heady and Dillon (1961,Ch.3).See also Srivastava and Heady(1973).

under discussion, for instance, the independent variable being investigated is a set of plant nutrients which is added to the soil in the form of fertilizer, rather than the total quantities of such nutrients available in the soil. Thus the familiar Cobb-Douglas function for example would not be appropriate, since (equation 8.1) its use would stipulate that yield would be zero when fertilizer input was zero.

$$Y = aX^b \qquad (8.1)$$

A much more satisfactory function under these conditions is the quadratic, or second degree curve, which does not impose such strict limitations. This curve takes the form :

$$Y = B_0 + B_1F + B_2F^2 \qquad (8.2)$$

where Y is crop yield and F is the level of fertilizer application. The condition of diminishing marginal returns would require the B_2 coefficient to be negative.

In practice, and indeed in view of what was said in footnote 6 above, it is advisable when fitting such a curve to empirical data to check whether the inclusion of the exponential term of equation 8.2 significantly improves the 'fit' of the curve to the data compared with the simple linear equation. Table 8.5 shows that although the expected positive relationship between crop yield

TABLE 8.5: Yield Response to Fertilizer for Ten Crops[a]

CROP/VARIETY	Regression Coefficients (st. errors)			No. of observations	Standard Error of Estimate	Coefficient of Determination	F-Ratio
	B_0	B_1	B_2				
Local Wheat	5.56	+ 0.026 (0.0114)		45	3.79	0.108	5.190
Kentana f.	4.60	+ 0.040 (0.0170)		15	3.18	0.303	5.657
Laketch 8156	5.14	+ 0.060 (0.0133)	-0.0002 (0.0001)	194	4.60	0.155	17.540
Romany	4.95	+ 0.086 (0.0261)	-0.0004 (0.0002)	42	3.44	0.291	7.993
Supremo	5.69	+ 0.047 (0.0102)		99	4.71	0.178	20.937
Barley, local	6.09	+0.066 (0.0177)	-0.0004 (0.0001)	251	4.88	0.062	8.229
Maize, local	11.55	+0.119 (0.0392)		48	8.55	0.166	9.146
Teff, Improved	7.50	+0.067 (0.0226)		14	3.31	0.421	8.730
Field Pea, local	3.40	+0.031 (0.0100)		68	0.94	0.124	9.357
Haricot, local	5.34	+0.032 (0.0150)		43	2.83	0.100	4.566

a/ In the case of horse bean the correlation was not found to be significant (5% level).

and fertilizer input was confirmed in ten cases out of eleven,[8/] the addition of the polynomial term improv--ed the 'fit' significantly in only three cases. In each of these cases, however, the B_2 parameter was found to be negative in conformity with the result predicted by theory.[9/]

Figures 8.1 to 8.3 provide scatter diagrams of the observations for these three crops to which the appropriate functions have been fitted. It is immed--iately obvious from these diagrams that the variation in reported yields is very large, although a clear patt--ern is nonetheless discernable. What is probably most outstanding in each of the three cases is the tendency for total returns to decline beyond a certain level of fertilizer input. This result is to be expected in practice since very heavy fertilizer dressings can cause problems not only of increased weed infestation but also with 'lodging' and can actually 'burn' the

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8/ At the five per cent level or better.

9/ It will be noted that two of these crops are those which were investigated on an inter-zonal basis (Table 8.4) while the figures for the third crop, romany, were provided in Zone C only. However when separate functions were fitted for each zone for laketch and local barley, no improvement in the over--all 'fit' was obtained. In fact in each case the exponential term had to be dropped from the equation on statistical criteria, indicating perhaps that the effect of soil fertility is too crudely measured by the variable 'zone'.

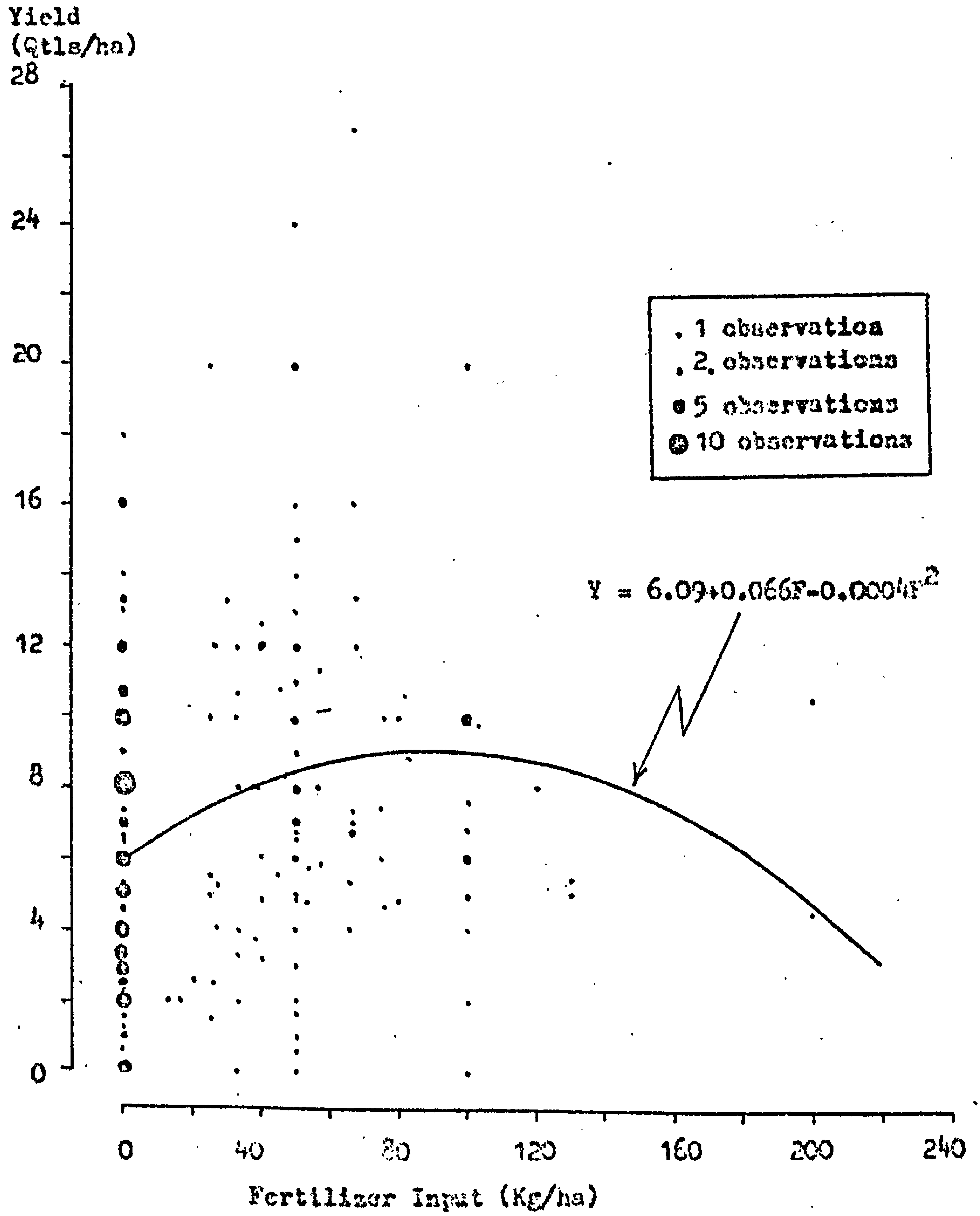

FIGURE 8.1: Yield Response to Fertilizer (Local Barley)

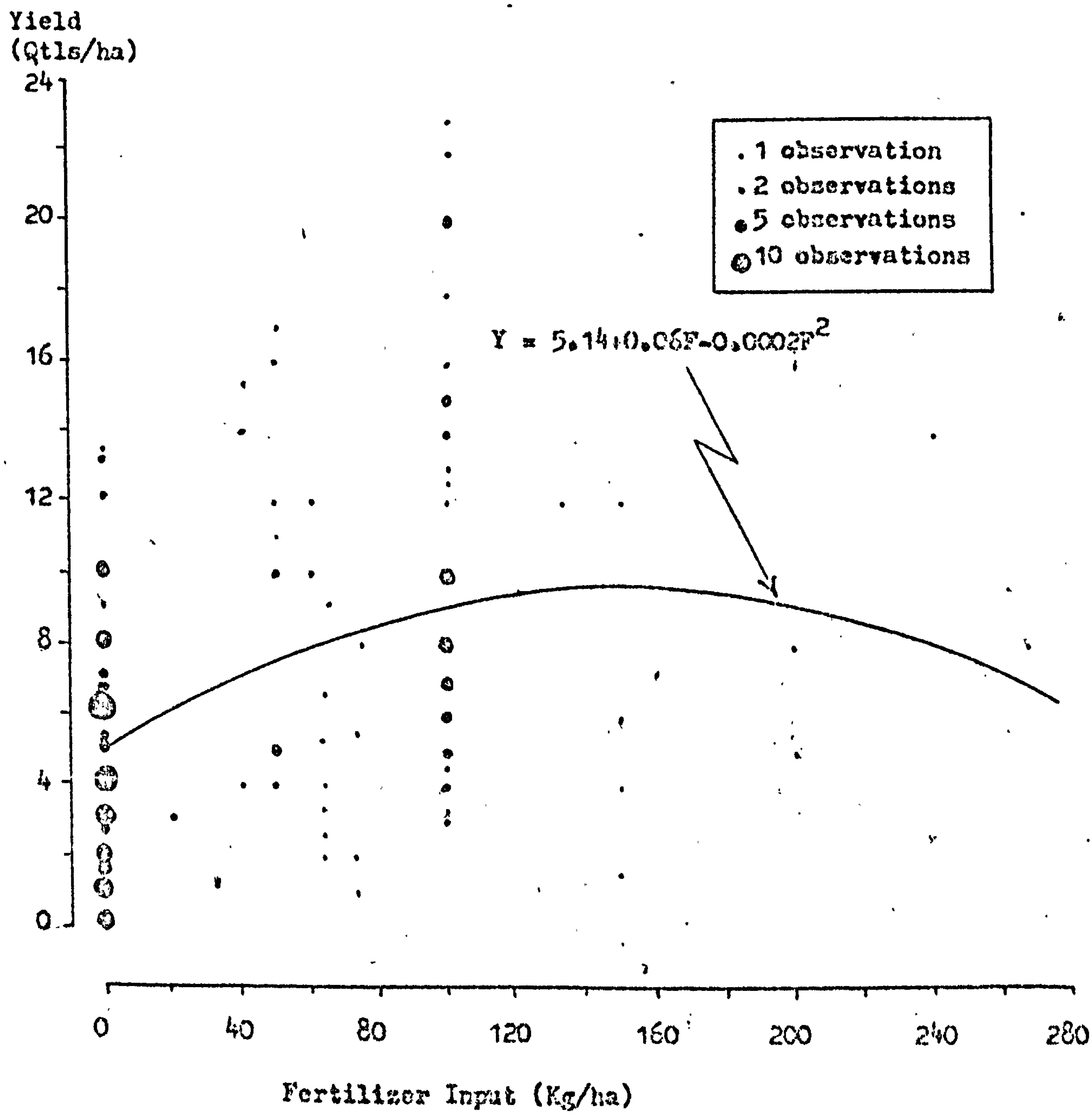

FIGURE 8.2: Yield Response to Fertilizer. (Laketch)

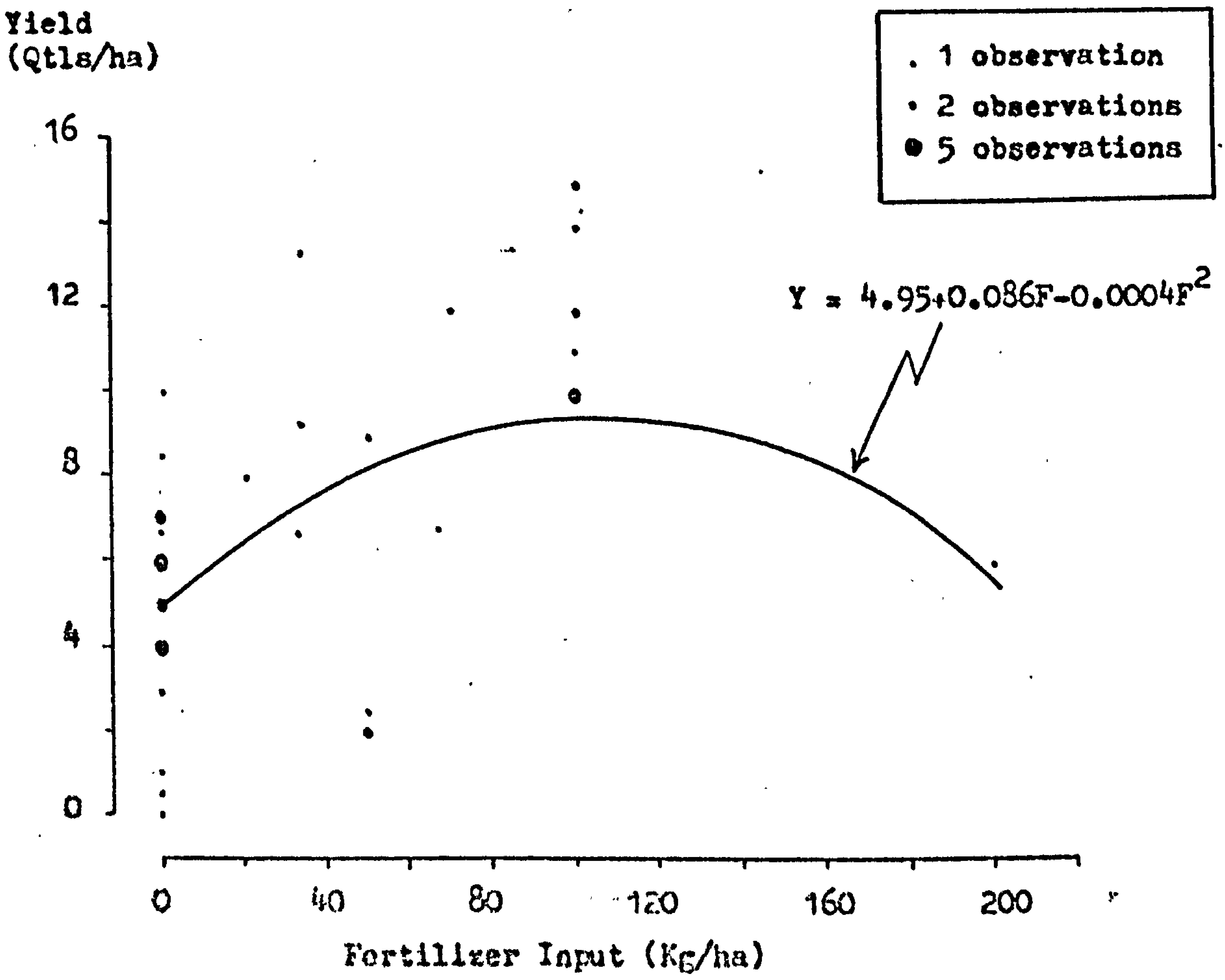

FIGURE 8.3: Yield Response to Fertilizer (Romany)

crops. All of these problems, it should be noted, were reported by some farmers in the sample.

Having derived curvilinear response functions of the type represented in equations 8.1 and 8.2, it is a theoretically straight forward matter to calculate several quantities which are of interest to the economist.

These include the average and marginal product of fertilizer, the elasticity of response and, for a given set of crop and product prices, the profit maximizing level of fertilizer input. However there are many pitfalls in the way of accurately estimating these quantities even when production functions have been estimated from experimental agronomic response studies.10/ In the cases under examination here, too few variables are subject to even statistical control to permit meaningful estimation of the above parameters.11/

10/ See Dillon 1968 for the most useful review of the approximate methodology for response studies and for an examination of the difficulties involved.

11/ For purposes of illustration only the appropriate variables will be calculated for <u>laketch</u> using the parameters from Table 8.5

(i) Average product of fertilizer = Y/F

$$=(5.14/F)+0.06-0.0002F;$$

(ii) Marginal Product of fertilizer = Y/ F

$$=0.06-0.0004F;$$

(iii) Elasticity of Response = Marginal Product/Average Product

(iv) Profit is maximised when the marginal product of fertilizer is equal to the ratio of its price to that of the crop. Assuming farm gate prices of Eth$20 per quintal for <u>laketch</u>, the profit maximizing level of fertilizer input is 70/Kg/ha

It is interesting to note that the level of applic--ation of fertilizer for the two wheats tends to be high--er than for barley. Inspection of Figures 8.1 to 8.3 show modal rates for farmers who apply fertilizer, of 100/Kg/ha for wheat but only 50/Kg/ha for barley. Table 8.6 shows the differences in mean yields for the two crops for which interzonal comparisons can be made, in this case including zero application levels. In every case higher mean rates of fertilizer are applied to wheat than barley and in almost every case the differences are statistically significant.12/

This provides another case of rational adaption on the part of the farmers. Lower fertilizer application rates for barley make sense economically on two grounds. First, one of the improvements bred into HYV wheats is an ability to tolerare relatively high rates of fertil--izer application without 'lodging'. Second, the unit price of wheat in Ethiopian is higher, generally by 10 to 20 per cent, than that of barley, so that the

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Footnote 11/continued.
which would yield 8.36 qtls/ha of laketch. This is of course less than the output-maximizing,level of fertil--izer application which is 150 Kg per hectare, yielding 9.64 qtls/ha.

12/Analysis of variance; the differences are not signif--icant in Zone B, but in the other three zones they are significant at the 5 per cent level or better.Overall the differences are significant at the 0.1 per cent level.

TABLE 8.6: Rates of Fertilizer Application on Eleven Crops

CROP/ZONE	No. of Obser-vations	Mean Rate (Kg/ha)	Coeff. of Variation	Standard Error	Confidence Interval[a]
Laketch A	91	53.2	1.04	5.82	41.6-64.8
Barley A	113	38.5	1.17	4.23	30.1-46.9
Laketch C	22	40.2	1.05	8.96	21.6-58.9
Barley C	63	22.2	1.23	3.44	15.4-29.1
Laketch B	49	58.0	1.01	8.39	41.1-74.9
Barley B	48	45.4	1.62	10.65	24.0-66.9
Laketch D	32	41.6	1.32	9.77	21.7-61.6
Barley D	18	10.0	1.94	4.57	0.4-19.6
LAKETCH[b]	194	51.0	1.08	3.95	43.2-58.8
BARLEY[b]	242	33.5	1.44	3.11	27.4-39.6

a/ i.e. 95 per cent confidence interval for means.

b/ All Zones.

input-output price ratio is lower for wheat and other things being equal, the profit maximizing rate of fertilizer application is therefore higher for wheat [13/] These results suggest that farmers operate according to rules of thumb which are economically rational.

Where farmers reported a level of yield both with and without fertilizer, it is possible to form a rough picture of the perceived contribution of fertilizer to yield, since farmers were asked to draw the compar--ison 'when other things are equal'. These distribut--ions are summarized in index form in Table 8.7. Farmers clearly tend to place a high value on the contribution of fertilizer to yield. The typical estimate was a 100 per cent increase, although in some cases farmers stated that without fertilizer they could get no crops at all. These last figures, it should be noted, are not includ--ed in the indices of Table 8.7 since they imply an index of infinity. The very high figure for maize requires some qualification since it is clear from the maximum that a single very large figure has had a disproportionate effect on the mean. When this figure is dropped, the index for maize falls to 226, which is compatable with

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13/ The response equations for romany, laketch and barley shown in Table 8.5 also suggest that the wheats, especially the short-strawed laketch, can absorb higher levels of fertilizer application before negat--ive marginal returns occur. It will be recalled also that wheat tends to receive rather more careful husbandry than barley (Tables 5.8 and 5.9)

TABLE 8.7 Indices of Yields Using Fertilizer in Eleven Crops (Yield without Fertilizer = 100)

Crop or Variety	Number of Observations	Mean Index	Coefficient of Variation	Standard Error	Minimum	Maximum
Wheat, local	16	167	0.53	22.3	0	400
Kentana F	7	299	1.11	122.3	133	1023
Laketch	82	235	0.67	17.4	38	1000
Romany	19	194	0.41	18.1	33	300
Supremo	46	238	0.77	27.0	80	1000
Barley, local	102	198	0.77	15.1	6	1245
Maize local	12	539	2.02	313.8	90	3980
Teff local	29	168	0.61	18.9	0	400
Field Pea local	25	244	0.63	30.5	18	800
Horse Bean local	13	175	0.43	21.0	25	300
Haricots local	20	135	0.48	14.5	40	300

the figures for other crops.

8.2 YIELD COMPARISONS

In order to place the reported yields of the prev--ious section in appropriate perspective, they must be compared with yields of the same crops from other regions, as in Table 8.8. This table provides some very interesting information indeed. First, comparing the sample yields with those for Ethiopia in general,the two sets of figures are highly consistent. The rank order is exactly the same for all crops except *teff*,[14] and the mean yield figures for the country as a whole fall in most cases within the 95 per cent confidence interval for the mean yields shown in Table 8.2. If anything the sample means are above the national average, as would be expected for farmers using improved seed and/or fertiliz--ers. This comparisonncreates a good deal of confidence in the sample farmers' reported yields.

Second at the inter-national level, it can be seen that the rank order of the Ethiopian and Chilalo yield figures is again broadly consistent with that of the other egions. However for most crops the distance even between the two sets of Ethiopian yields and those for

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[14] In the case of *teff* the overall Ethiopian figure is for a single year which was better than average for cereals.

TABLE 8.8: National and International Comparison of Crop Yields (qtls/hectare)

Crop \ Region	Chilalo Sample[a]	Ethiopia	Developing Countries	U.S.A.	U.K.	World
Wheat	9.1	7.6	12.2	20.1	45.7	16.2
Barley	9.5	8.3	10.4	21.8	39.0	18.6
Maize	16.5	11.0	13.4	52.1	-	27.5
Teff	6.2	7.0[b]	-	-	-	-
Field Pea	6.3	5.0	6.0	17.5	32.5	11.2
Horse Bean	7.2	6.9	4.6	13.8	-	5.1

Sources: a/ Table 8.2; the yield for wheat is the overall mean yield for all five wheats in the table.

b/ Ministry of Agriculture (1975).

All other figures are averages for the period 1973-75 computed from FAO Production Yearbook, 1975.

all developing countries as a group indicates the degree to which room for improvement might potentially exist. Natural endowments such as soil type and climate unquestionably help determine any region's potential for acheiving high yields with a given crop, but man-made factors too are of enormous importance. The fact that for the crops listed British yields are generally double the U.S levels reflects the much more intensive agriculture of the U.K.,which in turn is largely a result of relative factor and product prices.

Within the Chilalo District itself, it is possible to compare the sample farmers' reported yields with those from other Chilalo smallholders which are measured in a crop sampling survey conducted by CADU (CADU,1975a). Comparative figures are available for only nine of the eleven crops or varieties discussed earlier and these are shown in Table 8.9. The prospects opened up by the information in this table are actually quite fascinating. First it will be obvious that, with only one exception the crop sampling results suggest that farmers' yields are actually twice as high as those derived from the present sample farmers' reports. In addition, in the five cases where information is available for more than one year, there is certainly some degree of variation between years, but surely not enough to explain the differences between these yields and those reported

TABLE 8.9 Comparison of Yields Reported by Sample Farmers with Yields Derived from Crop Sampling

CROP/VARIETY	Sample Farmers		Crop Samples					
			1971		1972		1973	
	Yield	N	Yield	N	Yield	N	Yield	N
Wheat, local	7.5	23	-	-	-	-	17.8	134
Kentana f.	8.5	8	18.6	27	20.1	32	22.7	65
Laketch	9.4	89	22.0	72	21.0	88	22.2	330
Romany	8.8	22	16.6	130	19.6	63	19.9	67
Supremo	9.5	52	17.0	128	16.8	222	18.1	258
Barley, local	9.5	124	18.2	365	17.1	435	16.6	557
Maize, local	16.5	12	-	-	-	-	26.8	109
Teff, local	6.2	35	-	-	-	-	12.7	43
Haricots, local	6.6	21	-	-	-	-	6.7	36

Notes: Yield = mean yield (qtls/hectare)
N = number of observations

Sources: Table 8.2 for sample data and CADU (1975a) for other data.

by sample farmers as being 'normal'. And yet in Table 8.8 it was shown that the sample farmers' reported yields are broadly consistent with estimates for the country as a whole, estimates which are calculated by the Ministry of Agriculture from calculations of total production and total area under specific crops.

One important question which requires to be answer--ed at this point concerns levels of fertilization. Is it possible that the differences in yield in Table 8.9 arise from differences in this factor? All of the data shown in this table relates to farmers' actual yields whether or not fertilizer was used. In the CADU study the samples were divided into "fertilized"and"unfertilized" fields with no indication of application rates. However data are available for "unfertilized" fields separately in four cases for 1973 and if these are compared with the sample of the present survey as in Table 8.10 it is clear that in no case is there even any overlap between the 95 per cent confidence intervals. Thus the level of fertil--izer application can be discounted as a plausible explan--ation of the yield differences.

So far as is known, the only factor which could give rise to <u>real</u> differences between the yields actually obtained by farmers and those indicated by crop samples taken from their fields lies in the quantity of labour available for the harvest, the time at which it is av--ailable and the technique used for post-harvest

TABLE 8.10: Ninety-five Per cent Confidence Intervals for Mean Yields Reported by Sample Farmers and Derived from Crop Samples "Unfertilized"

Crop/Variety	Sample Farmers		Crop Sampling (1973)	
	Confidence Interval	N	Confidence Interval	N
Wheat, local	5.6 - 9.4	23	14.7 - 17.7	64
Laketch	8.2 -10.6	89	14.0 - 20.6	22
Supremo	7.9 -11.1	52	16.9 - 21.1	48
Barley, local	8.5 -10.5	124	15.5 - 17.5	142

operations. CADU's methods are fairly standard for such experiments and involve selecting at random from the farmers' fields three plots of two square metres each and harvesting them with sickles as far as possible when the crop is 'dead ripe'.Temporary employees are used for the reaping and they are supervised by staff from CADU's Planning and Evaluation Section in collaboration with the local extension agent. The crop is threshed with a threshing machine,cleaned and the grain weighed (CADU, (1975a,pp.1-8).There are evidently no problems or delays in finding labour to harvest the crop,[15] no need to collect oxen to thresh it and no losses such as those arising from the traditional threshing method which was discussed earlier.(Chapter 2, Section 2.3). It is there--fore reasonable to conclude that at least a substantial part of the differences between yields reported by the farmers and those indicated by crop sampling is to be explained in terms of lost potential yield suffered by the farmers because of sub-optimal timing and techniques in the harvest and in subsequent operation.

An important piece of corroberative evidence is

15/ There is unfortunately no direct indication of the number of men hired for these sample reapings or of the ratio of men to land when the work was done, but the level of expenditure on casual labour was relat--ively high - Eth$4,500 or 33% of the total budget for the entire crop sampling survey,(CADU,1975a, pp.7-8).

provided by the exception noted in Table 8.9,haricot bean. It was noted in Chapter 5 that unlike the other crops in Table 8.9 haricots are uprooted and shelled rather than cut with a sickle and threshed by oxen. Thus in case of haricots (and some other pulses) the harvest is completed more quickly and the shelling pro--cess does not result in any substantial level of wastage. It would of course be much more satisfactory if data had been available for pulses other than haricots and for more than one year, but the closeness of the sample farmers' reported yields to the crop sampling results provides a very useful clue in itself and helps support the above conclusion.

In addition to that on the yields obtained by small--holders, evidence is available on the topic of crop yields in three other types of farming situation in Chilalo: extension agents' demonstration plots,mechan--ized farming and agronomic experimental trials.

On the extension agents' plots a CADU plough and harrow are used to prepare the seedbed and the crop is harvest--ed with a sickle and processed in the same way as in crop sampling. Table 8.11 compares yields from these plots with those of smallholders in the same year.The CADU report in which these data are contained(1975a, p.33) noted very plausibly that one reason for the farm--ers' relatively better performance with local wheat than

TABLE 8.11 Comparison of Yields on Smallholders' Fields With Those from Extension Agents' Demonstration Plots (1973)

CROP	Mean Yield (qtl/ha)		Smallholders' yields as % age of extension agents' yields
	Extension Plots	small-holders	
Local Wheat	19.6	17.8	90.8
Laketch	27.3	22.1	81.0
Local Barley	23.5	17.3	73.6

Source: Computed from CADU (1975a), pp.32-33.

with 'laketch' might be the fact that extension agents use certified 'laketch' seed, whereas farmers produce their own. No certified 'local' seed is available of course. In the case of barley, the findings of the present Survey indicates that farmers' standards of husbandry (number of ploughings, number of times the crop is weeded) tends to be lower than in the case of wheat, and that the level of fertilizer application also tends to be less.These points will be taken up again at a later point in the section.

In many ways the most interesting yield comparis--on is that between smallholdings and highly mechanized farms, since, as was shown in Chapter 1 (Section i.4), there is still some disagreement as to whether or not mecnahisation _per se_ increases yields. The original intention of this study was to compare smallholders' crop yields with those of private mechanised farms in Chilalo but, as was noted in Chapter 3 (Section 3.2) these latter farms were thrown into such a state of disarray following their nationalisation that this proved impossible.Instead yield data were obtained from two large mechanised farms belonging to CADU, one of 673 hectares (1663 acres) at Assasa in Zone C, and the other of 410 hectares(1013 acres) at Kulumsa in Zone B. This comparision in fact, is by now prob--ably the more appropriate in any case, since any fut--ure mechanised state farms or collectives which are established as an alternative to individually operated smallholdings are likely to resemble the Assasa and Kulumsa operations more closely than those of the now expropriated private mechanised farm.

The farms at Kulumsa and Assasa are, it is worth observing, very highly mechanised indeed. Crop prod--uction equipment includes combine harvesters, tractors and tractor-drawn equipment: mouldboard ploughs, disc ploughs, harrows, seed-drills, planters, fertilizer spread--ers, rollers, rotovators and sprayers. Machine hours in 1973 totalled 3436 at Kulumsa (8.4 hours per hectare) and 3802 at Assasa (5.6 hrs/ha). Table 8.12 shows that machinery costs constitute the largest single item on both farms for both wheat and barley; the capital-labour ratio is clearly very large.[16/]

Comparative data for yields on smallholdings and mechanised farms are available for the year 1973, the former figures deriving from CADU crop samplings in the same agro-climatic zones as those in which the two mechanised farms are situated. These figures are pres--ented in Table 8.13, which in the case of wheat provides no evidence to support the view that large scale highly

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16/ These two farms are used by CADU for seed multiplic--ation (i.e. for growing HYV seed for distribution to farmers), but the extra cost of processing the crop for seed has been excluded from the calculations in Table 8.12. Comparative costs of production will be considered in Chapter 9.

TABLE 8.12: Direct Production Costs for Wheat and Barley on Two Mechanised Farms, 1973 (Percentage Breakdown)

Item	WHEAT		BARLEY	
	Kulumsa	Assassa	Kulumsa	Assassa
Machinery	50.3	40.9	62.4	53.1
Labour	6.0	2.0	3.8	4.3
Herbicides	2.5	2.6	2.6	1.1
Seed	14.9	22.1	12.4	16.9
Fertilizer	26.2	32.3	18.8	24.6

Sources: Kulumsa and Assassa farm records (unpublished).

TABLE 8.13: Comparison of Yields of Wheat and Barley on Extension Agents' Demonstration Plots, Large Mechanised Farms, Smallholdings and at Experimental Trials in Chilalo

CROP/VARIETY	ZONE B			ZONE C			Exper. Trials
	Agents	Mech.	Smallholdings	Agents	Mech.	Smallholdings	
	Yield (No)	Yield (No)	Yield (No)	(Yield (No)	Yield (No)	Yield (No)	Yield (No)
Wheat, Improved a/	-	23.0 (8)	-	-	17.2 (12)	-	-
" *Laketch*	33.5 (6)	-	24.5 ± 1.4 (113)	29.8 (3)	-	23.4 ± 1.8 (61)	45.1 (4)
" *Supremo*	-	-	18.4 ± 1.5 (89)	-	-	19.1 ± 3.5 (14)	33.9 (1)
" Local	22.3 (6)	-	19.1 ± 1.6 (40)	24.2 (3)	-	-	32.8 (9)
Barley, Improved	-	31.0 (3)	22.3 b/	-	25.0 (2)	26.0 b/	-
" Local	27.7 (6)	-	18.2 ± 1.9 (51)	21.8 (3)	-	21.2 ±1.9 (32)	36.0 (8)

Notes: a/ Specific varieties are not known in the case of the two mechanised farms; yield figures are in quintals per hectare; in the case of smallholdings the 95 per cent confidence limits are given. Figures in parentheses are the number of observations.

b/ Author's estimates (see text for explanation).

Sources: (i) Mechanised Farms: computed from Kulumsa and Assasa farm records;

(ii) Smallholders and Extension Agents: CADU (1975a); smallholders yields relate to fertilised fields only;

(iii) Experimental Trials: computed from CADU (1975).

mechanised farming results in higher yields than those that smallholders can achieve, provided that technically efficient methods are used for harvesting and for post-harvest operations.[17/] It is also worth recalling that on smallholdings, unlike the CADU farms, certified seed is not normally used, nor is the level of fertilizer applic--ation usually as high, even in the case of wheat, so that 'all other things' are not really equal.If they were, it is most probable that the smallholders' relative yields would be better still.

In the case of barley the comparison is rather more difficult to make since data for smallholders using improved barley seed are not available at the zonal level. However on the basis of figures for the whole of Chilalo, yields of imrpoved barley on smallholdings were found to average 23 per cent higher than those of local strains (CADU,1975a,p.26), and this ratio has been used to prov--ide rough estimates of yields of improved barley in Table 8.13. If these estimates are used, then in only one case,barley in Zone B, do the large mechanised farms obtain higher yields than the smallholdings. However, as can be seen from Table 8.14,yields of barley on the mechanised farm in Zone B were exceptionally high in 1973.

17/ A comparison of Tables 8.8 and 8.13 shows that yields in Chilalo generally compare favourably with U.S. levels under those conditions.

Table 8.14: Crop Yields at Kulumsa Farm, 1970-75

	YIELD (qtls/ha)						
CROP	1970	1971	1972	1973	1974	1975	MEAN
Wheat	26.7	23.2	20.5	23.0	23.0	26.0	23.7
Barley	25.3	27.5	15.0	31.0	27.0	-	25.2

Source: Kulumsa farm records (unpublished).

The yields obtained in the experimental trials are of course highest of all, but this is not at all surprising, since commercial crop production is not nearly so skill-intensive as is the case in these agronomic trials. This level of skill-intensity would greatly raise the cost of production and would probably not be profitable if attempted on a commercial scale.[18/] So long as this proviso is kept in mind, however, yield figures from such experiments are of some interest in that they provide the benchmark against which the yield performance of ordinary farms may be judged.

Although Table 8.13 presents data for a single year only, there is no reason to believe that conditions in that year were such that they resulted in relatively low yields on the mechanised farms. Table 8.9 shows that yields of improved wheats in the smallholder subsector in Chilalo as a whole have tended to improve slightly over the period 1971-73, while that of local barley tended to decline. CADU officials ascribe the improvement in wheat yields largely to "improved farming technique" rather than to climatic factors (CADU,1975a,p.36).In the case of mechanised farming,data are available at Kulumsa farm over the period 1971-75 and, as can be seen from Table 8.14, yields in 1973 were around the mean for

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18/ Dillon(1968,pp,115-116) summarises research data from Australia which shows that "farm yields tend to approach experimental yields the smaller the scale of farming and the more intensive the use of labour in production".

wheat, but above average for barley.

Of course beffore reaching any truly definitive con--clusions on this subject it would be necessary to con--duct a series of carefully controlled yield experiments over a number of years. Only one set of experiments of this type has been conducted at CADU and these involved a comparison of different methods of ploughing and of seed--covering,other things being held constant. The three methods of ploughing were: tractor-drawn disc plough, animal drawn mouldplough and local plough. The methods of seedcovering were the local plough and two types of harrow. These experiments could not produce entirely conclusive findings, owing to a relatively small number of replications and to the fact that they were not rep--eated in subsequent years. However, again the results which are available lend no support to the view that engine-powered seedbed preparation as such increases yields.

There was no statistically significant difference in yields comparing the different methods of ploughing (Table 8.15)although significant differences did emerge when seed-covering by plough and by harrow were compared (Table8.16). The comparison in this latter case, however, was between implements only, and not between power sources, since in each of the three methods recorded in Table 8.16) the equipment was ox-drawn. In view of the

TABLE 8.15: Yield of Wheat With Different Methods of Ploughing

(All other factors held constant)

Type of Plough	No. of Replications	Mean Yield (qtls/ha)
Local Type	8	24.85
Animal-Drawn Mouldboard	12	23.50
Tractor-drawn -	12	24.81

Source: CADU (1970) P.7.

TABLE 8.16: Yield of Wheat With Different Methods of Seed-Covering (All other factors held constant)

Method of Covering	No. of Replications	Mean Yield (qtls/ha)
Local Plough	4	18.68
Ariana Toolbar Harrow	29	22.26
Spike-Tooth Harrow	29	22.46

Source: CADU (1970) p.9.

above evidence it seems reasonable to conclude that a substantial part of the differences in yield between extension agents' and smallholders'wheat(Table 8.11) can be ascribed to the different methods of seedcovering, since the great majority of smallholders still use the local plough for this purpose.

Thus impirical evidence based on two quite independ--ent methodological approaches in which yields were physically recorded suggests fairly convincingly that the use of engine power as such in preharvest operations does not improve yields compared with the best tradition--al methods, other things being equal.Nor, it may be observed, do fully mechanised methods of harvesting, threshing and separating, as represented by the combine harvesters used on the mechanised farms, improve yields in comparison with the semi-mechanised methods used for extension demonstrations and in crop sampling. However, as was noted earlier in the case of barley, not all crops receive the same high standard of preharvest husbandry in the smallholder sub-sector, and this <u>can</u> have an adverse effect on yields.

There are three (not necessarily alternate) possible explanations for a rational farm faily's failing to achieve the same standard of husbandry on all crops that it achieves on the one which receives most attention. First it may be that all of the physical available 'energy' supplies are already fully committed at some crucial bottleneck period or periods in achieving existing standards and that these resources are then allocated among crops according to some rule(s) of thumb whereby total utility is most likely to be maximised.[19/]. Second, it may be that within the farm family the marginal utility of lei--sure at certain times of the year - again presumably at some 'peak' period(s) - exceeds the marginal utility of income when the latter is discounted both over time and for the risks involved.[20/] Third, the marginal cost of non-farm energy may exceed the (again discounted) marginal revenue from increased yields. As was shown in Chapter 7 (Section 7.5), these two discounting factors tend to--wards zero as the harvest period approaches.

No matter which of the above explanations may hold in a given case, the resultant limitations on energy supply will relate to a specific period of time, a specific phase in the farming cycle during which the operation in question must be completed. The fact that energy supply constraints may be eased over a longer time span will be

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19/ It was suggested in Section 8.1 that this type of reasoning seems to lie behind differences in the level of fertilizer application on different crops.

20/ The 'farm family' is here used as shorthand notat--ion for whatever decision making process operates within it.

of little practical significance in many cases, since the time at which a farming operation is performed can have at least as great an effect on yields as whether or not it is performed at all. Indeed with some operat- -ions the marginal return may be positive at one point in time and negative at another.[21/] Some indication of the impact on crop yields of timeliness of operation can be gained from the experimental findings presented in Table 8.17.

In the case of ploughing dates, a glance back at Figure 5.2 will show that first ploughing for most crops occurs in March in Zones A,B and C and in May(owing to the later onset of the rains) in Zone D. Thus in the case of first ploughing the farmers' timing usually coincides with the best date recorded by CADU. The main differences between wheat and other crops, as far as seedbed prepar- -ation is concerned, lies in the number of ploughings rather than in the timing of the first ploughing, as was shown in Table 5.8

Although the CADU experiments mentioned earlier did not establish significant yield differences comparing

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21/ It would be injudicious for example to harrow a field after the crop had germinated! This is not, however, to gainsay the observation that in some cases energy supplied for one operation may sub- -stitute for energy in another, as was noted in Chapter1 (Section 1.3).

Table 8.17: Variations in Wheat Yields with Different Dates of Ploughing and Sowing

Month of First Ploughing[a]	Yield (quintals/hectare)
March	26.3
April	25.7
May	23.1

Date of Sowing[b]	Yield (quintals/hectare)			
	V1	V2	V3	V4
June 14	32.2	28.1	52.7	36.0
June 28	25.8	18.1	43.6	35.8
July 12	33.1	14.7	33.0	35.7
July 28	23.9	14.6	25.3	23.1

Notes and Sources: a/Ploughing date: CADU (1970) p.10. These experiments were conducted in Zone B.

b/CADU (1975) p.27; V1, V2, V3 and V4 refer to four new wheat varieties undergoing experimental tests.

the best traditional methods of seedbed preparation with more modern methods Table 8.15), there are very great differences in their time requirements, as can be seen from Table 8.18. The tractor is obviously fast--est of all, but it must be remembered that these figures relate to operating times only. Since small--holders hire rather than own tractors, the addition of travelling time would substantially increase the total time required(and the cost) in almost all cases. There would also be the distinct possibility of delays while farmers awaited the tractor's arrival. In fact since smallholders can already achieve relatively high stand--ards of secondary cultivation with traditional imple--ments on wheat - which occupies around one-third of all the sample farms on average - then an implement like the ox-drawn harrow which achieves the same standard of cultivation in one-third of the time without loss of yield would comfortably permit the typical smallholder to achieve the same high standard of secondary cultiv--ation on all crops without purchases of 'energy' other than the implement itself.

It is perhaps worth recalling that time-saving was a major advantage of the spike-tooth harrow reported by the Sample farmers (Table 7.13). One owner estim--ated that, comparing his harrow with the local plough, "one pair of Oxen can do the work of four pairs", while

TABLE 8.18: Time Required for Secondary Cultivation and Seed Covering by Different Methods

OPERATION	Total Time Required (hours/hectare)		
	Local Plough	Ox-drawn Harrow	Tractor-drawn Implements
2nd Ploughing/1st Harrowing	30	8	1
3rd " 2nd "	22	9	1
Seed-covering	22	5-6	1
TOTAL	74	22-23	3

another stated that with the harrow he could cover three hectares in a single day. This latter figure is much better than the CADU estimates, and presumably reflects soil differences and/or stronger oxen. In seed--bed preparation too, speedier operation is achieved, an advantage which accrues in addition to that of higher yields shown in Table 8.16

Finally as regards weeding, no impirical data are available on mechanical methods of weed control, but comparisons of hand-weeding with various herbicide treatments, showed the former to be among the most eff--ective (CADU,1975. pp.151-84). It will be recalled that the question of returns to handweeding was discuss--ed in Chapter 2. (Section 2.3)

CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

9.1 A REVIEW OF THE EVIDENCE

9.1.1: The Issues in Perspective:

The starting point of the present essay was the extremely serious problem of unemployment in developing countries and the fact that it is now widely accepted that in most such countries the agricultural sector will of necessity remain the major source of productive employment in the foreseeable future. This approach is, however, complicated by the fact that agricultural employment in developing, even more than in developed, countries is intrinsically seasonal, having periods of relatively intense activity interspersed with periods of comparative inaction. Under these circumstances attempts to increase the labour-land ratio within the confines of traditional technology would simply aggravate the unemployment/underemployment problem in the slack season while reducing the average level of farm incomes.

Although in some, particularly African, countries there is often scope for bringing new land under cultivation, in virtually all areas increased land productivity is essential if farm output and incomes are to increase. The introduction of 'labour augmenting' technological change in Third World agriculture has come to be known as the 'green revolution' and comprises for the most part new high yielding crop varieties together with fertilizer. However in many developing countries this 'revolution' has been accompanied by serious net labour displacement partly because it has resulted in the creation of some short, but often very pronounced, peaks in energy demand with which existing labour and other traditional energy resources have been unable to cope.

The end result has been a tendency for both farm size and the degree of farm mechanization to increase sharply, and for a number of economic and institutional reasons this mechanization has been both extensive and largely indiscriminate. There is reason to believe on both theoretical and empirical grounds that the justification for extensive agricultural mechanisation is very largely a function of farm size and consequent administrative and supervisory problems, and that output per unit area can be at least as high, and cost per unit output at least as low on smallholdings as on large mechanised units, provided that seasonal bottlenecks can be overcome.

Many writers now argue that what is required is selective mechanization using as far as possible improved manual or animal-powered equipment or minimal engine power (which would in turn enhance the prospect of domestic manufacture). This argument has in many developing countries, including Ethiopia, been accepted at least in principle and as a basis for experimentation.

Numerous agricultural engineering research establishments have been founded for the purpose of designing, developing, testing and adapting 'intermediate technology' for smallholders. In Ethiopia the major effort in this field has taken place under the auspices of the Chilalo Agricultural Development Unit, but the emphasis at CADU - and there is good reason to believe that this is fairly typical, certainly of East African experience - has been on testing and, it should certainly be acknowledged, considerable intelligent adaptation. However very little designing and even less development has taken place. What has gone into production has largely been determined by available designs and prototypes rather than by the perceived needs of the farmers who are supposed to use the equipment.[1/] It is small wonder, therefore, that sales levels are often disappointingly low.

This situation is obviously quite unsatisfactory and carries the danger that 'intermediate' technology will come to be regarded as inappropriate technology without having had the benefit of a fair trial. Basically what is required in this type of situation is a (rather special) form of market research aimed at establishing which, if any, production processes are regarded by the farmers themselves as 'bottlenecks', either because they tend to limit yields or because they entail

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1/. CAU's original full-cleaning thresher, for example, was simply a copy of one which happened to belong to the farm of a neighbouring Lutheran mission.

extreme drudgery. Only after the completion of such an investigation can suitable equipment be designed for the elimination of such bottlenecks through a process of selective mechanisation, and only after this exercise has in turn been completed can the resulting technological design be evaluated in comparison with such alternatives as traditional technology and highly mechanized methods or some combination thereof.

The above outline will hopefully have placed in its proper perspective the investigation which provides the empirical content of the present study. The issues which this work is intended to investigate can usefully be considered in three stages. The first comprises an examination at the level of the individual farm of the seasonal balance between farm 'energy' availability and the 'energy requirements' of individual crops, and of changes which have occurred in these patterns as a result of the introduction of the main ingredients of the 'green revolution'. The central concern of the second stage is with the effects of the above imbalances and of inadequacies in traditional technologies, insofar as the first elicits appropriate or 'rational' responses from the farmer (within the confines imposed by the availability of suitable alternatives) and to the extent that they both result in a loss of productive potential. The final section, perhaps the most ambitious, will widen the scope of the study and try to reach firm conclusions concerning the overall form that selective mechanisation of agriculture in Chilalo ought to take and then to evaluate this as an alternative to both traditional and highly mechanised technology. Before attempting this final stage, however, it will be useful to review the evidence so far uncovered on the questions subsumed under the other two headings.

9.1.2 Seasonality of Energy Requirements

The fact of seasonal variations in energy requirements is very easily established, as a glance at Figure 5.3 will show. The uneveness of crop requirements is most clearly seen if a single crop is viewed in isolation as in the case of maize monoculture (Diagram 5.3.13), where labour requirements are zero during four months and oxen requirements zero during six months of the year, while in three months in the case of labour and one month in that of oxen estimated requirements are at least double estimated on-farm supplies.

The effect on seasonal energy requirement-availability patterns of the introduction of fertilizer and high-yielding varieties (HYV's) can be very pronounced indeed. In most cases requirements have, often substantially, increased, but in some instances a reduction has occurred, or existing requirments have been spread over a longer period of time.

Seedbed preparation is a task in which both types of change have taken place. On the one hand farmers have now largely abandoned the very arduous traditional practice of soil-burning, while on the other hand a majority of them report that they now plough the land more frequently than previously in order to achieve the finer tilth which, they say, fertilizer and HYV's require. A substantial minority also report ploughing earlier than before for the same reason. However against the saving of energy achieved through the abandonment of soil-burning should be set two qualificatory factors which reduce its beneficial effects. First, where the practice has been abandoned the energy saved tends to be only in a relatively slack period, and second since soil-burning destroys weed seeds which are dormant in the soil, an increase in weed infestation may well ensue when this practice is discontinued. It is nevertheless desirable for other reasons that soil-burning be discontinued.

More than half of the farmers surveyed reported changing the time at which they sow at least one crop (i.e. comparing an improved variety with a traditional variety of the same crop). Slow-maturing HYV's are sown earlier at higher elevations because of frost late in the harvest season. The most popular improved wheat, laketch, is short strawed and fast maturing and is sometimes sown early in order to provide food in the normally hungry pre-harvest period or sown late, which would permit the easing of any bottlenecks which may occur during the sowing period.

The great majority of farmers state that weed infestation of their fields has increased as a consequence of the introduction of fertilizer, and this is very widely ascribed to increased soil fertility, although it could also result indirectly as was noted from the discontinuation of soil burning. Many farmers also reported that there are repeated crops of weeds. In most cases it has become necessary to weed more frequently. Another reason for weeding more frequently is that short-strawed varieties like laketch are especially vulnerable to weed competition and can be deprived of both sunlight and nutrients if weeds are not kept under control.

Harvesting and post-harvest operations are areas where great changes have taken place, for three reasons. First, there is a greater volume of material to be processed. Second, the new varieties have different characteristics from traditional strains. Most of the new wheats are long-strawed and easier to reap, but again laketch is an exception and many farmers reported that it s short straw makes reaping more difficult. Certain wheats - laketch and supremo - must be harvested fairly quickly after they ripen because of their tendency to 'shatter'. However these varieties are for the same reason relatively easy to thresh and winnow whereas wheats which do not shatter easily are ipso facto also more difficult to thresh and winnow. Third, farmers must now market their crops by a specific date in order to repay CADU loans on time and this not only means that many of them must sell when the price is low, but the period during which harvesting and post-harvest operations must be completed is also considerably shortened.

Farmers' own opinions of changes in seasonal workloads can be summarised as follows: problems of weed control have increased most since the introduction of new inputs, but harvesting has been and still remains the period of hardest work. Seedbed preparation is certainly a period of arduous labour, but owing to limitations on the strength of the oxen the working day is relatively short - around half the peak for other tasks. However the period of final ploughing, sowing and seed covering is one in which timeliness is essential, although sowing itself, as well as winnowing, seems to present few problems.

The above point about limitations on the strength of oxen highlights a very important issue, namely the fact that the peak periods of energy requirement for oxen and labour do not coincide. During the first ploughing when the oxen are relatively weak and their stamina fully committed, the ploughman is almost certainly working below his own capacity. On the other hand there are times when labour may be fully employed, for example during weeding or at the harvest, when the oxen are quite idle. This factor has important policy implications which will be discussed later in the chapter.

9.1.3: The Effects of Seasonality:

The methods used by the Chilalo smallholder in achieving on a seasonal basis mutual adjustment between crop energy requirements and energy availability may be classified according to whether they reduce the former or increase the latter. In the former case the ultimate solution is obviously to reduce the standard of husbandry, but rather more positive methods are also in use, especially the adoption of crop mixes which place complementary demands on energy resources by including crops not all of which impose their peak energy demands at the same time. The advent of new wheat varieties has broadened the scope for this sort of adjustment, as was shown earlier.

The only traditional device for increasing total energy supply for a given holding is the hiring of labour. Initially, this was effectively achieved through the sharecropping system, but more recently labour has been hired for a wage, usually on a casual basis for specific tasks. Neither of these options is now open. More recently still other, more modern, sources of 'energy' (broadly defined) have been tapped by smallholders: herbicides, tractors, combine harvesters and improved implements now contribute an important part of the smallholders' total 'energy' supply for crop production.

Finally there is one traditional institution, the mutual labour exchange group, which without increasing the total supply of energy within the group enables its members to take advantage of slight inter-farm differences in the incidence of peak energy requirements in order to enable to group's collective energy resources to be devoted to meeting peak demands on individual members' farms in succession. This system also permits members to realise economies of scale, especially in threshing.

The above points have clearly demonstrated that the smallholder is by no means the passive victim of climate and geography. Moreover the mere fact that so many of these farmers have begun to use high-yielding inputs such as fertilizer and improved seed, despite the fact that this entails harder work, is in itself sufficient evidence that their economy is not "characterised by backward-sloping curves of effort and risk-taking". Indeed their reactions, observations and conclusions as recorded in the course of the present study show that many of them have gained important insights into both the petential and the drawbacks of modern agricultural technology and have reacted accordingly. One case in which this emerges very clearly is that of fertilizer application rates. Many farmers noted, in less formal language of course, that diminishing and eventually negative returns obtain to this input. In their actions too a basic economic rationality is manifest, as when, for example, they apply more fertilizer per unit area to HYV wheats than to local barley.[2/]

The ability of even the most rational of smallholders to eliminate bottlenecks in the production process is, however, limited by the range of available technology. His incentive to do so depends upon the relationship between on the one hand

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2/. Religious observances which limit the availability of energy for crop production cannot of course be described as 'irrational', but rather reflect a scale of values which is less materialistic than that with which we are familiar in the West.

the marginal utility of income discounted over time and for risk, and on the other hand by the marginal utility of leisure during periods of energy shortfalls and the marginal cost of purchased energy during such periods. No matter what their origin, however, any remaining bottlenecks will tend to manifest themselves in the level of crop yields.

The evidence from the Survey indicates that the level of crop yields reported as being 'normal' by smallholders is approximately equal to, or slightly greater than, official estimates for the country as a whole. Yet, with only one exception, Survey farmers' reported yields of only around half the levels calculated by CADU on the basis of crops sampled from smallholders' fields - mainly, it is here argued, because the methods of harvesting and crop handling used in crop sampling are much more technically efficient than those traditionally used by smallholders. Two factors lend support to this view. First the single exception mentioned above, haricot bean, is a crop whose traditional processing tends to produce a much higher rate of recovery than the methods used for grain; yields of haricots reported by Sample farmers were the same as those estimated from CADU crop sampling. Second, in the case of grains, evidence from other sources suggests that the traditional method of threshing alone results in losses of around one-third due to heads not being properly threshed, produce being trampled into the threshing floor and oxen eating the grain while they are threshing it.

No precise figures are avilable concerning losses due to inefficient or untimely harvesting, but these can be very substantial. It is worth quoting the observation of a nineteenth century American authority on the subject. Writing at a time when within recent memory the sickle and the scythe had been the only common harvesting implements in the United States and elsewhere, he commented:

> "The harvesting of grain when ripe and ready to gather has been, until within a few years, the most burdensome and exacting operation on the farm. It may not be delayed like other work, for if not properly done the farmer might lose all the fruits of his previous labours, and unless properly and carefully performed his losses may still be severe". (Ardrey, 1894, p.40).

Much more recently within the context of the type of traditional agricultural practices found in Chilalo one of today's agricultural engineers has noted that "the cutting of cereals - wheat - by hand sickles is very slow and often the crops are past their optimum condition by the time the harvest is finished and high shedding loss is very common" (Matthews, 1974).

In the course of the present study farmers reported several sources of loss between the time when the crop was ripe for harvest and the commencement of threshing. These included theft, depredations by animals and birds, spoilage by rain, hail or frost and losses due to shattering - in this last case this is especially true of laketch and supremo, the two most widespread of the HYV wheats. The figures presented earlier suggest that these losses on average might total around twenty-five per cent. If these estimates are correct, then although the proportionate loss in threshing is higher than during harvesting, transportation and stacking taken together, the absolute volume of loss is roughly the same in both cases.

Turning to the comparison of smallholder yields with those obtained using fully engine-powered methods, evidence from two independent approaches in which yields were physically recorded suggests quite convincingly that the use of engine power in seedbed preparation does not increase yields compared with the levels that can be achieved with the best traditional methods. Nor was the use of fully mechanised crop handling found to improve yields in comparison with the semi-mechanised techniques used in extension agents' demonstration plots and in crop sampling.

Evidence from further experiments suggests that the use of one piece of CADU's cultivation equipment, the spike-tooth harrow, could help increase yields by as much as twenty per cent because of improved seed-covering. The time saved by the use of this implement in secondary cultivation, which is around two-thirds, could also help improve the standard of cultivation of crops which, unlike wheat, do not at present always receive the best possible standards of traditional husbandry. No quantitive estimates are avilable in this last instance, however.

If on the basis of all the evidence presented in this section the bottlenecks in the process of crop production in Chilalo were to be placed in order of importance insofar as they adversely affect yields, harvesting and threshing would be placed equal first and seedcovering a close second. Secondary cultivation may also be of some importance (particularly the last cultivation immediately before sowing), but all of the available evidence indicates that the standard of primary cultivation which can be achieved with the traditional Ethiopian plough produces yields as high as those which are achieved with tractor draught, all other things being equal. Nor does the evidence suggest that CADU's mouldboard plough produces higher yields than the traditional implement.

Turning now to the farmers' views of bottlenecks, there are two sources of evidence in the Sample survey. First the statements of farmers themselves concerning the period(s) at which they consider their work is hardest and the reasons, if any, why they regard their workloads as having increased since adopting the use of fertilizer and/or improved seed. Second, further evidence may be inferred from the farmers' purchases of additional 'energy' and from the tasks for which mutual labour exchange groups are most frequently used. This information is summarised in Table 9.1, which ranks seven farm operations in the order in which Survey farmers listed them, but some words of commentary are necessary before any firm conclusions can be based upon this information. First, it will be clear that some forms of purchased 'energy' can be used for some tasks, but not for others. Herbicide is the most obvious example, but farm machinery and CADU implements also come under this heading. Second, even where a farmer would wish to purchase a partiular form of assistance, physical barriers may prevent him from doing so: for example his fields may be unsuitable or

TABLE 9.1: Indicators of the Relative Difficulty of Seven Farm Operations

	RANK ORDER						
	Seedbed Preparation	Sowing	Weeding	Harvesting	Threshing	Winnowing/ Separating	Transporting Crops
Task Requiring Hardest Labour[a/]	3	7	2	1	4	6	5
Greatest Increase in Labour[b/]	3	-	1	2	-	-	-
Mutual Labour Exchange Group[c/]	2	6	3	1	4	7	5
Hired Casual Labour[d/]	4	6	2	1	3	5	7
Hired Machinery[e/]	4	-	-	2	1	1	-
CADU Implements[f/]	1	-	-	-	-	-	2

Sources: a/ Table 5.13; b/ Section 6.5.5;
c/ Table 4.15; d/ Table 4.17;
d/ Table 7.4; f/ Table 7.9.

too inaccessible for the operation of a combine harvester or tractor. Third, certain types of equipment contain an important element of 'indivisibility' in that they are designed to peform a number of operations sequentially. The combine harvester, for example, may either reap, thresh and separate or it may thresh and separate only, but no other combination is possible. CADU's full-cleaning thresher provides another such example. The effect of this in Table 9.1 is probably to understate the relative importance of reapdng and almost certainly to overstate that of separating.

Taking all of the above qualifications into account, the order in which crop operations should be listed according to their importance for farmers as periods of peak workload, is: reaping, weeding, seedbed preparation/seed covering, threshing and transporting crops. The other two tasks are of relatively minor importance. There is in fact a double motivation for seeking to provide additional 'energy' for harvesting and threshing. The fact that they are among the most important bottlenecks for the farmer and the fact that the farmers' informal discounting factors for uncertainty, and over time tend towards zero as the harvest approaches, so that he is more likely to purchase energy at this time in any case.

A further question which now arises is the extent to which the above tasks can be considered to constitute genuine 'bottlenecks' (in the sense that energy shortages actually restrict yields) or simply periods of relatively hard work.[3/] The

3/. The problem of distinguishing between the two can be very thorny indeed, especially in the context of agriculture in a poor country. For a most interesting discussion see Smith (1976).

evidence presented earlier on yields certainly indicates that the former interpretation is valid for at least some tasks. Where yields are not affected, however, it is quite often assumed that there is no justification for supplying additional 'energy' (broadly defined). De Wilde, for example, is of the opinion that

> "the use of equipment which simply alleviates labour burdens without significantly contributing to production can hardly be defended" (1971, p.378);

but why not? Surely on grounds of equity alone the farmer is just as entitled to purchase leisure as is his fellow citizen in the town when the latter for example rides on a bus or buys a bicycle in preference to walking. Moreover if there are certain tasks which make farming a relatively unattractive profession because of the extreme drudgery they entail, then it can very reasonably be argued that equipment which alleviates this drudgery, even if its use does not contribute to increased yields, might nevertheless have a positive contribution to make to the implementation of employment policy if it reduces 'urban drift'.

There will of course be other policy factors in operation in a case like this. For example the need to save foreign exchange, capital, skilled manpower and other scarce resources may indicate that expensive engine-powered machinery should not be used merely to alleviate labour budens, but this argument should not be used to prohibit all labour-saving equipment. The promotion of simple manual or animal-powered implements, especially if they can be manufactured domestically, can be fully justified, even if they are not expected to increase yields, for the same reasons that the promotion of domestically manufactured consumer goods can be justified.

9.2 'INTERMEDIATE' TECHNOLOGIES

The type of simple manual and animal-powered equipment which CADU has been attempting to produce and popularise is now commonly classified under the heading 'intermediate technology'. It is intermediate in the sense of being rather more capital-using than traditional methods, but much less so than the technology currently in use in developed countries. This need not, of course, imply that any given intermediate technology is necessarily either 'appropriate' or 'least cost' technology[4/]. The present section will be devoted to an evaluation of the intermediate technology produced at CADU and to how the range of choice might be somewhat widened in the light of the findings of the present study; but first it will be worthwhile to note several desiderata of intermediate farming equipment designed for use in areas such as Chilalo.

Technical efficiency is an obvious criterion; four others are simplicity, robustness, inexpensiveness and versatility. It hardly needs to be said that in practice there will always need to be some compromise between the first objective and the other four. Simplicity and rubustness are extremely important, since improved implements must be capable of withstanding considerable abuse in areas where repair and maintenance facilities are negligible. If an

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4/. The expression 'intermediate technology' was originally coined by the late Dr. E.F. Schumacher. The concept of 'village technology', a kind of intermediate 'intermediate technology', was later developed by MacPherson (see for example MacPherson and Jackson, 1975). It is rather odd that the expression 'labour intensive' has come to be applied to technologies which have relatively low capital-labour ratios, when the phrase itself implies the precise opposite, i.e. the intensive use of labour. 'Labour-extensive' would have been a better description of this type of technology; 'capital intensive' would have been better still, but its use might by now result in some confusion!

implement breaks down during a critical farming operation the farmer may be much worse off than he would have been had he never used the improved implement at all. This is particularly true of large, heavy implements which are very difficult to transport to the nearest repair facility, especially if a wheel or wheel bearing is broken. It is virtually axiomatic that a badly-designed implement is worse than none at all, since it creates a bad impression and will tend to prejudice the chances of introducing further intermediate implements - even those of proven worth.

Inexpensiveness- which in this context refers to the total level of investment in a piece of equipment - is an obvious enough criterion, although equally clearly it should never be regarded as the most important one. Perhaps there is considerably more scope than CADU has explored with its stationary threshing service for hiring implements to farmers or farmers' associations rather than attempting to sell them outright. It has been shown throughout the course of this study that farmers tend to hire 'energy' for peak periods rather than purchase a permanent addition to farm 'energy' resources. In addition to the rather special cases of tractors and combines, this can be seen in the case of labour (eight farmers hired casual labour for every one having permanent employees) and in that of CADU's implements since twice as many farmers hired them as bought them. Such a policy would reduce the 'lumpiness' of the investment, and would assist in the popularisation of new equipment. There are of course special difficulties inherent in such a policy when compared with the alternative of outright sales, but experience with the stationary threshing service indicates that these problems are capable of solution.

Traditional Ethiopian implements have the advantage of being highly versatile. This is most true of the indigenous plough, which can be used for four separate operations: primary ploughing, secondary cultivation, seed-covering and weeding (of tall crops). The advantage of this feature is again obvious, but its disadvantage lies in the fact that its lack of specialisation tends to be achieved at the expense of efficiency - most noticably in this instance in the case of seed-covering. Improvements in productivity have historically been achieved through increasing specialisation of both labour and capital, and there is little doubt that improvements in Ethiopian agricultural equipment will ultimately follow the same pattern. However whenever possible opportunities for making implements multi-purpose should be sought, since this will greatly increase their chances of acceptance by farmers.

Versatility applies not only to implements, but to power sources also. This is obviously true in the case of a highly versatile energy input such as labour, but oxen too are multipurpose workers, being used for cultivation, threshing and, to a lesser extent, transportation. However it was noted earlier that there are periods when labour may be heavily committed while oxen are not employed, and it should be an important aim of implements policy to try to bring all of the energy resources of the farm to bear upon the problems created by peak energy requirements through the development of suitable ox-powered equipment for as many operations as possible[5/]. This question will become increasingly urgent if engine-powered threshing machines begin to replace traditional techniques to an appreciable extent, since such a trend would aggravate the problem of unemployed traditional energy resources and would make the alternative of abandoning ox-cultivation in favour of tractor draught seem relatively more attractive. This may of course be undesirable for other reasons.

9.2.1: CADU's 'Intermediate' Implements:

If any of the above comments seems to be at all trite or obvious, it is worth pointing out that the simple criteria set out in the previous few paragraphs have not always been adhered to in the design of agricultural implements in Chilalo - or elsewhere in the developing countries. It must be emphasised, however, that neither this observation nor those that follow should be viewed as any kind of blanket condemnation of the staff of CADU's Agricultural Engineering Section (AES). In the early days of its existence, the Section's staff had little

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5/. In comparison with many other African countries, Ethiopia enjoys the advantage that ox-powered cultivation is a traditional technique, so that no period of training is required for its introduction nor is more than one ploughman required per team of oxen (in some African countries two or even three men per team are used). See Weil (1970) and Kline et al (1969) for actual examples of both of the above problems in Africa.

more than intuitive guidance as to relevant technical and economic parameters which would vitally affect the design of equipment. Nor did they have any data such as the present study is meant to provide, as to which farming operations, if any, constituted, or were likely to become, major bottlenecks. Moreover, AES staff are aware of many of the criticisms put forward below (indeed they suggested some of them themselves) and have improved the design of some of their equipment - for example the spike-tooth harrow and the stationary thrasher.

Nevertheless, it is sad to have to record that even as late as the end of 1975 there was apparently no recognition at CADU of the need to canvass farmers' opinions as to their own seasonal 'energy' problems before new designs of intermediate technology were embarked upon. A CADU committee was established in 1975 to "study and examine the factors which (have) contributed to" the fact that "the rate of utilization of CADU-developed agro-implements by farmers is not up to the expectation of the Project" (CADU, 1975b, p.1). Their report criticised a number of features of the research and production practices of CADU in this field, and put forward a number of thoughful suggestions for improvement but did not include among its findings any suggestion that the basic initial strategy ought to be simply to find out the farmer's own views as to what he required (CADU, 1975 b).

Of the four intermediate implements produced by CADU's Agricultural Engineering Section, the mouldboard plough has been by far the least successful. This may possibly be due in part to the fact that primary ploughing is apparently not a major bottlebeck period for labour, but much more important it is because of design defects in the plough itself. It is in fact rather difficult to understand why this plough was ever put into production, since the early trials at CADU showed that in comparison with the local implement the CADU plough demanded at least as much draught, was equally time-consuming and did not increase yields (CADU, 1970, pp 1-19). A later evaluation by the Agricultural Engineering Section confirmed that the plough had "few cultural advantages" (Cobbald, 1974, p.1). In fact any cultural advantages conferred by an inverting plough in a country like Ethiopia with a mainly wet growing season are liable to be outweighed by its potential contribution to soil erosion, as was shown earlier (Section 2.3). The most common advantage claimed for the CADU plough is that it saves time, but this advantage is actually conferred by the spike-tooth harrow which is used in conjunction with the plough. A combination of the local plough for primary cultivation and the spike-tooth harrow for secondary cultivation and seed covering would appear to be just as effective and certainly a good deal less expensive[6/].

CADU's harrow is, in contrast to its plough, a rather successful implement, and is the only one which has met with success at higher altitudes. As was shown earlier (Table 7.13), farmers' reactions to the harrow tend to be very favourable and many of them see no disadvantages at all in this implement.

6/. Costs of production with various technologies will be discussed in Section 9.3.

The fact that farmers who do not possess a harrow are willing to pay as much as Eth. $.1.00 per day to rent one - i.e. almost as much as they would pay to hire a labourer - is an indication of the value they place on this implement. The most important advantage of the CADU harrow is that it does a much better and faster job of secondary cultivation and seed covering than does the indigenous plough.

As was indicated in Table 8.16, its use in seed covering can evidently increase yields by as much as twenty per cent and its use for secondary cultivation saves sufficient time to permit a higher standard of secondary cultivation to be applied to all crops (see Section 8.2.). Farmers are aware of this and are also aware that the more uniform seed covering which the harrow permits allows the seed to grow more quickly and gives better stand of grain (Table 7.13).

It was noted in Chapter 7 that around three times as many farmers use the harrow as have actually bought one. Assuming that the sample was typical in this respect, this would mean that the CADU harrow is used by around two thousand Chilalo farmers, but even so this is only a tenth as many as use fertilizers in the Project area. It certainly seems that CADU's sales promotion approach in the case of implements is much less forceful than for fertilizers. Many of the farmers in the sample survey who used both fertilizer and improved seed did not seem to have heard about CADU's implements, and did not recognize them even when shown photographs of them.

CADU's ox-cart is a piece of equipment which has been very successful in the lowlands: more than half the farmers interviewed in Zone D had used ox-carts. In the highlands, where the terrain is much more rugged, wheeled transport is only possible where there are roads: one gorge, even a fairly shallow one, along a route will in most cases force the farmer to resort to pack-animal transport for the entire journey.

Again a fairly substantial number of users feel that there is no disadvantage in using ox-carts (Table 7.14), but most users, and more particularly owners, stress the problem of frequent breakages and the difficulty of having the cart repaired locally. The existing design certainly needs to be modified in order to make the cart sufficiently robust to withstand the normal wear and tear of farm use. As was suggested earlier, a simple repair kit should be supplied with each cart and farmers should be instructed in the use of such tools.

Finally, the stationary threshing service is one which is rather difficult to evaluate, since CADU has very recently changed the type of thresher it uses from a full-cleaning to a non-cleaning type. A preliminary evaluation of the changeover suggests however that it was basically a very wise move in that the new service is cheaper, the new machine is more robust, and the new approach attempts to widen only a genuine bottleneck leaving winnowing to be handled in the traditional fashion. Farmers using the new machine seem on the whole to be very satisfied with it, and indications are that the future for this machine could be very bright indeed.

9.2.3. The 'Missing Links':

This study has established that harvesting can be considered a major, if not the major, 'bottleneck' period (however defined) in traditional techniques of grain production in Chilalo. Yet none of the 'intermediate' implements which CADU has attempted to popularise is designed to help directly with this operation. Indeed it has been officially stated, on what basis it is not known, that:

> "harvesting methods seem not to be an urgent problem in the prevailing system of farming in the project area, as are seedbed preparation, weeding and threshing". (CADU, 1969, p.21).

Weeding has indeed been shown to be a 'bottleneck' period at least to the extent that it constitutes a period of arduous physical labour, and it has become more so with the introduction of fertilizer and improved varieties, yet again there has been little attempt to develop methods of mechanical control of weeds once they have become established.

The purpose of the present discourse is to describe briefly some mechanical devices for weed control and harvesting which could form a suitable basis for experimentation at CADU. In accordance with the criteria discussed earlier the main emphasis will be upon simple, robust, inexpensive animal-powered equipment which as far as possible is multi-purpose.

In the case of weed control it was pointed out earlier that there are three main sources of contamination: weeds and weed seeds which are in the soil when the crop is sown, those sown with the crop and those which become established after the crop has been seeded. Improved seedbed preparation, and the use of clean seed would do most to reduce contamination from the first two sources, but weeds which appear among the crop are the most difficult to eradicate without causing damage. Where herbicides are unsuitable, and many would argue that in view of their potentially adverse environmental impact they are virtually always unsuitable, animal-drawn hoes such as those illustrated in Figure 9.1 might be used, but only if the crop has been planted in rows. Row-planing by hand is a much more arduous procedure than broadcasting and CADU has been trying unsuccessfully for some years to persuade farmers to adopt this practice in order to facilitate hand-hoeing. Only one farmer in the course of the sample survey reported having row-planted a crop and he had subsequently abandoned this practice.

Designs are certainly available for animal-drawn seed drills which would speed up the process of row-planting, (see Figure 9.2.), but these would almost certainly prove far too expensive and, in relation to available repair and maintenance facilities, mechanically complex. One exception however is an implement which is commonly used in Eritrea. This is similar to the traditional plough, but has a vertical tube fitted behind the share. When the farmer is ready to sow his seed he drops it into the mouth of this tube, so that it falls into the furrow and is covered by the crumbling of the furrow sides. This technique not only rowplants the crop, it also covers the seed to a uniform depth, unlike the traditional method of seed-covering in Chilalo, which is simply to

FIGURE 9.1: Animal-Drawn Hoes
(Source: Partridge, 1969)

FIGURE 9.2: An Animal-Drawn Seed Drill

(Source: Partridge, 1969)

plough in the seed. Preliminary tests at CADU on this method of sowing showed that it requires a learning period before the farmer can judge accurately the amount of seed to pour into the sow tube, but the tests appear to have been abandoned at a very early stage for reasons that were probably connected with changes in personnel.[7/].

The animal-drawn hoes illustrated in Figure 9.1 are rather less complex and a good deal more robust than the seeding drill of Figure 9.2, but they will nonetheless seem expensive when compared with the few dollars the Ethiopian farmer is used to paying for his equipment. However time does not play such a crucial role in weed control as it does in sowing, so that this would be a suitable implement for joint ownership through a Peasants' Association or by CADU, which could rent the implement to farmers in rotation. It would also be worth investigating whether a dual purpose implement for harrowing and hoeing might be produced, since the upper drawing in Figure 9.1 has many of the features of a harrow.

In the case of harvesting, the need for suitable equipment is much more urgent in view of the economic loss as well as the drudgery which attends traditional methods. CADU has conducted experiments using the scythe in place of the

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7/. One of the unfortunate problems which accompany the employment of expatriate staff in experimental projects in developing countries arises from the normally short-term nature of their contracts of employment which means that continuity of work often suffers as personnel leave and are replaced by others who may have different views and different fields of interest.

sickle for harvesting grain, since the former implement is generally known to be capable of reaping grain crops two or three times as fast as the latter. However, as was noted earlier (Section 2.3), the scythe cuts the crop close to the ground and therefore produces a much larger volume of straw to be transported and threshed, so that a bottleneck in harvesing was being eased at the expense of further restricting an equally serious one in threshing.

In the case of animal-powered harvesting machinery, again many examples exist, such as the one shown in Figure 9.3. However, even more so than in the case of the seeding drill, this equipment is (again in relation to available repair and maintenance facilities) mechanically complex and not particularly robust. The same can be said of more recently developed simple engine-powered reaping equipment such as the pedestrian-operated cereal cutter shown in Figure 9.4. In addition, in the case of this latter machine, the experience of the National Institute of Agricultural Engineering based on "an independent assessment conducted in Malawai" shows that with this machine "losses due to shattering might be unacceptably high."[8/]

There did exist in the past, however, one very simple animal-powered harvesting machine of which unfortunately no surviving example or design exists today. This machine was known as the 'Gallic Stripping Header', and the available evidence has been summarized by White, who has also produced an analysis of the probable technical characteristics of such

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8/. D.C. Kemp: Personal communication.

FIGURE 9.3: An Animal-Drawn Reaping Machine
(Source: Partridge, 1969)

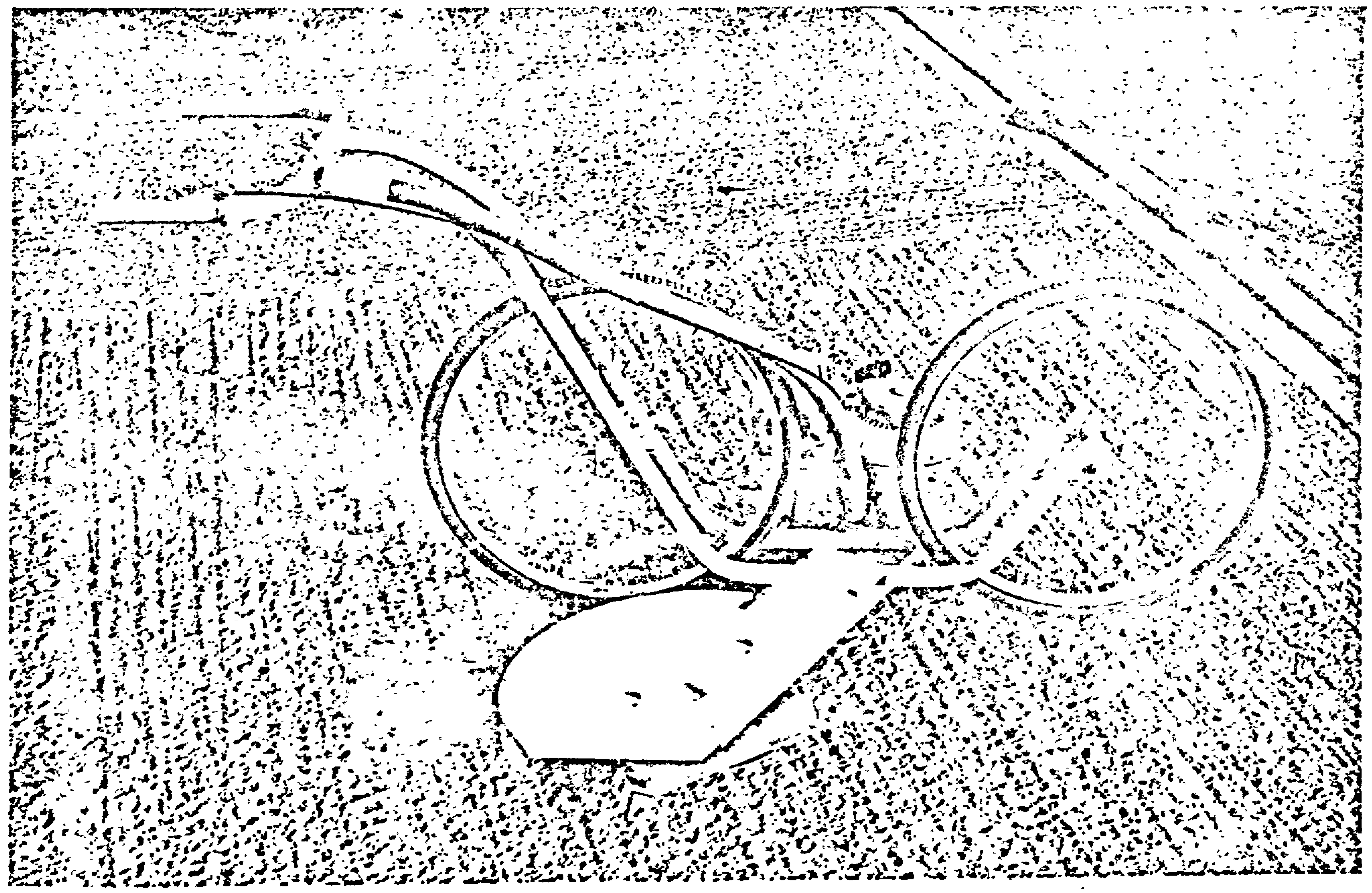

FIGURE 9.4: A Pedestrian-Operated Cereal Cutter
(Courtesy of the National Institute of Agricultural Engineering, Silsoe, Bedford)

machines, their advantages and disadvantages and the conditions under which they could profitably have been used (White, 1967, Ch. 10, and 1967 a).

Two versions of the machine are known to have existed and these are illustrated in Figure 9.5. These sketches show quite clearly the principles along which such 'heading' machines are designed to function: the operator adjusted the comb to the height of the crop by raising or lowering the shafts (and presumably also by adjusting the harness) and the machine was then driven through a field of standing grain so that the teeth of the comb engaged the heads, stripping them off and allowing them to fall back into the cart. The machine would have to be stopped periodically in order to permit the operator to clear the comb of any accumulated trash. Two or more 'passes' would probably be required, with different comb adjustments to allow for variations in the height of the crop. (Grazing cattle on the stubble would ensure that any grain which still remained unstripped would not quite be lost.)

White (1967, Ch.10) has noted a number of essential features of the above machine. It is particularly important first that teeth of the comb should curve upwards so as to induce a scooping action which would prevent their becoming clogged, and second that the outer edges of the comb frame be splayed in order to draw the stalks into the machine and prevent the wheels from becoming entangled in the crop. It

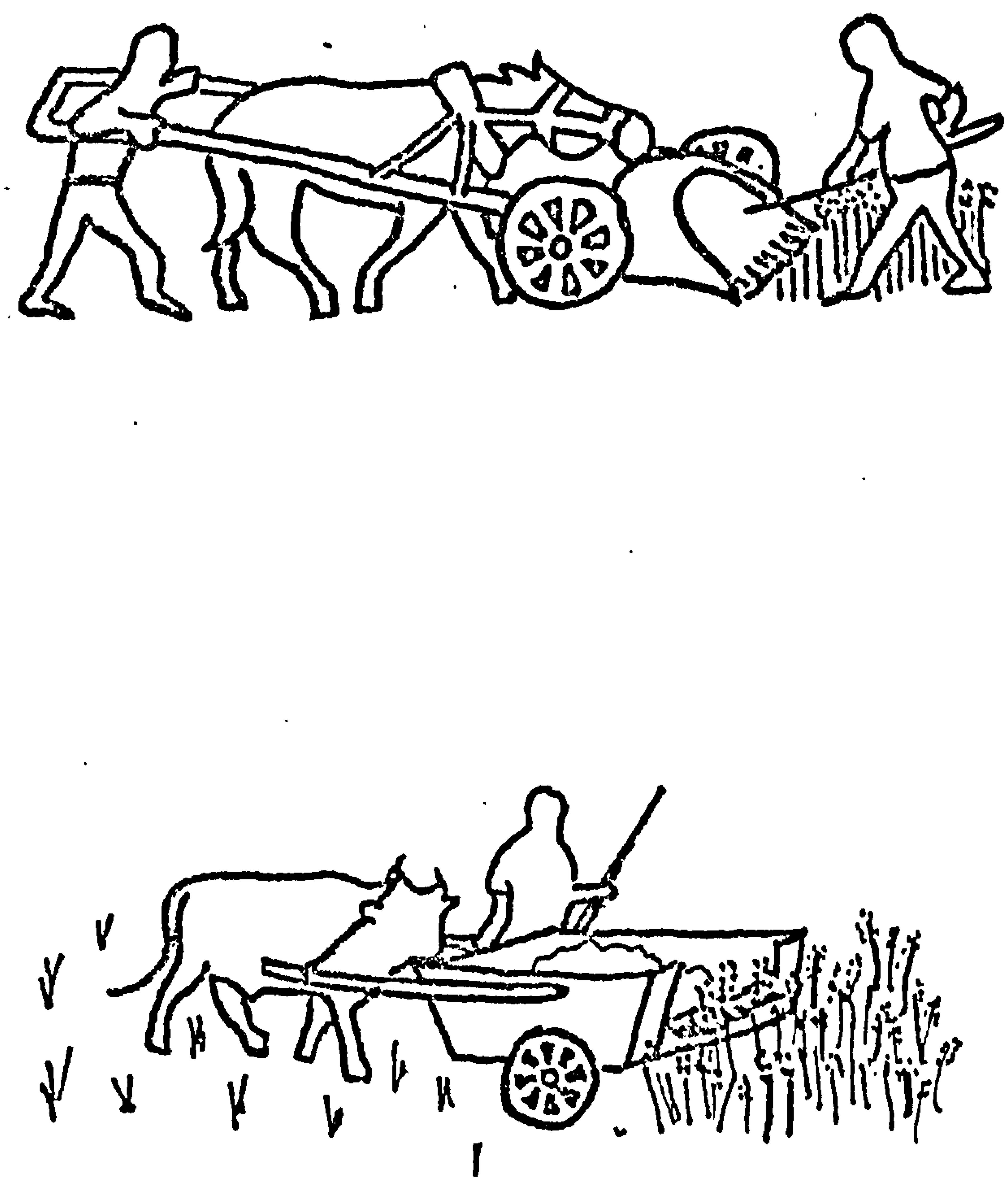

FIGURE 9.5: Two Versions of the Gallic Stripping Header (Based on White, 1967, p.157)

might also be added that the original method of adjusting for the height of the crop could usefully be improved upon by a system which permitted the comb to be raised or lowered within the rails at the front. A canvas, leather or rubber apron fitted beneath the comb would prevent the grain from falling out.

A machine of this type would not however be suitable under all conditions. Professor White notes that "this machine is useful on open plains or where the ground is level, and in areas where the straw has no economic value" (White, 1967, p.156). Mr. John L.E. Boyd of the National Institute of Agricultural Engineering has pointed dut the further important conditions that the crop would have to be grown in pure stand, that the soil would have to be heavy (or else the crop could bepulled up by the roots) and that crops with relatively thin, brittle stems would be most suitable for this type of treatment.[9/] In fact in most parts of Chilalo all of the above conditions would be met, with one exception, the last one in the case of laketch which, as noted earlier, has a thick, brittle stem and it remains to be seen how serious a limitation this might prove to be in practice. The condition that the straw should be of no economic value is effectively met in that farmers using the traditional Ethiopian reaping technique leave a very long stubble in any case. This is later cut close to the ground if it is required for building purposes, or else it has livestock grazed upon it or in some cases it is simply burnt before ploughing begins.[10/]

9/. Personal communcation

10/. A description of this machine, which was also known as the 'Gallo-Roman Reaper' was published recently in the hope of interesting suitable agricultural engineering research establishments in developing and testing prototypes (Gill,1977b).

One further advantage of the stripping header in Chilalo, or at least at the lower elevations, lies in the fact that the comb and its fittings might be designed as an attachment for the CADU ox-cart, so that a dual purpose implement could be produced.

A final note might usefully be added on the subject of primary ploughing, since CADU's efforts to introduce intermediate technology in this area have had such meagre success. The traditional technique of using the ard for primary cultivation may be adequate in most years, but occasionally other operations are required such as deep ploughing, subsoiling, turning in a green manure crop or breaking land which has become very overgrown and compacted. In these cases draught requirements will be much higher than the norm and it may be that only a tractor will suffice for this purpose. However, the alternative of employing very large teams of oxen should also be investigated, since in practice several farmers could lend their animals as they presently do for threshing. The equipment required for these purposes would be most suitable for renting rather than purchase, since they would tend to be expensive and would be required only occasionally.

9.3: COMPARATIVE COSTS OF PRODUCTION

In this section an analysis will be presented of the comparative costs of using alternative 'energy' (broadly defined) sources in agriculture in Chilalo. It will be assumed that other factors - type of seed and seeding rate, type of fertilizer and application rate, farm-gate product prices, etc - are determined independently of energy source, so that these factors can be excluded from the analysis for this purpose. In this particular case the analysis will be restricted to Chilalo's most important cash crop, wheat, since most data are available for this crop and since the restriction will help keep the analysis within reasonable bounds. There is in any case no reason to suppose that this crop is in any way atypical insofar as the prospects for using alternative technologies are concerned. The available options will first be considered from the standpoint of the individual smallholder and then the differences between this viewpoint and that of those responsible for formulating national agricultural policy will be considered. First, however, it is necessary to tackle the problem of placing a monetary value on traditional forms of energy. It will be understood, of course, that in the smallholder subsector no farm records are kept and many resources are both produced and consumed on the farm itself.

9.3.1. Costing Traditional Energy Resources:

The two traditional sources of energy in Chilalo agriculture, labour and ox-power, present very different costing problems. In the case of labour it has been shown that the hiring of casual workers was a fairly common practice in the

District before the 1975 land reform and that the modal wage rate for casual labourers was Eth $.150 per day.

In the case of oxen, however, the farmers who were questioned on the subject were unanimous in agreeing that oxen were never hired for cash, only loaned reciprocally for threshing. Costings of traditional farming in Ethiopia, nevertheless, frequently place cash values on ox-power, normally in the range Eth $ 0.25-1.00 per day,[11/] but without any explanation as to the methodology (if any) employed. This is clearly an unsatisfactory situation in view of the importance of the ox as a traditional source of energy and also in view of the cost of feeding him.[12/]

The cost of using ox-power should first be divided into capital and operating costs. The former will be computed from the sample farmers' estimates of (a) the cost of a young ox when he is trained and ready to begin work, (b) that of an old ox when he is sold for slaughter, and (c) the average working life of an ox. It will be recalled that where it has been possible to check such estimates they have been found to be reliable. The relevant figures were presented in Table 4.25 (page 86), and the mean values of Eth $ 90, Eth $ 72 and nine years respectively will be used in subsequent calculations.

11/. Sea, for example, CADU (1969) pp 21-41 for fairly detailed calculations based on such a 'guestimate'.

12/. It is estimated that Ethiopia's national herd of draught oxen comprises approximately five million beasts (Tucovic, 1974).

Acceptable estimates of the operating costs of draught oxen - costs of feeding, care and maintenance - are, however, a good deal more difficult to arrive at. CADU livestock management staff have calculated that 2 - 3 hectares of natural grassland in Chilalo would be required to support one ox, but that with fertilizer and proper range management this could become 1 hectare per ox. With improved grasses, fertilizer and proper range management, however, 1 hectare could support 2 or 3 oxen, while with fodder beet, 9 to 11 oxen per hectare is possible.[13/] However, in practice such figures cannot be used to calculate the cost of feeding oxen, since in Chilalo land is not normally devoted exclusively to their maintenance. The common practice is to allow all stock to forage under the care of small boys and use is made of such feed resources as roadside and waterside grass, the margins of cultivated plots, trees and bushes,

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13/. I am grateful to Ato Alemayehu Mangistu of the CADU Crop and Pasture Section for providing these estimates. Makhijani (1975, p 16) has reached the perhaps rather surprising conclusion that the total amount of energy (measured in British Thermal Units) used per cultivated hectare on farms in developing countries is often higher than that in industrialised countries. He goes on to remark of the "ill-fed, weak draft animals common in India and Africa" that compared with better-fed beasts "a greater share of the energy they consume goes toward the maintenance of their metabolism" (p 18). Thus the total energy output of one strong, well-fed draught animal could be more than double that of a pair which between them consume as much feed. CADU is therefore well-advised to continue with its campaign for better feeding of workstock at least as a long-term aim.

stubble and crop residues. It is nonetheless possible with the exercise of a little ingenuity to estimate the opportunity cost of maintaining workstock under these conditions.

Bull calves commonly reach 'slaughter age' in Ethiopia at around three years, at which point they can either be slaughtered for beef or trained for use as oxen after they have been gelded. The closest alternatives facing the farmer in these circumstances are (a) to use available feed, care and maintenance facilities to support working oxen for nine years after they have reached slaughter age, or (b) to use these same resources to raise beef calves to slaughter age, sell them and replace them.

Adjustments have to be made in the calculations to allow for the fact that bull calves are less expensive than young oxen (reflecting in part a higher rate of mortality) and for the fact that the calves initially require less feed. (There is also the question of the additional cost of grain eaten by oxen while they are threshing, but this is best treated as an additional cost of threshing by trampling.) Relative prices of bull calves and oxen are not presently available for Chilalo, but a detailed study of the neighbouring district of Ada (Getachew and Tilehun, 1974) shows the mean price of a bull calf to be 23 per cent of that of a young ox, and, based on this ratio, the price of a calf which will be assumed for Chilalo is Eth $ 21. It will also be assumed that the value of a bull calf increases in proportion with its age until it reaches three years, so that its value at the end of the first year is an estimated Eth $ 44 and at the end of the second year Eth $ 67.

On the question of differences in feed intake, the following estimates are avilable from CADU (1973, p 58): if a mature ox is taken to equal one livestock unit (lu), a calf can be considered to average 0.4 lu after weaning. Assuming proportionate increases in feed intake with increasing age, one calf wil equal approximately 0.6 lu in its second year and 0.8 lu in its third. Thus the grazing required by a pair of oxen is roughly equal to that required by three bull calves, one each in the first, second and third years of life,[14/] and the alternative investment 'portfolios' which will be considered here will be (a) three immature bulls, one each in the first, second and third years of life, the eldest being sold each year and replaced with a calf in its first year: (b) two mature oxen maintained for nine years from the age of maturity and then sold for slaughter. The opportunity cost of using oxen over the nine-year period is the net present value (NPV) of alternative (a) minus that of alternative (b). This figure can be converted to an annual basis by multiplying the NPV by the 'partial payment factor' to give the average annual net opportunity cost.[15/]

14/. These calves would in fact total 1.8 lu compared with 2 lu for the oxen, but the farmer who raised beefstock may decide to keep them slightly longer than three years in order to market at a favourable time, so that these two 'portfolios' are considered an approximately equal number of livestock units.

15/. The 'partial payment' or 'capital recovery' is given by:

$$\frac{i}{1 - \frac{1}{(1+i)^n}}$$

where n = the number of years, and i = the interest rate.

See Gittinger (1972) pp 64-65 and Gittinger (1973) Mathematical Appendix for a discussion of this approach. Gittinger does not, however, examine the use of this quantity in the estimation of opportunity costs.

The rate of interest currently charged by CADU for short- and medium-term loans for the purchase of fertilizer, seed, implements and improved livestock is twelve per cent per annum. This is also the rate which CADU pays for farm machinery credit, so that this is a very meaningful discount rate to use in calculations of for example NPV's. However, since the rate of discount used in this type of calculation should ideally equal the opportunity cost of capital, and since this last quantity is not known with any degree of certainty in a country such as Ethiopia, two other rates, ten and twenty per cent, will be used in alternative calculations, since these are reasonable estimates of the upper and lower limits of the opportunity cost of capital and their use will permit analysis of the sensitivity of the figures to changes in the discount rate.

Table 9.2 presents the relevant figures and the sensitivity analysis shows that doubling the rate of discount increases opportunity cost by just five per cent, a range which is obviously not very critical. The twelve per cent discount rate will therefore be used as the basis of subsequent calculations of the cost of using oxen. The opportunity costs are converted to an annual basis in the last row of Table 9.2, but their conversion to a daily basis in order to make them compatible with the figure for labour will depend on the assumed level of utilization. This question will be considered under subhead 9.2.3.

Finally, the evaluation of traditional implements does

TABLE 9.2: Net Present Values with Alternative Uses of Resources, and Opportunity Costs of One Pair of Draught Oxen at Three Discount Rates (Eth $)

	RATE OF DISCOUNT		
	10%	12%	20%
Beef Cattle (NPV)	321.35	283.25	171.72
Draught Oxen (NPV)	-118.93	-128.07	-152.09
Opportunity Cost of Oxen	440.28	411.32	323.81
Opportunity Cost per annum	76	77	80

TABLE 9.3: Choices of Technique for Crop Production in Chilalo

OPERATION	AVAILABLE TECHNIQUES
Primary Ploughing:....	Traditional Plough, CADU Plough, Tractor.
Secondary Cultivation:	Traditional Plough, CADU Harrow, Tractor.
Sowing:..............	Broadcasting, Manual Rowplanting, Tractor-drawn Seed Drill.
Seed Covering:........	Traditional Plough, CADU harrow, Tractor.
Weed Control:.........	Manual, Herbicides, Tractor.
Harvesting:...........	Sickle, Scythe, Combine Harvester.
Transportation:.......	Ox-sled, Pack-animal, Tractor-and-Trailer
Threshing:............	Oxen, CADU Thresher, Combine Harvester.
Separating:...........	Winnowing, CADU Thresher, Combine Harvester

not merit any very sophisticated costing since they, relatively speaking, are inexpensive and since, unlike oxen, the variable cost is negligible. The following annual cost estimates, based mainly on Table 4.25, will be used:

Local Plough: (including harness and wooden parts)..Eth $ 2.00

Sickle: (factory-produced)........................Eth $ 0.75

Other Implements: (wooden threshing and winnowing tools)......Eth $ 0.50

9.3.2: The Smallholder's Options:

The range of choice of technology in agriculture is often considerable, although not unlimited: there are certainly discontinuities in the production function. In the case of smallholder farming in Chilalo, the options for performing various crop production tasks are shown in Table 9.3. When all practicable combinations are considered, these options provide a total of 4,536 different technologies which, not all but a substantial number of, Chilalo smallholders can use.[16/]

In practice, however, each farm operation can be evaluated as a separate task, except for the various rigidities such as that noted in footnote 16. These with some techniques necessitate treating the harvesting-threshing-separating process as a

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16/. In theory, of course, if there are three possible ways of performing each of nine operations the number of possible combinations is $3^9 = 19,683$, but the rigidities noted earlier (eg a combine used for reaping will automatically thresh and separate also) reduces this theoretical total.

single operation which may be performed in any one of several ways. Two other operations, secondary cultivation and seed-covering, will also be considered in combination, since the same technique is normally used for both. Transportation by ox-sled from field to threshing floor will be included with threshing by oxen. In other cases in the subsequent analysis only those combinations of techniques which have been found to exist in practice will be considered, since this will help keep the ensuing calculations within manageable limits.

On the question of costs of non-traditional farming, a considerable volume of data are available from CADU[17]. These figures have been calculated with commendable skill and care, but in the case of modern engine powered techniques (as distinct from CADU's 'intermediate' technology) these data are based on out-of-date prices and therefore require modification in the light of recent price changes. The items in question are tractors and combine harvesters and both the original and the revised hourly costs of these machines are presented in Table 9.4. It should be pointed out, however, that even these revised estimates may be regarded as conservative, since largely local costs have not been subjected to revision. It should also be noted that the figures in Table 9.4.

17/. CADU's estimates of the times required per hectare are 2-2½ hours for primary tractor ploughing and 1-1¼ hours for combining. Using the hourly cost data of Table 9.4. this gives per hectare costs (exclusive of travel) of Eth \$ 22.00-27.50 for ploughing and Eth \$ 47.00-58.75 for combining. These figures compare very closely indeed with the mean rates of Eth \$ 24.50 and Eth \$ 51.00 per hectare calculated from smallholders' reports.

TABLE 9.4: Estimated Costs of Using Oxen at Various Levels of Utilization (Eth $ per Hectare)

Tasks for Which Oxen are Used[a/]	OVERHEAD COSTS			Extra Cost of Threshing[b/]	TOTAL
	PP	SC	Tr		
PP Only	26	-	-	-	26
SC Only	-	26	-	-	26
Tr Only	-	-	26	12	38
PP + SC	10	16	-	-	26
PP + Tr	9	-	17	12	38
SC + Tr	-	11	15	12	38
All Three	6	9	11	12	38

a/ The abbreviations are: PP=Primary Ploughing; SC=Secondary Cultivation; Tr=Threshing.

b/ This estimate is based on average yields adjusted for harvesting loss, post-harvest grain prices (at the farm gate) and CADU estimates of the proportion of grain eaten by oxen while threshing.

are based on the assumption that agricultural machinery will continue to be imported into Ethiopia free of customs duty..

An additional cost which arises in the case of large farm machinery is the cost of travel between the machinery depot and the farmer's fields. Figures on farm machinery costs reported in the present survey were provided by smallholders living very close to large-scale mechanised farms from whose owners they had hired the equipment. However for those living further afield the cost of travel could be very considerable: over good roads the charge would be approximately Eth $ 1.00 per kilometre for a tractor and Eth $ 7.00 for a combine.[18/] Where no roads exist or where they are very poor - and this is of course the norm in areas such as Chilalo - travelling speeds will be greatly reduced and total costs consequently increased, and in cases where communications are especially difficult it would not be possible to use farm machinery at all. This is especially true of the relatively cumbersome combine harvester. Problems would of course arise for the same reason if the new Peasant Associations attempted to introduce machinery hire services for their members. Obviously the cost of transportation will vary with the distance from a given smallholding to the tractor

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18/. These figures are based on CADU estimates of hourly operating costs and on manufacturer's specifications in the case of travelling speeds.

depot, but here a 'typical' smallholding two kilometres from the depot with two hectares under mechanised cultivation will be assumed. It should be obvious that these assumptions are more likely to understate than to overstate the cost of mechanised farming.

In the case of weed control, the question of physical accessibility obviously does not arise when herbicides are used, but it has been shown that this technology is technically inappropriate in many areas. An 'intermediate' alternative to traditional hand-weeding is therefore still desirable.

Returning to the evaluation of costs of traditional techniques, it should be noted that an important complication again arises in the case of oxen, since as was noted earlier in the present section, the cost of these animals for any given task will depend upon the number of different tasks for which they are employed. Reference back to Table 5.12 will show that if oxen are used for all three of the major tasks at which they are ever employed, namely primary ploughing, secondary cultivation/seed-covering and transportation/threshing, the ratio of tims spent on these tasks is 23:34:43 respectively. Table 9.5 shows the division of costs among these three operations, assuming the average of approximately three hectares of cultivated land per smallholding which was shown in Table 4.1 and using the twelve per cent discount rate (Table 9.2) to give a total

TABLE 9.5: Original and Revised Hourly Costs of Tractors and Combines (Eth$)[a]

ITEM	TRACTOR[b] ORIGINAL	TRACTOR[b] REVISED	COMBINE[b] ORIGINAL	COMBINE[b] REVISED
Depreciation[c]	1.20	2.25	20.73	29.54
Interest[d]	0.78	1.46	8.24	11.31
Fuel, Oil & Lubricants[e]	1.75	1.75	3.57	3.57
Repair & Maintenance	2.50	2.50	8.00	8.00
Spare Parts	2.35	4.40	2.92	4.16
Operator's Wages	2.20	2.20	2.20	2.20
Insurance[e]	0.20	0.41	1.14	1.62
Storage	0.03	0.03	0.20	0.20
TOTAL	11.01	15.00	47.00	60.60

NOTES

a/ Based on the Massey Fergusson MF 126 tractor and MF 520 combine, the two machines most commonly in use at CADU.

b/ 'Original' costs are those calculated by CADU; revised capital costs are based on data kindly provided by Massey Fergusson (Export) Ltd. and Massey Fergusson (Ethiopia) Ltd.

c/ Straight line method : Depreciation $= \dfrac{\text{New Cost} - \text{Salvage Value}}{\text{Service Life}}$

New cost is the delivered Asella *price; Salvage value (for canibalization) is estimated by CADU to be 10% of the new cost of the tractor and 6% of that of the combine. Service lives are 10,000 hours (tractor) and 3,000 hours (combine).*

d/ Interest $= \dfrac{50\% \text{ of new cost} \times 12\%}{\text{Service Life}}$

e/ Actual charges (Fuel charges have been kept up to date in CADU costings).

estimated annual cost of oxen of Eth $ 77 per pair.

An important question <u>still</u> remains, however, concerning the correct treatment of costs associated with the employment of oxen. Almost all of the farmers in the sample survey reported possessing oxen; those who did not tended to be those with the smallest size of holding. There is no indication that the hiring of engine-powered machinery is regarded as a substitute for the ownership of oxen[19/]. This is hardly surprising, since most smallholders would be running a very grave risk indeed if they were to rely entirely upon the prospect of being able to hire farm machinery for cultivation and threshing and not have any oxen as insurance against the prospect of being unable to do so. The question then arises; if a farmer habitually hires say a tractor for primary ploughing and a combine for harvest and post-harvest operations, and uses his oxen for secondary cultivation/seed covering only, is the entire cost of maintaining the ox-team to be debited to this last operation only, or is some part of it to be regarded as an insurance premium paid against the possibility of loss arising from the non-availability of machinery when it is required, and therefore to be debited to the account of the mechanised operations? Figures based on both assumptions

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19/. The mean number of oxen owned by those who had used tractors, combines and the CADU thresher is in fact in each case greater than those owned by farmers who had never used these services. In the case of combines, the difference in means was significant (ANOVA) at the ten per cent level.

are presented in Table 9.6, but since in view of the evidence the second of the two approaches is the more realistic, the figures shown in subsequent tables will be based on the second approach only. Thus the summary figures in Table 9.7, for example, are based on this second approach only. The actual opportunity cost of oxen is divided by the number of working days for all three tasks taken together and the cost of the appropriate number of days is then debited to each of these three operations whether or not machinery is actually used.

On the basis of all of the available data, Table 9.6 draws a comparison between the costs of wheat production in Chilalo with three different types of technology. These are: (i) purely traditional technology is used for all operations; (ii) CADU's 'intermediate' equipment is used for all appropriate operations and traditional technology is used otherwise; (iii) modern technology (tractors, herbicides and combines) is used for all operations. For the sake of convenience these figures are summarised in Table 9.7.

It is clear from this latter table that the smallholder who wished to minimise the unit costs of wheat production would, when faced with the above range of alternative techniques, use the traditional plough for primary ploughing and the CADU harrow for secondary cultivation and seed-covering. In the case of weed control the relative cost advantage of herbicide is clearly very great, although technical or ecological considerations may restrict its use.

TABLE 9.6: Smallholders' Production Costs for Wheat at Three Levels of Technology (Eth $ per Quintal at Market Prices)[a/]

OPERATION	TYPE OF TECHNOLOGY																
	TRADITIONAL							CADU							MODERN		
	(Potential Yield)	Labour	Equipment	OXEN				(Potential Yield)	Labour	Equipt.	OXEN				(Potential Yield)	E	F
				A	B	C	D				A	B	C	D			
Primary Ploughing	(24.0)	0.78	0.01	1.08	0.42	0.38	0.25	(24.0)	0.78	0.47	1.08	0.54	0.38	0.28	(24.0)	1.48	1.73
Secondary Cult./ Seed Covering	(19.2)	1.41	0.02	1.35	0.83	0.57	0.47	(24.0)	0.38	0.47	1.08	0.54	0.38	0.28	(24.0)	1.26	1.64
Weed Control	(19.2)	3.67	-	-	-	-	-	(24.0)	-	-	-	-	-	-	(24.0)	0.27	0.27
Harvesting	(14.4)	2.34	0.02	-	-	-	-	(18.0)	-	-	-	-	-	-	(24.0)	3.50	3.95
Threshing	(9.6)	2.81	0.01	2.71	1.77	1.56	1.15	(17.1)	0.45	0.30	1.52	0.99	0.99	0.73	(17.1 to 22.8)		
Separating	(9.6)	0.70	0.01	-	-	-	-	(17.1)	-	-	-	-	-	-	(17.1 to 22.8)		

a/ See following page for notes

Notes on Table 9.6

1. Based on the findings of Chapter 8, the following assumptions about yields have been made :
(a) the 'potential' yield if the most technically efficient of available methods are used throughout is 24 quintals per hectare;
(b) with traditional technology twenty per cent of the potential is lost in seed covering, a quarter of the remainder during harvesting and a third of the balance in threshing (including grain consumed by the oxen);
(c) with machanical threshing five per cent loss is assumed in threshing (manual methods are actually the most technically efficient means of threshing, but are very time-consuming);
(d) the two 'potential yield' figures for turnkey threshing/ separating depend upon the method of harvesting used)

2. Columns A, B, C and D are alternatives based on the number of tasks for which oxen are employed (see Table 9.4). Columns E and F are alternatives which depend upon whether or not the cost of oxen are included.

3. Labour and oxen costs are averages based on the times shown in Table 5.12 (page 109). A 'going' wage rate of Eth $ 1.50 is assumed.

4. 'Turnkey' technology here means tractors, combines and herbicides. 'Intermediate' technology refers to the CADU plough, harrow and non-cleaning thresher. It has not been possible to include other items of intermediate thechology such as those discussed in Section 9.2 in the calculations, since no data are available on such vital questions as construction costs, operating costs and technical efficiency. Where no intermediate technology is available for a given operation it is assumed that traditional technology is in use. but this assumption will later be relaxed and tentative cost estimates produced for the 'gallic stripping header' (9.3.5).

(continues overleaf)

Notes on Table 9.6 (contd)

5. The cost of the CADU plough and harrow have been calculated as : (NPV of costs x partial payment factor). The actual interest rate charged (twelve per cent per annum) has been used for discounting purposed and a (minimum) five year life is assumed in each case.

6. The cost of the thresher is based on CADU estimates of throughput and on the daily rental charged by CADU.

7. Costs of tractors and combines are based on the mean figures reported by farmers (Table 7.5, p 192).

8. The cost of herbicide is :(1 kg MCPA @ Eth $ 5.00 plus labour charges @ Eth $ 1.50) per hectare.

TABLE 9.7: Summary of Smallholders' Production Costs for Wheat at Three Levels of Technology (Eth $ per quintal at market prices)[a]

OPERATION	TYPE OF TECHNOLOGY		
	Traditional	CADU	Modern
Primary Ploughing	1.05	1.55	1.75
Secondary Cultivn/ Seed Covering	1.90	1.15	1.65
Weed Control	3.65	—	0.25
Harvesting	2.35	—	
Threshing	3.95	1.50	3.95 (Harvesting, Threshing and Separating combined)
Separating	0.70	—	

a/ All figures rounded to the nearest five cents.

In harvesting and post-harvest operations, however, the choice facing the smallholder is rather less straightforward than in the case for the above pre-harvest tasks. This is because of the technical rigidities noted earlier (footnote 16). In practice the smallholder can choose (subject to availability) from the following four techniques: I traditional harvesting, threshing and separating; II traditional harvesting and separating plus the CADU stationary thresher; III traditional harvesting and use of a combine to thresh and separate, and IV combine harvesting. The costs of wheat production using these four techniques are summarised in Table 9.8. These should be compared with an estimated cost of Eth $ 7.60 per quintal when the most modern techniques are used for all operations and Eth $ 13.65 per quintal when only traditional techniques are used (Table 9.7).

The figures in Tables 9.7 and 9.8 indicate that the least cost combination of techniques for the 'typical' Chilalo smallholder is traditional primary ploughing, secondary cultivation and seed-covering by CADU spike-toothed harrow, herbicides for weed control (where possible) and a combine harvester for harvesting and post harvest operations. Where fields are too small, too inaccessible or otherwise unsuitable for the use of a combine for reaping, CADU's stationary thresher plus traditional separating is considerably less costly than is the use of a combine for stationary threshing/separating.

TABLE 9.8: Smallholders' Production Costs for Wheat with Various Harvesting and Post-Harvest Techniques (Eth $ per Quintal at market prices).

	COST OF OPERATION				
Technique[a]	Pre-Harvest Operations[b]	Harvest	Threshing	Separating	TOTAL
I	2.45	2.35	3.95	0.70	9.45
II	2.45	2.35	1.50	0.70	7.00
III	2.45	2.35	————3.40————		8.20
IV	2.45	————3.95————			6.40

a/ These four techniques are as described earlier in the text.

b/ These are: traditional ploughing, CADU harrow for secondary cultivation/seed covering, and herbicide for weed control. If fields are hand-weeded, cost under this head should be increased by Eth $ 3.40 per quintal, as do the totals, but relative positions are unaffected.

The narrowness of the cost advantage of modern farm machinery over the 'intermediate-plus-traditional' alternative (Techniques IV and II respectively in Table 9.8) for harvesting and post-harvest operations draws immediate attention to the very high cost of the traditional method of harvesting grain in Chilalo, since this constitutes the largest single item of cost in Technique II. It will be noted that by introducing CADU's technology into secondary cultivation/ seed covering it is possible to reduce costs by 40 per cent compared with traditional techniques, while the substitution of CADU's stationary thresher for traditional threshing techniques reduces unit costs by over 60 per cent (Tables 9.7 and 9.8 respectively). In comparison with these savings, it is readily shown from Table 9.8 that an 'intermediate' technological innovation which saved just 26 per cent in harvesting costs would make the 'intermediate-plus-traditional' technology the least cost way of conducting the harvest and post-harvest operations.

In view of the very great importance of this question, an attempt will be made to arrive at tentative estimates of the cost of harvesting using an animal-powered machine of the type described earlier (9.2.3.). The assumptions on which this analysis will rest seem reasonable, but where doubt exists rather high costs will be assumed, so that any error in these assumptions will not tend to overstate the potential for such machines. The relevant assumptions are as follows. (a) Construction is based on the CADU ox-cart, but costs are greater by 50 per cent per annum. Annual cost is therefore Eth $ 64.50. (b) The average smallholding has two hectares of suitable small grains, but the machine is used by at least three farmers, so that minimum total coverage is six hectares per annum.

(c) Yield losses are assumed to be half those of manual methods (because of speedier operation) and therefore three qts/ha more than with the combine. Yields are therefore assumed to be 21 quintals per hectare.

(d) Oxen costs are Eth $ 0.55 per quintal: this is based on the same total cost as for traditional threshing.

(e) Time requirements are the most difficult to estimate, but assuming two men per machine, it is difficult to imagine that harvesting would require more than one day per hectare (implying an average forward speed less than quarter that of an ox-cart); however this estimate will be doubled, giving a total of four man-days per hectare, costing Eth $ 0.30 per quintal.

One very great saving which results from the use of a stripping header of this type is that it eliminates the threshing process and leaves a mixture of grain and chaff which requires only separating (winnowing). The total cost of harvesting and post-harvest operations with a machine of this type is therefore Eth $ 2.05 per quintal, which compares very favourably with the figure of $ 3.95/qtl for combine-harvesting shown in Table 9.8.

9.3.3: National Agricultural Priorities:

In the preceding section (with the sole exception of workstock) market prices were used in the evaluation of alternative technologies on the grounds that these prices constitute the basic data which the smallholder must use in deciding between alternative technologies. At the level of national agricultural policy formulation, however, various additional, or even alternative, criteria may be applicable in view of national policy aims. In particular, overall policy may aim at maximising returns to such scarce resources as capital, foreign exchange and perhaps agricultural land and not be quite so concerned as the smallholder himself with returns to the farm family's labour. Thus it is desirable to re-evaluate the above technological alternatives in order to determine the optimum strategy for the achievement of national goals in the agricultural sector. As was noted in Chapter 2, the moment for such an evaluation is now particularly opportune in Ethiopia in view of the complex institutional and economic changes consequent upon the recent land reform.

In the subsequent analysis it will be assumed that if the government feels that the current market prices of resources such as capital and foreign exchange do not adequately reflect their opportunity costs, then the readjustment of these prices is best achieved through alterations in for example interest rates, foreign exchange rates and the tariff. Market prices will therefore continue to be used in estimating the costs of mechanised operation.

In the cases of agricultural land and 'unskilled labour,[20/]

20/. Which in fact means labour with only traditional skills, however well developed these may be.

however, costing problems are less straightforward than they are for machinery, since the land reform proclamation's provisions detailed earlier have now made land a 'non-traded' good and labour a largely non-traded service. As in the case of workstock, however, it should be possible to calculate opportunity costs.

LABOUR: Three basic assumptions underlie the subsequent analysis. First it is assumed that 'unskilled' labour is a plentiful resource in that its continued employment in agriculture will not by itself affect costs of production in other sectors of the economy. The second assumption (which will be challenged later) is that the social marginal utility of leisure in the smallholder subsector is negligible. Finally it will be assumed that it is a fundamental aim of policy to ensure that every citizen should have as an irreducible minimum right, access to a basic minimum diet (however defined), even if there is no work available for him or her to do. Under these circumstances it can be argued that the opportunity cost of the smallholder's labour is from a national point of view equal only to the value of any increase in energy resources which he or she must consume when working rather than resting, ie it is equal to the value of the extra food intake required to generate the necessary additional energy.

In the absence of detailed nutritional/energy studies in Chilalo itself, standard FAO/WHO figures for energy consumption will be used. These figures indicate that a 'reference man' will consume approximately 1900 kcal of energy per day when leading a purely sedentary existence, but that if the same individual follows a 'very active' occupation during an eight-hour working day, his energy consumption will increase by an average 1200 kcal per day, which is the equivalent of 0.33 kg of wheat (FAO/WHO, 1973, Table 1 and Annex 2). At an average Eth $ 20 per quintal (ie the average price paid by CADU in recent years) the opportunity cost of labour from a national viewpoint becomes approximately Eth $ 0.07 per man-day. However, since the additional food in question will largely be consumed a considerable time after the harvest, and since wheat prices can be very much higher at their peak than at their lowest in Ethiopia (see Figure 6.2) a cost of Eth $ 0.10 per man-day will be assumed instead.

If this figure is used to place a value on smallholders' labour, and the figures in Tables 9.6 to 9.8 recalculated on this basis, the traditional technology emerges as 'least (opportunity) cost' technology for every operation, but it would be difficult for a number of reasons to defend the above method of calculating the opportunity cost of labour.

The first is the explicit assumption that smallholders' leisure has zero social value. This view is both inequitable, in that it descriminates unfairly against one group vis a vis others, and counter-productive in that policies based on such an assumption would tend further to encourage rural-urban migration for the reasons discussed at the beginning of the present chapter. It was partly for this reason that the cost of smallholders' labour was assumed to equal the (previously) 'going' wage rate for farm labour, but the calculations in the present section serve as a useful reminder that a case can be made for assuming that the opportunity cost of such labour is less than the market wage rate. If such assumptions are made, then the cost position of more 'labour intensive' technologies will tend to improve relative to technologies with higher capital-labour ratios.

The second reason for objecting to the above method of calculating the opportunity cost of labour relates to the question of land productivity and the implicit assumption that land as well as labour can be regarded as a plentiful resource.

LAND: It was shown earlier that the various alternative energy sources can be assumed to result in different levels of yield and therefore of land productivity. Although all three technologies of Table 9.6 have the same potential yield at the outset of the farming cycle, traditional techniques entail such heavy physical losses that final yields are very different. Taking yield when modern technology is used in all operations to be 100, intermediate-plus-traditional technology produces 75 and purely traditional technology only 42. (It will be noted however, that the losses in the second case derive only from the traditional part of the mixture.)

From the standpoint of total output, it might be argued that since modern technology maximises returns to land, a given level of output could be produced from a smaller area, or alternatively, the same land resources could produce a greater volume of output, if modern technology is adopted in preference to other alternatives. This is indeed one of the more familiar arguments advanced in favour of such technology, but it must be seriously qualified for at least two reasons. First, it must be remembered that not all (indeed only a small part) of the land resources of a country like Ethiopia are both physically suitable and sufficiently accessible for mechanised agriculture. Thus even if this type of farming is regarded as the most appropriate technology it would still be necessary to farm large areas using simpler methods.

The second qualification once again invokes the concept of opportunity cost. Even in those areas which are both physically suited and sufficiently accessible for mechanised farming, the foreign exchange costs of mechanisation _per se_ must be taken into account, since these resources oould equally well have been used to purchase foreign agricultural produce. Thus in the case of wheat production in Chilalo it is necessary to calculate the foreign exchange costs of machinery per hectare, translate these into terms of the volume of wheat imports foregone and deduct this last figure from yield under mechanised cultivation in order to arrive at a net figure for output per unit area.

Figures are available from CADU farm records for machinery costs per hectare (see Table 8.12) and these may be translated into estimates of foreign exchange costs, since a fiarly detailed cost breakdown for farm machinery is available, as was shown in Table 9.5. Machinery costs over the five years

1971 - 75 are available and these averaged US $ 80 per hectare in wheat production, of which (and the estimate is conservative) 66 per cent represents direct payments abroad, ie US $ 53 per hectare.[21/]

It will moreover be recalled that these figures apply to circumstances which are very favourable to mechanised farming - ie a large commercial farm (situated, it might be said, alongside a major all-weather road).

The foreign exchange costs of Chilalo's traditional farm technology can safely be assumed to be negligible, while that of the available intermediate technologies can be calculated in the same way as was used for 'modern' methods. Again using CADU data as the basis of the exercise, it is estimated that the foreign exchange cost of the harrow is approximately US $ 1.60 per hectare and that of the stationary thresher US $ 1.70.

The price of wheat is of course subject to a very marked degree of fluctuation from year to year. This feature has been especially pronounced in the present decade with a very steep price rise up to 1973/74 and an almost equally precipitous decline since then.[22/] Such fluctuations in f.o.b. prices are, moreover, aggravated by changes in the shipping,

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21/. At the official exchange rate of U$ S 1.00 = Eth $ 2.07.

22/. US mean fo.b. wheat prices more than trebled betwen 1970 and 1974, but at the time of writing (September 1977) the price of wheat in the USA stands at US $ 2.00/bushel (US $ 8.00/qtl) compared with US $ 3.00/bu a year ago and US $ 4.50/bu four years ago.

insurance and other charges which help determine the c. i.f. price. It would therefore be most inadvisable to use the price of wheat in a single year in an analysis such as this. Instead the mean c.i.f. price of wheat actually imported into Ethiopia over the five years 1971-75 (ie the same period for which costs of farm machinery are available) will be used, that is US $ 9.02 per quintal,[23/] so that against the estimated US $53 of foreign exchange expended on farm machinery for each hectare of wheat under mechanised cultivation must be set the 5.9 quintals of wheat which could otherwise have been imported. Similar calculations show the opportunity cost of intermediate technology to equal 0.4 quintals per hectare.

If the above opportunity costs are subtracted from the relevant final yield estimates of Table 9.6, the 'net' yields for the three alternative technologies, again in index form, become: Turnkey technology, 100; Intermediate-plus-traditional technology, 99; Traditional technology, 57. Thus with the introduction of intermediate technology in only two farm operations, it becomes possible to achieve virtually the same effective level of land productivity that can be accomplished with more modern methods operating in a favourable environment.

23/. This average wheat price is calculated from FAO (1976) Table 36.

Under such circumstances, only a relatively small improvement in technical efficiency in harvesting technique would render the intermediate-plus-traditional technology the more productive of the two as far as land resources are concerned. Traditional technology <u>in toto</u>, on the other hand, is clearly very wasteful of agricultural land.

<u>9.3.4. The Special Case of Transportation:</u>

Transportation off the farm will be discussed separately because it is not an integral part of the process of crop production as such. The following three techniques are available:

Traditional: Pack animal (almost always donkeys);

Intermediate: The CADU ox-cart;

Turnkey: Tractor and trailer.[24/]

The third of these options can be evaluated, but is in practice seldom if ever used by Chilalo smallholders.

The opportunity cost of using donkeys have been calculated in exactly the same way as those of oxen in Subhead 9.3.1. and averages Eth S 20 each per annum.[25/] The average pack-load

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24/. The traditional ox-sled of Chilalo is used only for on-farm transportation. Tractor-and-trailer comprise a less expensive means of transport than trucks, and this is at least in part because the latter attract import duty while the former do not.

25/. One donkey = 0.5 livestock unit; mean estimated working life = 11 years, mean initial cost = Eth $ 37; discount rate = 12 per cent. per annum. In this case there is of course no salvage value.

carried by donkeys was calculated by weighing grain brought to CADU marketing centres on donkeys and this was found to be 75 kg. (165 lbs.). The annual cost of the CADU ox-cart was calculated in the same way as that of the spike-tooth harrow and is Eth $. 43 per annum.[26/] A cart of this type should be capable of carrying at least 500 kg. but in view of the high rate of breakdowns, ten per cent less, the equivalent of six donkey-loads, will be assumed instead. If this implied that one ox-cart could replace six donkeys, then a net saving of Eth $ 77 (which is exactly equal to the calculated cost of one pair of oxen) per annum would result before the cost of the oxen were debited, and since the oxen would be used for other farm operations also, the cost of the oxen for transportation would be considerably less than Eth $ 77 per annum.[27/]

Again a number of qualifications must be placed on the estimates. The first concerns the relative levels of utilization of donkeys and ox-carts. Chilalo farmers are accustomed to the mutual exchange of donkeys, just as they are with oxen, so that a farmer who buys an ox-cart will seldom thereby displace six donkeys of his own. However,

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26/. Assumed five year life; rate of discount = 12 per cent per annum.

27/. It could well be argued that the opportunity cost of using oxen for transportation is virtually zero - only the cost of any supplementary feeding - since the annual cost of these animals has already been fully debited to crop production.

as was shown in Chaper 7 farmers who own ox-carts also generally permit other farmers to use them, usually of course for payment, so that capacity utilization can be quite high in this case as well as that of pack animals. It is interesting to note in this context that one of the farmers included in the sample survey was a member of a consortium of seven who had purchased a cart jointly. Another had purchased a cart in co-operation with a close relative who had a separate but nearby holding. Second, it is also worth observing that the time required to load even one donkey is very much greater than that required to load a cart. The final and most decisive factor in determining comparative advantage in these circumstances, however, is technical rather than economic: physical barriers such as gorges, steep slopes and mud will very often make wheeled transportation impossible, especially in the rainy seasons, so that the spread of this type of innovation in the broken, seasonally inundated terrain which characterises so much of Chilalo and indeed of Ethiopia, depends largely upon the spread of at least simple feeder roads.

Finally, examination of the costs of the modern alternative is of some interest. Since smallholders' estimates are not available in the case of tractor transport, CADU's internal costing will be used in their place.[28/] These charges are Eth $ 11.00 per hour for the tractor plus Eth $ 4.00 for a

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28/. The tractor hire rates reported by smallholders are very similar to those charged by CADU, so that the latter are acceptable figures to use for this purpose. (See footnote 17 above).

five ton trailer. Five tons is, however, very much more produce than the typical smallholder would wish to market and hence transport off the farm, so that co-operation between smallholders would be necessary in order to provide a full load. At the above rates a total of three hours tractor-and-trailer hire per annum would cost virtually the same as one ox-cart. Given a maximum road speed of 20 kilometres per hour, it is clear that the use of tractor and trailer for transportation would be uneconomic alternative for smallholders living more than a few kilometres from the market and/or tractor pool.[29/] Even for those living nearby it would have to be assumed that the ox-cart was used only for marketing produce before the modern alternative became a relatively attractive proposition. (Discussion of the question of transportation will be resumed in Section 9.4.).

9.4. POSSIBILITIES FOR SLACK-SEASON EMPLOYMENT

Ever since it was established in Chapters 5 and 6 that important seasonal energy imbalances not only exist, but have recently tended to intensify within Chilalo smallholdings,

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29/. Timeliness of operation is not so crucial in this task as it can be in crop production and handling, so that the tractor's higher road speed (20 kph compared with 5-6 kph for the ox-cart) would not be of any practical significance.

discussion has centred on the major problem of how to ease or eliminate what have been identified as energy bottlenecks. In this last section the focus of attention will be switched to the reverse side of the picture, namely the problem of providing smallholders with the opportunity to obtain (or provide themselves with) remunerative employment during the slack season(s) in agriculture. No very formal investigation can be undertaken here, since the necessary data are lacking, but an attempt will nevertheless be made to suggest a number of areas towards which future research efforts might fruitfully be directed.

One relevant point to note at the outset is that the introduction of improved equipment which reduces peak season bottlenecks might also require increased effort during the slack season in its routine care and maintenance. If equipment does break down it is obviously much more likely to do so during the busy season when it is being fully employed, but with proper care and maintenance, which can be carried out in the slack season, such a mishap will be less likely. This consideration, incidentally, provides a further argument in favour of trying to ensure that equipment is not too mechanically complex.

This observation apart, it must be acknowledged that the problem of finding productive, remunerative and recognised employment in rural areas on a season basis is a notoriously difficult one. A familiar suggestion is that crop processing industries, which are by their nature both seasonal and post-harvest operations, ought to be located close to the areas of production, both for the sake of transportation economies and in order to provide slack season employment. This is certainly a sound theoretical argument, but one suspects that where such processing facilities are not located in the crop-producing areas there are frequently sound economic explanations. It may, for example, be necessary to locate industry close to power supplies or to skilled labour which is reluctant to move to rural areas, or it may be that a centrally-located processing facility permits economies of scale in the case where the crop in question is grown in a number of different parts of the country. This last reason probably largely accounts for the location of most of Ethiopia's flour mills in and around Addis Ababa. The above argument should not of course deter further investigation of the topic in question.

In the case of non-processing industries, Sen (1975, p.77) has pointed out that the attempt to provide slack season work in the countryside would make capital intensity high because of low average capacity utilization across the year as a whole. Even operations which require little or no machinery - Sen gives the example of labour-intensive road construction - will, he notes, require relatively large quantities of working capital if wage employment is provided. It should be noted in this context that, certainly in sub-Saharan Agrica, the slack season can in many cases be equated with the latter half of the longer dry season when the energy of both human and draught animals tends to be at a low ebb and, making a bad situation worse, the ground is extremely hard so that operations like roadmaking which entail earthmoving would be extremely difficult and arduous. The problem of drudgery would therefore once more arise in these circumstances. Such roadmaking works would therefore probably require some earthmoving equipment in addition to the working capital noted by Sen.

Nevertheless, a mere cataloguing of difficulties is not sufficient, and most certainly must not terminate examination of the potential for slack season employment in road construction. In view of the immense importance of transportation to the development of an economy in general and of agriculture in particular, some further discussion of this topic is certainly merited. Although no studies are available of transportation problems which focus specifically upon Chilalo District, some such data are available for Ethiopia as a whole and these general findings may certainly be applied to the particular situation of Chilalo which, as far as transportation issues are concerned, presents many of the national problems in microcosm: great variations in altitude within a geographically limited area, broken terrain, mountains, gorges and swift-flowing seasonal torrents. Modern transportation facilities are therefore at once more necessary and more expensive than in most areas.

In Ethiopia as a whole, Mesfin estimates that there is only one kilometre of all-weather road to serve on average 140 square kilometres of territory (Mesfin, 1972). The equivalent ratio in the United States is 1 km: 1.5 km^2.

Mesfin also estimates that 80 to 85 per cent of Ethiopia's rural population lives more than ten kilometres from even a dry-weather trail - of which there are about 16,000 kilometres (ibid). These last, however, are often no more than tracks made through the bush by the passage of trucks. By definition such trails are closed to wheeled traffic during the rainy season(s). Chilalo District, with around 1 km of all-weather road to 60 km^2 of territory is rather better provided with road communications that the national average, but the ratio is still clearly a very long way from being satisfactory.

Comparison of costs between all-weather roads and dry-weather trails reveals some stark contrasts. On the latter costs are high because vehicles must be stronger, wear and tear is greater, breakdowns are more frequent, and most costly to repair, running speeds are lower, fuel consumption is higher, less intensive employment of crews and vehicles is possible, capital is tied up longer in goods in transit and produce is more liable to damage. On the former, on the other hand, at least in the past, competition was often fierce and charges relatively low.

A recent study of a dry-weather trail in Kaffa Province (Southwestern Ethiopia) showed that dry season motor freight charges on the trail averaged Eth $ 1.80 per tonne-kilometre compared with Eth $ 0.30 on an adjacent all-weather road. Pack animal transportation on connecting tracks was even more expensive, averaging Eth $ 3.75 per tonne-km. Vehicles on the all-weather road also travelled about twice as fast as those on the trail and fifty times as fast as pack animals on fairly long runs (because of overnight stops in the latter case); (Gill, 1973, pp.24-30). These results support the findings of an earlier study by a World Bank mission which reported that on the routes to Addis Ababa from Gore, Ghimbe and Jimma the charges per tonne-km on the initial dirt trail sections averaged ten times as high as those on the all-weather sections (King, 1967). Average time savings from road construction in three areas were as follows:

	AVERAGE TIME BY TRUCK (ONE WAY)	
ROUTE	Before road Construction	After Road Construction
Addis Ababa - Jimma (335 km)	2 - 3 weeks	8 - 10 hours
" " - Lekempte (331 km)	7 - 8 days	7 - 8 hours
" " - Assab (860 km)	2 weeks	2 - 3 days

In view of the importance of rural transportation in Ethiopia, illustrated by the above statistics, Sen's worries about the cost of working capital, even when bolstered by the thought that some machinery will also probably be required, should not be too discouraging, but interpreted rather as a reminder that every care must be taken to ensure that such scarce (but certainly not non-existent) resources are invested wisely.

Once again there are no data available to indicate what might be the comparative costs and benefits of road construction in Chilalo with various capital-labour ratios, but in view of the numerous theoretical advantages of methods with a high (seasonal) labour content, the various possibilities would repay careful investigation. Present methods of road construction in Ethiopia certainly tend to have relatively high capital-albour ratios[33/]. What is required ideally is that, wherever technical and economic factors permit, mechanised methods of road construction should be used to supplement rather than supplant labour. The seasonality of supply of labour need not necessarily imply seasonal use of machinery or skilled labour, since work such as levelling and grading of the roadbed and the construction of bridges and culverts could proceed throughout the year, with labour being recruited seasonally for later completion of tasks which do not require special equipment or skills. While it may be true that oranisational problems will be aggravated if such an approach is adopted, it would be extremely defeatist to regard any such problems as insuperable from the outset.

Turning now to the agricultural sector itself, and to the prospect of increasing slack season employment therein, it should be noted that the seasonality of rainfall which lies at the root of much of the energy imbalance problem might be circumvented by the provision of irrigation facilities which would permit year-round cultivation. While such investment would not eliminate the problem of seasonal

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33/. A very critical, but highly constructive, economic evaluation of highway construction and design policy in Ethiopia has been provided by Dodge (1972).

energy imbalances, it would, in addition to any other advantages it conferred, widen the scope for research into methods of eliminating such problems. However, the scope for the introduction of irrigation facilities themselves is greatly constrained by technical and economic considerations and it is certain that the vast majority of smallholdings in the developing countries will continue to be based on rainfed farming only.

Where irrigation is not feasible, increased slack season employment within agriculture is still possible, but a fundamental distinction must be drawn before proceeding further. What is frequently termed the 'slack season' in single-cropping rainfed agriculture is really two slack seasons. One occurs after the crops have been sown and before harvesting begins. The other comes after the harvest and crop handling are completed and before the start of ploughing for the new season. This pattern can be seen very clearly in Figure 5.3. The distinction is an important one, since some activites may be appropriate to one slack season but not to the other. Two examples will help illustrate this point and will also serve to indicate further opportunities for slack season employment in agriculture.

In Figure 5.3 it was shown how different crops within a given crop mix can impose energy requirements which, seasonally speaking, are either complementary or competitive, and how smallholders' crop mixes in Chilalo often exhibit the former characteristic. This type of complementarity of activity clearly can provide employment only during the cropping season itself, and hence only during slack periods of the first of the two types listed above. It would be very worthwhile if research at organisations such as CADU were to be devoted to designing crop mixes which exhibit this type of complementarity instead of relying purely on the present approach which often tends, perhaps understandably in view of limited resources at all levels, to view single crops in isolation and to promote new varieties without regard to their effect on the seasonal energy requirements of a whole cropping system.

The second example concerns land improvement. Farmers during the course of the sample survey frequently noted the ill-effects on production of problems caused by sloping fields, flooded fields and obstructions such as tree roots and stumps. It is probably true to say that 'improved' land is virtually non-existent in the smallholder subsector in Chilalo. Such measures as land levelling and terracing and the construction of field drains are clearly desirable in many areas, at least from a technical point of view and most probably from an economic viewpoint also. Equally clearly, such activities must be confined to that slack season during which there are no crops growing in the fields.

REFERENCES

ABERCROMBIE, K. C. (1972): 'Agricultural Mechanization and Employment in Latin America'; International labour Review, Vol. 106, No. 1.

AHMED, I. (1976): 'The Green Revolution and Tractorisation: Their Mutual Relations and Socio-Economic Effects'; International labour Review, Vol. 114, No. 1.

ARDREY, R. L. (1894): 'American Agricultural Implements'; Chicago (Reprinted by Arno Press, New York, 1972).

BARKER, MEYERS, CRISTOMO and DUFF (1972): 'Employment and Technological Change in Philippine Agriculture'; International labour Review, Vol. 106, Nos. 2-3.

BARNETT, V. M. (1974): 'Implementation of Policies for Fuller Employment in Less Developed Countries'; World Development, Vol. 2, No. 6.

BELL, C. (1972): 'The Acquisition of Agricultural Technology: its Determinants and Effects'; Journal of Development Studies, Vol. 9, No. 1.

BENGTSSON, B. (1968): 'Cultivation Practices and the Weed, Pest and Disease Situation in Some Parts of Chilalo Awraja', Chilalo Agricultural Development Unit, Asella, Ethiopia.

BLAUG, M. (1974): 'Employment and unemployment in Ethiopia'; International labour Review, Vol. 110, NO. 2.

BOEKE, J. H. (1953): 'Economics and Economic Policies of Dual Societies'; New York, 1953.

BROOKINS, O. T. (1975): 'Analysis of Variance Techniques - A Comment'; Journal of Development Studies, Vol. 11, No. 3.

BROWN, L. R. (1973): 'Conservation for Survival: Ethiopia's Choice'; Addis Ababa.

REFERENCES (Contd.)

BROWN, L.R.. (1970): 'Seeds of Change: The Green Revolution and Development of the 1970s; Praeger for Overseas Development Council, Washington.

BRUCE, J. W. (1975): 'Ethiopia: Nationalization of Rural Lands Proclamation'; University of Wisconsin, School of Law (mimeo).

BUNTING, A. H. (1976): 'Change in Agriculture, 1968-74', in Hunter, G., Bunting, A. H. and Bottral, A.: 'Policy and Practice in Rural Development: Proceedings of the Second International Seminar on Change in Agriculture, Reading, 9-19 September, 1974'; Croom Helm in Association with ODI, London.

CADU (1969) (Chilalo Agricultural Development Unit): 'Implement Research Section Progress Report No. 1'; Asella, Ethiopia.

- (1970): 'Implement Research Section Progress Report No. 2'; Asella, Ethiopia.

- (1971): 'Annual Report, 1970-71'; Asella Ethiopia.

- (1973): 'General Agricultural Survey, 1972'; Planning and Evaluation Section, Asella, Ethiopia.

- (1975): 'Report on Surveys and Experiments Carried out in 1974'; Crop and Pasture Section, Asella, Ethiopia.

- (1975a): 'Crop Sampling Survey, 1973-74'; Planning and Evaluation Section, Asella, Ethiopia.

- (1975b): 'Findings and Recommendations of the Committee for Agro-Implements Policy'; Asella, Ethiopia (mimeo).

CEPEDE, M. (1972): 'The Green Revolution and Employment'; <u>International labour Review</u>, Vol. 105, No. 1.

CLAYTON, E. S..(1972): 'Mechanization and Employment in East African Agriculture'; <u>International labour Review</u>, Vol. 105, No. 4.

- (1974): 'A Note on Farm Mechanization and Employment in Developing Countries'; <u>International labour Review</u>, Vol. 110, No. 1.

REFERENCES (Contd.)

CLEAVE, J. H. (1974): 'African Farmers: Labour Use in the Development of Smallholder Agriculture'; Praeger, New York.

CLEAVER, H..M. (1972): 'The Contradictions of the Green Revolution'; American Economic Review, Vol. 62, No. 2.

COBBALD, T. (1974): 'Agricultural Engineering Section: Reports, 1967-74'; Asella, Ethiopia (mimeo).

COHEN, J. (1974): 'Rural Change in Ethiopia: the Chilalo Agricultural Development Unit'; Economic Development and Cultural Change, Vol. 22, No. 4.

- (1975): 'Effects of Green Revolution Strategies on Tenants and Small-Scale Landowners in Chilalo, Ethiopia'; Journal of the Developing Areas, Vol. 9, No. 3.

COLLINSON, M. P. (1972): 'Farm Management in Peasant Agriculture: A Handbook for Rural Development Planning in Africa'; Praeger, New York.

- (1974): 'Transferring Technology in Developing Economies: The Example of Applying Farm Management Economics in Traditional African Agriculture'; World Development, Vol. 2, No. 2.

CROON, I. (1974): 'Effects of Labour Intensive Versus Capital Intensive Methods of Production at Different Sizes of Farms on the Economy of a Peasant Agriculture Society'; Asella Ethiopia (mimeo).

CSO (1975): (Ethiopian Government Central Statistical Office) 'Land Area and Utilization' (Statistical Bulletin No. 10, Vol. V), Addis Ababa.

DAVID, P. (1966): 'The Mechanization of Reaping in the Ante-Bellum Midwest' in Rosovsky, H. (ed): 'Industrialisation in Two Systems: Essays in Honour of Alexander Gerschenkron'; Wiley, New York.

DE WILDE, J. C..(1967): 'Experiences with Agricultural Development in Tropical Africa'; Johns Hopkins U.P./World Bank, Baltimore.

REFERENCES (Contd.)

- (1971): 'The Manpower and Employment Aspects of Selected Experiences of Agricultural Development in Tropical Africa'; International labour Review, Vol. 104, No. 5.

DILLON, J. L. (1968): 'The Analysis of Response in Crop and Livestock Production'; Pergamon Press, Oxford.

DODGE, W. H. (1972): 'The Economics of Road Design Standards for Feeder/Access Roads: The Agaro-Chira Feeder Road Case', Ministry of Communications, Telecommunications and Posts, Addis Ababa (mimeo),

DONALDSON, D. F. and McINERNEY, J. P. (1973): 'Changing Machinery Technology and Agricultural Adjustment'; American Journal of Agricultural Economics, Vol. 55, No. 5.

ELLIE, G. (1972): 'Man or Machine, Beast or Burden (sic): A Case Study of the Economics of Agricultural Mechanization in Ada District, Ethiopia'; Unpublished PhD dissertation, University of Tennessee, Knoxville.

ETHIOPIA (1968): (Ethiopian Government) 'Third Five Year Development Plan 1968 to 1973', Addis Ababa.

- (1975): 'Public Ownership of Rural Lands Proclamation No. 31 of 1975'; Negarit Gazeta (the official gazette), Addis Ababa.

EVANSON, R. (1974): 'The"Green Revolution" in Recent Development Experience'; American Journal of Agricultural Economics, Vol. 56, No. 2.

FALCON, W. P. (1970): 'The Green Revolution: Generations of Problems', Vol. 52, No. 5.

FAO (1976): 'Trade Yearbook', 1975'; Rome.

- (1976a): 'Production Yearbook, 1975'; Rome.

FAO-WHO (1973): 'Energy and Protein Requirements' (Report of a Joint FAO/WHO ad hoc Expert Committee); Geneva

FEI, J. C. H. and RANIS, G. (1964): 'Development of the Labor Surplus Economy: Theory and Policy'; Irwin, Holmwood, Ill.

REFERENCES (Contd.)

FRANK, C. R. Jnr. (1968): 'Urban Unemployment and Economic Growth in Africa'; Center Paper No. 120, Economic Growth Center, Yale University.

GETACHEW, T. M. and TILAHUN, M. (1974): 'Socio-Economic Characteristics of Peasant Families in the Central Highlands of Ethiopia (Ada Woreda)'; Addis Ababa University, College of Agriculture Branch Research Station, Debre Zeit, Ethiopia.

GILL, G. J. (1973): 'Agro-Chira Feeder Road Survey, Part I: Transportation and Trading Patterns'; A Report to the IBRD from Addis Ababa University, Institute of Development Research, Addis Ababa.

\- (1974): 'Readings on the Ethiopian Economy' (ed); Addis Ababa University, Institute of Development Research/Faculty of Arts, Addis Ababa.

\- (1975): 'Ethiopia's Agricultural Sector'; Addis Ababa University, Institute of Development Research.

\- (1976): 'Improving Traditional Ethiopian Farming Methods: Misconceptions, Bottlenecks and Blind Alleys'; Rural Africana (Spring).

\- (1977): 'The Green Revolution and Tractorisation: A Comment'; International Labour Review, Vol. 115, No. 3.

\- (1977a): 'How Reliable is Ethiopia's National Sample Survey?'; Ethiopian Journal of Development Research, (forthcoming).

\- (1977b): 'A Simple Reaping Machine'; Appropriate Technology, Vol. 4, No. 2.

GITTINGER, J..P. (1972): 'Economic Analysis of Agricultural Projects'; Johns Hopkins U.P. for Economic Development Institute, IBRD, Baltimore and London.

\- (1973): 'Compounding and Discounting Tables for Project Evaluation' (ed); Economic Development Institute, Washington.

REFERENCES (Contd.)

GOERING, T. J. (1971): 'Some Thoughts on Future Strategies for Agricultural Development in Ethiopia'; (mimeo , reprinted in Gill, 1974).

GOLDBERGER, A. S. (1964): 'Econometric Theory'; Wiley, New York.

GOTSCH, C. (1974): 'Economics, Institutions and Employment Generation in Rural Areas' in Edwards, E.O.: 'Employment in Developing Nations'; Colombia U.P., New York and London.

GREEN, D. A. G. (1974): 'Ethiopia: An Economic Analysis of Technological Change in Four Agricultural Production Systems'; African Studies Center/Institute of International Agriculture, Michigan State University, East Lansing.

GRIFFIN, K. (1974): 'The Political Economy of Agrarian Change: An Essay on the Green Revolution'; MacMillan, London.

HAMMAR, O. (1974): 'Fertilization with Phosphorous on Different Soils'; Crop and Pasture Section, CADU, Asella, Ethiopia.

HEADY, E. O. and DILLON, J. L. (1961): 'Agricultural Production Functions'; Iowa State U.P., Ames, Iowa.

HENOCK, K. (1972): 'Investigation of Mechanized Farming and its Effects on Peasant Agriculture'; CADU, Asella, Ethiopia.

HIGGINS, B. (1959): 'Economic Development: Principles, Problems and Policies' (2nd Ed); Constable, London.

HUFFNAGEL, H. P. (1961): 'Agriculture in Ethiopia'; FAO, Rome.

HUMPHREY, D. H. (1974): 'Innovation Theory and Patterns of Rural Development'; <u>Oxford Bulletin of Economics and Statistics</u>, Vol. 36, No. 3.

HUNTER, G. et al (1974): 'Final Report on the Appraisal of CADU and EPID'; Ethiopian Government Ministry of Agriculture and Swedish International Development Agency, Addis Ababa, Stockholm and London.

REFERENCES (Contd.)

ILO (1972): 'Employment, Incomes and Equality: A Strategy for Increasing Productive Employment in Kenya'; International Labour Office, Geneva.

- (1973): 'Mechanization and Employment in Agriculture (Case Studies from Four Continents)'; International Labour Office, Geneva.

INUKAI, I. (1970): 'Farm Mechanization, Output and Labour Input: A Case Study in Thailand'; International Labour Review, Vol. 101, No. 5.

JOHNSTON, J. (1972): 'Econometric Methods' (2nd Ed); McGraw Hill, Tokyo.

JONES, W. O. (1960): 'Economic Man in Africa'; Food Research Institute Studies, Stanford Calif.

JONSSON, I. (1975): 'Diffusion of Agricultural Innovations in Chilalo Awraja, Ethiopia'; Addis Ababa University, Institute of Development Research, Addis Ababa.

KHAN, A. U. (1976): 'Mechanization Technology for Tropical Agriculture' in Janquier, M. (ed): 'Appropriate Technology: Problems and Policies'; OECD, Paris.

KING, J.A. (1967): 'Ethiopia, Third Highway Program'; in IBRD: 'Economic Development Projects and their Appraisal'; Johns Hopkins U.P., Baltimore.

KINSEY, B. H. (1976): 'Economic Research and Farm Machinery Design in East Africa'; Development Studies Centre Discussion Paper No. 10, University of East Anglia, Norwich.

KLINE, GREEN, DONAHUE and STOUT (1969): 'Agricultural Mechanization in Equatorial Africa'; Research Report No. 6, Institute of International Agriculture, Michigan State University, East Lansing.

KUO, L. T. (1972): 'The Technical Transformation of Agriculture in Communist China'; Praeger, New York and London.

REFERENCES (Contd.)

LEANDER, L. (1967): 'Grain Marketing Experiment in Arussi'; Swedish Regional Development Project (later CADU), Addis Ababa.

LEWIS, W. A. (1954): 'Economic Development with Unlimited Supplies of Labour'; The Manchester School, Vol. 22.

LITTLE, SCITOVSKY and SCOTT (1970:- 'Industry and Trade in Some Developing Countries'; Oxford U.P. for OECD Development Centre, Paris.

LMB (1974): (Ethiopian Government Livestock and Meat Board): 'Still Sleep the Highlands: A Study of Farm and Livestock Systems in the Central Highlands of Ethiopia'; Addis Ababa.

MACDONALD, S..(1975): 'The Progress of the Early Threshing Machine'; Agricultural History Review, Vol. 23, No. 1.

MACPHERSON, G. and JACKSON, S. (1975): 'Village Technology for Rural Development: Agricultural Innovation in Tanzania'; International Labour Review, Vol. 111, No. 2.

MAKHIJANI, A. with POOLE, A. (1975): 'Energy and Agriculture in the Third World'; Ballinger, Cambridge, Mass.

MARSDEN, K. (1973): 'Technological Change in Agriculture, Employment and Overall Development Strategy'; in ILO (1973).

MATTHEWS, M. D. P. (1975): 'A Pedestrian-Operated Cereal Cutter'; National Institute of Agricultural Engineering, Silsoe, Beds. (mimeo).

MELLOR, J. W. (1969): 'Production Economics and the Modernisation of Traditional Agricultures'; Australian Journal of Agricultural Economics, Vol. 13, No. 1.

MESFIN, W. M. (1970): 'An Atlas of Ethiopia'; Addis Ababa.

\- (1972): 'An Introductory Geography of Ethiopia'; Addis Ababa.

MINISTRY OF AGRICULTURE (Ethiopia) (1975): 'Agricultural Sample Survey: 1974-75'; Addis Ababa (2 vols.)

REFERENCES (Contd.)

MIRACLE, M. P. (1976): 'Interpretation of Backward-Sloping Labour Supply Curves in Africa'; Economic Development and Cultural Change, Vol. 24, No. 2.

- and FETTER, B. (1970): 'Backward-Sloping Labour Supply Functions and African Economic Behaviour'; Economic Development and Cultural Change, Vol. 18, No. 2.

NATH, S. K. (1974):' Estimating the Seasonal Marginal Products of Labour in Agriculture'; Oxford Economic Papers, Vol. 26, No. 3.

NULTY, L.. (1972): 'The Green Revolution in West Pakistan: Implications of Technological Change'; Praeger, New York.

ORCUTT, GREENBERGER, KORBEL and RIVLIN (1961): 'Microanalysis of Socio-economic Systems: A Simulation Study'; Harper and Row, New York.

OWEN, W. F.. (1970): Discussion on Falcon (1970); American Journal of Agricultural Economics, Vol. 52, No. 5.

PANKHURST, R. K. P. (1961): 'An Introduction to the Economic History of Ethiopia'; Lalibela House, London.

PARTRIDGE, M. (1969): 'Early Agricultural Machinery'; Hugh Evelyn, London.

PERRIN, R. and WINKELMAN, D. (1976): 'Impediments to Technical Progress on Small Versus Large Farms'; American Journal of Agricultural Economics, Vol. 58, No. 5.

RAJ, K. N. (1972): 'Mechanization of Agriculture in India and Sri Lanka'; International Labour Review, Vol. 106, No. 4.

RAJU, V. T. (1976): 'Impact of New Agricultural Technology on Farm Income Distribution in West Godavari District, India'; American Journal of Agricultural Economics, Vol. 58, No. 2.

RATTAN, V. W. and HAYAMI, Y. (1971): 'Agricultural Development: An International Perspective'; Johns Hopkins U..P., Baltimore.

RICHARDS, P.W. (1952): 'The Tropical Rain Forest'; Cambridge University Press, London.

REFERENCES (Contd.)

ROBINSON, J. (1937): 'Essays in the Theory of Employment'; MacMillan, London.

ROSENSTEIN-RODAN, P.. N. (1957): 'Disguised Unemployment and Underemployment in Agriculture'; Monthly Bulletin of Agricultural Economics and Statistics, Vol. 6, No. 7.

RUTHENBERG, H. (1964): 'Agricultural Development in Tanganyika'; IFO, Munich.

- (1968): 'Smallholder Farming and Smallholder Development in Tanzania' (ed); IFO-Weltforum Verlag, Munich.

SCHULTZ, T. W. (1964): 'Transforming Traditional Agriculture'; Yale U.P., New Haven.

SEN, A. K. (1962): 'Choice of Techniques'; Basil Blackwell, Oxford.

- (1966): 'Peasants and Dualism with or Without Surplus Labour'; Journal of Political Economy, Vol. 74, pp 425-50.

- (1975): 'Employment, Technology and Development'; Oxford U.P., Oxford.

SIDA (1966): (Swedish International Development Authority) 'Project Preparation Team, Report No. 1 on the Establishment of a Regional Development Project in Ethiopia'; Addis Ababa.

SIMPSON, I.G. (1974): 'Appropriate Technology for Agriculture Under Conditions of Rapid Population Growth'; Journal of Agricultural Economics, Vol. 25, No. 3.

SINGH, R. and DAY, R. H. (1975): 'A Microeconometric Chronicle of the Green Revolution'; Economic Development and Cultural Change, Vol. 23, No. 4.

SMITH, L. D. (1975): 'The Political Economy of Employment Creation in Agriculture'; Journal of Agricultural Economics, Vol. XXVII, No. 3.

SPENCER, D. S. C. and BYERLEE, D. (1976): 'Technical Change, Labor Use and Small Farmer Development: Evidence from Sierra Leone'; American Journal of Agricultural Economics, Vol. 58, No. 5.

REFERENCES (Contd.)

SRI (1969): 'production of Grains and Pulses in Ethiopia'; Stanford Research Institute, Menlo Park Calif.

SRIVASTAVA, U. and HEADY E. O. (1973): 'Technological Change and Relative Factor Shares in Indian Agriculture: An Empirical Analysis'; American Journal of Agricultural Economics, Vol. 55, No. 3.

STEVENS, S. S. (1946): 'On the Theory of Scales of Measurement'; Science, Vol. 103, No. 2684.

STIGLITZ, J. E. (1969): 'Rural Urban Migration, Surplus Labour and the Relationship Between Urban and Rural Wages'; Eastern Africa Economic Review, Vol. 1.

STOUT, B. A. and DOWNING, C. M. (1976): 'Agricultural Mechanization Policy'; International Labour Review, Vol. 113, No. 2.

TIMES (1975): 'The Times Atlas of the World' (Comprehensive Edition) London.

TUCOVIC, M. (1974): 'Estimated Production of Meat, Hides and Skins During the Third and Fourth FYP'S in Ethiopia'; Ethiopian Government Livestock and Meat Board, Addis Ababa (mimeo).

UNITED NATIONS (1971): U.N. ECA/FAO Joint Agricultural Division: 'A Comparative Analysis of Agricultural Extension Systems'; Addis Ababa.

UPTON, M. and DALTON, G. (1976): 'Linear Production Response'; Journal of Agricultural Economics, Vol. XXVII, No. 2.

VINER, J. (1957): 'Some Reflections on the Concept of "Disguised Unemployment"'; Contribucoes a Analise do Desenvolvimento Economico.

WATSON, R. M. et all (1973): 'Aerial Livestock, Land Use and Land Potential Surveys for the Central Highlands of Ethiopia'; (Report to the Ethiopian Government Livestock and Meat Board), Nairobi.

WEIL, P. M. (1970): 'The Introduction of the Ox-Plough in Central Gambia' in McLoughlin P. F. M.: 'African Food Production Systems: Cases and Theory'; Johns Hopkins U.P., Baltimore.

REFERENCES (Contd.)

WESTPHAL, E. (1975): 'Agricultural Systems in Ethiopia'; Centre for Agricultural Publishing and Documentation, Wageningen.

WHITE, K. D. (1967): 'Agricultural Implements of the Roman World'; Cambridge U.P., Cambridge.

- (1967a): 'Gallo-Roman Harvesting Machines'; Latomus Vol. XXVI, pp 634-47.

WHITE, L. (1974): 'Technology Assessment from the Standpoint of a Medieval Historian'; American Historical Review, Vol, 79, No. 1.

WINKELMAN, D. (1972): 'The Traditional Farmer: Maximization and Mechanization'; OECD Development Centre, Paris.

WONNACOTT, R. J. and WONNACOTT, T. H. (1970): 'Econometrics'; Wiley, New York.

YUDELMAN, BUTLER and BANERJI (1971): 'Techological Change in Agriculture and Employment in Developing Countries'; OECD Development Centre, Paris.

A P P E N D I X   A

THE SURVEY QUESTIONNAIRE

I D R - C A D U

F A R M T E C H N O L O G Y P I L O T S U R V E Y

CADU Extension Area.............................. Zone: A B C D

Altitude...............metres; Place of Reading.............

Name of Farmer..........................Peasant Association Member? ..

1 YES 2 NO 3 OTHER...........

SECTION A: INPUTS

A1 A1.1 Which of the following do you use on your farm? (circle as many as necessary):

1 FERTILIZER (If YES please state date first used)...........E.C.

2 IMPROVED SEED " " " " " " ...........E.C.

3 HERBICIDES (weedkiller) " " " " ...........E.C.

A1.2 When fertilizer is used, please state:

CROP (State Variety, EG: 'Supremo'	RATE APPLIED (quintals/ hectare)	"AVERAGE" YIELD	
		WITH FERTILIZER	WITHOUT FERTILIZER
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

n.b. 1 hectare = 4 kert

A2 PLOUGHING: Since you started using fertilizer and/or improved seed,

A2.1 Do you now plough:

1 EARLIER If so, why?..

2 LATER If so, why?..

3 AT THE SAME TIME

4 OTHER ....

PLOUGHING = ዩና SEED = ሰጌ CROP = ምኝን YIELD = ጠሰ፡ገለቻ

A2.2 Before planting or sowing your crop, do you now plough:

1 MORE OFTEN If so, why?...

2 LESS OFTEN If so, why?...

3 SAME AS BEFORE

4 OTHER ....

A3 SOWING: Since you started using improved seed:

A3.1 Are there some varieties which are sown earlier than the traditional varieties of the same crop?

1 YES 2 NO 3 OTHER......................................

→ If Yes, Which varieties?......................................

WHY?...

A3.2 Are there some varieties which are sown later than the traditional varieties of the same crop?

1 YES 2 NO 3 OTHER......................................

→ If Yes, which varieties?......................................

WHY?...

A4 WEEDING: Since you started using fertilizer and/or improved seed

A4.1 Are there now:

1 MORE WEEDS If so, why?...

2 FEWER WEEDS If so, why?..

3 SAME AS BEFORE

4 OTHER ....

A4.2 Do you now weed your fields,

1 MORE OFTEN If so, why?...

2 LESS OFTEN If so, why?...

3 SAME AS BEFORE

4 OTHER ....

A5 HARVESTING: Since you started using fertilizer and/or improved seed

A5.1 Do you now find that harvesting certain varieties takes more time than with traditional varieties of the same crop?

1 YES 2 NO 3 OTHER......................................

→ If YES, which varieties?......................................

WHY?...

PLOUGHING = ቆና SOWING = ፈጂሱ WEEDING = ኣረሙ

WEEDS = ኣረሟ HARVESTING = ሃሙ

A5.2 Do you find that harvesting certain varieties takes less time than with traditional varieties of the same crop?

1 YES 2 NO 3 OTHER...

→ If YES, which varieties?...

WHY?...

A5.3 Do you now harvest certain varieties earlier than with traditional varieties of the same crop?

1 YES 2 NO 3 OTHER ....

→ If YES, which varieties?...

Why?...

A5.4 Do you now harvest certain varieties later than with traditional varieties of the same crop?

1 YES 2 NO 3 OTHER...

→ If YES, which varieties?...

WHY?...

A6 THRESHING: Since you started using fertilizer and/or improved seed

A6.1 Are there any varieties for which it takes more time to thresh one quintal than with traditional varieties of the same crop?

1 YES 2 NO 3 OTHER ....

→ If YES, which varieties?...

WHY?...

A6.2 Are there any varieties for which it takes less time to thresh one quintal than with traditional varieties of the same crop?

1 YES 2 NO 3 OTHER...

→ If YES, which varieties?...

WHY?...

A7 WINNOWING: Since you started to use fertilizer and/or improved seed

A7.1 Are there any varieties for which it takes more time to winnow one quintal than with traditional varieties of the same crop?

1 YES 2 NO 3 OTHER...

→ If YES, which varieties?...

WHY?...

A7.2 Are there any varieties for which it takes less time to winnow one quintal than with traditional varieties of the same crop?

1 YES 2 NO 3 OTHER...

→ If YES, which varieties?...

WHY?...

THRESHING = ጓዉ WINNOWING = ዶቢሱ፡ ጤላሱ

A8 MARKETING: Since you started using fertilizer and/or improved seed

A8.1 Do you now market more or less of your crop?

1 MORE If so, why?.......................................

2 LESS If so, why?.......................................

3 SAME AS BEFORE

4 OTHER ....

A8.2 Do you now market your crop earlier or later in the year?

1 EARLIER If so, why? ....

2 LATER If so, why? ....

3 SAME AS BEFORE

4 OTHER ....

A9 LABOUR: Since you started using fertilizer and/or improved seed

A9.1 Do you find that your work is harder, easier or the same?

1 HARDER If so, why?.......................................

2 EASIER If so, why?.......................................

3 SAME AS BEFORE

4 OTHER ....

A9.2 At what time(s) of the year do you have to work hardest?

(Read out list; circle as many as are mentioned.)

1 PLOUGHING	3 WEEDING	5 THRESHING	7 TRANSPORTING CROPS
2 SOWING	4 HARVESTING	6 WINNOWING	

8 OTHERS ....

A10 OXEN: Since you started to use fertilizer and/or improved seed do you need:

1 MORE OXEN If so, why?.......................................

2 FEWER OXEN If so, why?.......................................

3 SAME AS BEFORE

4 OTHER ....

A11 STORAGE: Since you started using fertilizer and/or improved seed do you find that you need

1 MORE STORAGE SPACE If so, why? ....

2 LESS STORAGE SPACE If so, why? ....

3 SAME AS BEFORE

4 OTHER ....

MARKETING = ሰታ፡ ዝር ዝሩ
PLOUGHING = ቆፃ
WEEDING = ኣረመ
THRESHING = ንጉ
WINNOWING = ምዝሪት፡ ጨለሉ
SOWING = ሬቢዉ
OXEN = ቆት ዩታ
STORAGE = ኅምበ
HARVESTING = ሃው
TRANSPORTING = ሬኮ
CROP = ምንን

[A12] AREAS: Since you started using fertilizer and/or improved seed have you changed the areas under the following crops:

WHEAT	1 MORE	2 LESS	3 SAME	4 OTHER................
BARLEY	1 MORE	2 LESS	3 SAME	4 OTHER................
MAIZE	1 MORE	2 LESS	3 SAME	4 OTHER................
PEAS	1 MORE	2 LESS	3 SAME	4 OTHER................
BEANS	1 MORE	2 LESS	3 SAME	4 OTHER................

[A13] What, in your opinion, are the main advantages of using fertilizer?

1 ....

2 ....

3 ....

[A14] What, in your opinion, are the main disadvantages of using fertilizer?

1 ....

2 ....

3 ....

[A15] What, in your opinion, are the main advantages of using improved seed?

1 ....

2 ....

3 ....

[A16] What, in your opinion, are the main disadvantages of using improved seed?

1 ....

2 ....

3 ....

[A17] Do you intend to continue using fertilizer in the future?

1 YES 2 NO 3 DON'T KNOW 4 OTHER ....

....

[A18] Do you intend to continue using improved seed in the future?

1 YES 2 NO 3 DON'T KNOW 4 OTHER....................

....

[A19] Do you intend to continue using herbicides (weedkiller) in the future?

1 YES 2 NO 3 DON'T KNOW 4 OTHER ....

....

WHEAT = ቀመ ዷ BARLEY = ገርስ MAIZE = በቆሎ

PEAS = አተር BEANS = ባቄላ

A20 A20.1 Before you started to use fertilizer did you burn the soil?

1 YES 2 NO 3 OTHER ....

If YES, what were the advantages of this? ....

....

And what were the disadvantages? ....

....

A21 Do you burn the soil now?

1 YES 2 NO 3 OTHER ....

A22 Do you clean your seed (to remove weed seed) before sowing?

1 YES 2 NO 3 OTHER ....

A23 (FOR FARMERS WHO USE IMPROVED SEED) Where do you obtain your seed LAST TIME?

1 GROWN ON THIS FARM 2 BOUGHT FROM CADU 3 BOUGHT FROM TRADER

4 BOUGHT FROM OTHER FARMER 5 OTHER ....

....

A24 How do you sow your crops?

1 BROADCAST 2 ROWPLANT 3 OTHER ....

SECTION B: LABOUR

B1 MEMBERS OF THE FARM FAMILY

B1.1 How many of the following live in the farm household?

ADULT MEN (number) .... ADULT WOMEN (number)..........

SCHOOLCHILDREN (no) ...... OTHER CHILDREN (no) ....

B1.2 How many people from the above list are able to perform the following work:

	ADULT MEN	ADULT WOMEN	SCHOOL-CHILDREN	OTHER CHILDREN
PLOUGHING				
SOWING				
WEEDING				
HARVESTING				
THRESHING				
WINNOWING				

WEED = አረማ
PLOUGHING = ቆና
HARVESTING = ሃሙ
BROADCAST = በቲምሱ፡ ፈጫሱ
SOWING = ፈጫሱ
THRESHING = ዻው
ROWPLANT = ተረን
WEEDING = አረሙ
WINNOWING = ቡበሱ፡ ጨሉሱ

[B2] B2.1 Did you hire any labourers to work on the farm <u>BEFORE</u> last year's Land Reform Proclamation?

1 YES 2 NO 3 OTHER ....

B2.2 If YES, were they:

1 PERMANENT 2 TEMPORARY 3 OTHER ....

B2.3 What type(s) of work did they do? (Circle as many as necessary.)

1 PLOUGHING 3 WEEDING 5 THRESHING 7 TRANSPORTING CROPS

2 SOWING 4 HARVESTING 6 WINNOWING

8 OTHER..

B2.4 How much were they paid? ....per...............

[B3] B3.1 Do you belong to a mutual labour exchange group?

1 YES 2 NO 3 OTHER.......................................

If YES, what type(s) of work does the group do? (Circle as many as necessary.)

1 PLOUGHING 3 WEEDING 5 THRESHING 7 TRANSPORTING CROPS

2 SOWING 4 HARVESTING 6 WINNOWING

8 OTHER ....

B3.2 Did you belong to such a group before last year's Land Reform Proclamation?

1 YES 2 NO 3 OTHER..

[B4] CROP OPERATIONS:

	WHEAT	BARLEY	MAIZE	FIELD PEAS	HORSE BEANS
Number of ploughings BEFORE sowing crop					
Date of first ploughing					
Date of sowing crop					
Number of weedings					
Date of first weeding					
Date of harvest					

PERMANENT = ዻበታ [illegible]
TEMPORARY = ኢርፍ
PLOUGHING = ቆና
SOWING = ፈጫሱ
WEEDING = አረሙ
HARVESTING = ሃሙ
THRESHING = ዻኡ
WINNOWING = ቡቢሱ፣ ጪለሱ
TRANSPORTING = ፌኡ
WHEAT = ቀመዲ
BARLEY = ገርቡ
MAIZE = በቆሎ
FIELD PEAS = አተር
HORSE BEANS = በቄላ

B5 RELIGIOUS HOLIDAYS

B5.1 Please state your religion

1 CHRISTIAN 2 MUSLIM 3 OTHER.........................

IF CHRISTIAN

B5.2^{c} Do you normally work on saturdays? (Include marketing as work.)

1 USUALLY
2 OCCASIONALLY
3 PART OF THE DAY
4 LIGHT WORK ONLY
5 NEVER

B5.3^{c} Do you normally work on sundays?

1 USUALLY
2 OCCASIONALLY
3 PART OF THE DAY
4 LIGHT WORK ONLY
5 NEVER

B5.4^{c} Which of the following yearly feast days do you celebrate? (Circle as many as necessary.)

1 KUDUS YOHANNES 5 KUDUS MIKAEL
2 MASKAL 6 SIKLET
3 GENNA 7 TINSAEA
4 TIMKAT 8 FILSETTA

B5.5^{c} Which of the following monthly feast days do you celebrate? (Circle as many as necessary.)

1 ABO (5th day of the month)
2 KUDUS MIKAEL (12th day)
3 KUDUS GABRIEL (19th day)
4 KIDIST MARIAM (21st day)
5 MEDHANE ALEM (27th day)
6 BE'ALE EGZIABHER (29th day)
7 OTHERS.........................

IF MUSLIM

B5.2^{m} Do you normally work on fridays? (Include marketing as work.)

1 USUALLY
2 OCCASIONALLY
3 PART OF THE DAY
4 LIGHT WORK ONLY
5 NEVER

B5.3^{m} Do you normally work on sundays?

1 USUALLY
2 OCCASIONALLY
3 PART OF THE DAY
4 LIGHT WORK ONLY
5 NEVER

B5.4^{m} Which of the following yearly feast days do you celebrate? (Circle as many as necessary.)

1 1st Mahuram (Islamic New Year)
2 Ashura
3 Maulid (Mohamed's Birthday)
4 Mehraj
5 Id el Fitre
6 Arafa (Id el Adaha)
7 OTHERS ....

B5.5^{m} During the month of Ramadhan, do you usually work:

1 NORMAL FULL WORKING DAY
2 LESS THAN A FULL WORKING DAY
3 LIGHT WORK ONLY
4 NO WORK AT ALL
5 OTHER.........................
....

USUALLY = ሌና: ሁንዴ፤ ሰለ ሁንዴ፤ ኤሮ ሁንዳ
OCCASIONALLY = ሉና ሌና ዴርቤ ያርቤ
NEVER = በሬዋ፤ ጉንኩዋ፤ ፊጥዋ

SECTION C: IMPLEMENTS & EQUIPMENT

C1 DETAILS OF TRADITIONAL IMPLEMENTS OWNED:

	NUMBER OWNED	BOUGHT (1) OR HOME-MADE (2)	IF BOUGHT STATE PRICE (Eth$ EACH)	NORMAL LIFE (years)
METAL PLOUGH TIP		1 2		
METAL PLOUGH 'HOOK'		1 2		
OX-SLED		1 2		
SICKLE (local)		1 2		
SICKLE (factory-made)		1 2		
LEATHER HARNESS FOR OXEN		1 2		

C2 TRACTOR USE

C2.1 Have you ever used a tractor, whether your own or rented?

1 YES 2 NO 3 OTHER..

→ C2.2 If YES, was it your own or rented?

1 OWN 2 RENTED OTHER..............................

C2.3 If rented, what did you pay for it?

Eth$.............per..............................

C2.4 For which crops did you use the tractor?.............

....

C2.5 What are the main advantages of using a tractor?

1 ....

2 ....

3 ....

C2.6 What are the main disadvantages of using a tractor?

1 ....

2 ....

3 ....

C2.7 Will you use a tractor next year if one is available?

1 YES 2 NO 3 OTHER...................................

C3 COMBINE HARVESTERS

C3.1 Have you ever used a combine, whether your own or rented?

1 YES 2 NO 3 OTHER ....

→ C3.2 If YES, was it your own or rented?

1 OWN 2 RENTED 3 OTHER ....

C3.3 If rented, what did you pay for it?

Eth$.............per..............................

(QUESTION CONTINUES OVERLEAF)

PLOUGH TIP = ማረሻ PLOUGH 'HOOK' = ቀኚ SICKLE = ሦም ተ

HOME MADE = መነት ከን ተሰራሚ LOCALLY MADE = ቢየት ከን ተሰራሚ

FACTORY MADE = ፋብሪካት ከን ተሰራሚ OX-SLED =

C3 COMBINE HARVESTERS (CONTINUED)

C3.4 For which crops did you use the combine?.............

....

C3.5 Did you use it for harvesting and threshing or for stationary threshing only?

1 HARVESTING AND THRESHING   2 STATIONARY THRESHING ONLY

3 OTHER..

C3.6 What are the main advantages of using a combine?

1 ....

2 ....

3 ....

C3.7 What are the main disadvantages of using a combine?

1 ....

2 ....

3 ....

C3.8 Will you use a combine next year if one is available?

1 YES   2 NO   3 OTHER ....

C4 CADU PLOUGH

C4.1 Have you ever used a CADU plough, whether your own or rented?

1 YES   2 NO   3 OTHER...

→ C4.2 If YES, what are the main advantages of the CADU plough over the traditional method?

1 ....

2 ....

3 ....

C4.3 What are the main disadvantages of the CADU plough compared to the traditional method?

1 ....

2 ....

3 ....

C4.4 Was the plough you used your own or rented?

1 OWN   2 RENTED   3 OTHER.................................

IF OWNED

C4.5° When did you buy it?

..........E.C.

C4.6° Have you ever hired your plough to other farmers?

1 YES   2 NO   3 Other..........

C4.7 If yes how much did you charge? ....per...............

IF RENTED

C4.5r For how many days did you use it last year? .....

C4.6r How much did you pay?

..........per.............

GO TO QUESTION C5, page 11

PLOUGH = ቶና   HARVESTING = ሃመ   THRESHING = ጓው

STATIONARY = ጓበታ   TRADITIONAL METHOD = ዋን ቱጓ

C4 CADU PLOUGH (CONTINUED)

IF OWNED (CONTINUED)

C4.8 Has your plough ever broken down since you got it?

1 YES 2 NO 3 OTHER.................................

C4.9 If YES, could you state: 1 Cost of repairs Eth$......

2 Cause of breakdown.................................

3 Number of days out of use.................................

4 Who repaired it.................................

C5 CADU SPIKE-TOOTH HARROW

C5.1 Have you ever used a CADU harrow, whether your own or rented?

1 YES 2 NO 3 OTHER.................................

C5.2 If YES, what are the main advantages of the CADU harrow?

1 ....

2 ....

3.................................

C5.3 What are the main disadvantages of the CADU harrow?

1 ....

2 ....

3 ....

C5.4 Was the harrow you used your own or rented?

1 OWN 2 RENTED 3 OTHER.................................

IF OWNED

C5.5° When did you buy it?

............E.C.

C5.6° Have you ever hired it to other farmers?

1 YES 2 NO 3 OTHER ....

IF RENTED

C5.5^r For how many days did you use it last year?......

C5.6^r How much did you pay?

..........per..............

GO TO QUESTION C6, page 12

C5.7 If YES, how much did you charge?..........per..........

C5.8 Has your harrow ever broken down since you got it?

1 YES 2 NO 3 OTHER ....

C5.9 If YES, could you state: 1 Cost of repairs Eth$......

2 Cause of breakdown.................................

3 Number of days out of use.................................

4 Who repaired it.................................

HARROW = ጦማሽ BREAKDOWN = መበ REPAIR = ጥገና

C6 CADU OX-CART

C6.1 Have you ever used a CADU ox-cart, whether your own or rented?

1 YES 2 NO 3 OTHER..

→ If YES,

C6.2 What are the main advantages of the CADU ox-cart?

1 ....

2 ....

3 ....

C6.3 What are the main disadvantages of the CADU ox-cart?

1 ....

2 ....

3 ....

C6.4 Was the ox-cart you used your own or rented?

1 OWN 2 RENTED 3 OTHER..............................

IF OWNED

C6.5° When did you buy it?

................E.C.

C6.6° Have you ever hired it to other farmers?

1 YES 2 NO 3 OTHER ....

IF RENTED

C6.5r For how many days did you use it last year?......

C6.6r How much did you pay?

.........per...............

C6.7 If YES, how much did you charge?.........per..............

C6.8 Has your ox-cart ever broken down since you got it?

1 YES 2 NO 3 OTHER......................................

C6.9 If YES, could you state: 1 Cost of repairs Eth$...........

2 Cause of breakdown......................................

3 Number of days out of use...............................

4 Who repaired it...

C7 CADU STATIONARY THRESHER (NOT COMBINES)

C7.1 Have you ever used the CADU stationary thresher?

1 YES 2 NO 3 OTHER ....

→ If YES,

C7.2 What are the main advantages of this thresher?

1 ....

2 ....

3 ....

C7.3 What are the main disadvantages of this thresher?

1 ....

2 ....

3 ....

OX-CART = ከንከላታ ቆተ ዩን አርኪበን BREAKDOWN = ጫገ REPAIR = ሱፋ

SECTION D: WORKSTOCK & CROP AREAS

D1 D1.1 How many of the following animals do you own?

OXEN......... DONKEYS....... MULES....... HORSES.......

D1.2 How much, approximately would you normally expect to pay for the following when they are young:

1 An ox: From Eth$...........to Eth$............

2 A donkey From Eth$..........to Eth$.............

3 A mule From Eth$........... to Eth$..............

4 A horse From Eth$.............to Eth$.............

D1.3 How much approximately is an old ox worth when it is sold for slaughter?

From Eth$............... to Eth$ ....

What is the average WORKING life (in years) of:

AN OX...... A DONKEY..... A HORSE...... A MULE......

D2 D2.1 How much land did you farm last year? (Include rented land)

1 CROP LAND.................. 2 OTHER LAND..................

D2.2 What was the area under various crops last year?

CROP	VARIETY	AREA (unit?)
1...............	....	....
2...............	....	....
3...............	....	....
4...............	....	....
5...............	....	....
6...............	....	....
7...............	....	....

N.B. 1 hectare = 4 kert

CONTINUE OVER LEAF IF NECESSARY

OXEN = ቆቲ ዮታ DONKEYS = ሃሮታ MULES = ጋንጎታ HORSES = ፈርዶታ

INTERVIEWER'S NAME........................... DATE.................

INTERVIEWER'S EVALUATION OF RESPONSE: 1 VERY CO-OPERATIVE 2 CO-OPERATIVE

4 UNCO-OPERATIVE OTHER ....

A P P E N D I X B

THE PRE-TEST QUESTIONNAIRE

FARM TECHNOLOGY PILOT STUDY

NAME OF FARMER:..

NAME OF GASHA LEADER:..

NAME OF GOLMASSA:..

SECTION A: FERTILIZER/IMPROVED SEED

A1 Have you ever used chemical fertilizer or CADU seed on your farm?

FERTILIZER ONLY/__/ CADU SEED ONLY/__/ BOTH/__/ NEITHER/__/

If NEITHER, go to question A9, page 6; if SEED ONLY, go to A1.3.

Otherwise:

A1.1 When fertilizer is used, please state

CROP	TYPE OF FERTILIZER	RATE APPLIED (unit??)	"AVERAGE" YIELD	
			WITH FERTILIZER	WITHOUT FERTILIZER

A1.2 When did you first use fertilizer? .... (EC)

A1.3 When did you first use CADU seed? .... (EC)

A2 When you use fertilizer or CADU seed in a certain field, do you notice changes in any of the following:

A2.1 WEEDS: are there:

FEWER WEEDS/__/ If so, why? ....

MOPE WEEDS /__/ If so, why? ....

NO CHANGE/__/ OTHER ....

WEEDS= አረም SEED= ሰጊ CROP= ምርት YIELD= ጠሰ፦ ገለቻ

A2.2 HARVESTING: Do you find harvesting,

EASIER /_/ If so, why? ....

MORE DIFFICULT/_/ If so, why? ....

SAME AS BEFORE/_/ OTHER....................................

A2.3 TRANSPORTATION OF CROPS: Do you find transportation of crops:

EASIER /_/ If so, why? ....

MORE DIFFICULT/_/ If so, why? ....

SAME AS BEFORE/_/ OTHER....................................

A2.4 THRESHING: Do you find threshing:

EASIER /_/If so, why? ....

MORE DIFFICULT/_/If so, why? ....

SAME AS BEFORE/_/ OTHER....................................

A2.5 WINNOWING: Do you find winnowing:

EASIER /_/If so, why? ....

MORE DIFFICULT/_/If so, why? ....

SAME AS BEFORE/_/ OTHER....................................

A3 Since you started using fertilizer or CADU seed, have you changed any of the following farm practices:

A3.1 PLOUGHING:

(a) Do you now plough:

EARLIER/_/If so, why? ....

LATER /_/If so, why? ....

AT THE SAME TIME/_/ OTHER....................................

(b) Before planting your crops, do you now plough:

MORE OFTEN/_/If so, why? ....

LESS OFTEN/_/If so, why? ....

SAME AS BEFORE/_/ OTHER....................................

A3.2 WEEDING

(a) Do you now weed:

MORE OFTEN/_/If so, why? ....

LESS OFTEN/_/If so, why? ....

SAME AS BEFORE/_/ OTHER....................................

(b) Does weeding a given size of field now take:

MORE TIME/_/If so, why? ....

LESS TIME/_/If so, why? ....

SAME AS BEFORE/_/ OTHER....................................

HARVESTING= ሃጨ TRANSPORTATION= ፈሎ THRESHING= ጿሙ

PLOUGHING= ዩና WINNOWING= ሮገሱ፡ ጢለሱ

WEEDING= አረሙ

A3.3 HARVESTING:

(a) Do you now harvest:

EARLIER/_/If so, why? ....

LATER /_/If so, why? ....

AT THE SAME TIME/_/ OTHER..

(b) Does harvesting a given size of field now take:

MORE TIME/_/If so, why? ....

LESS TIME/_/If so, why? ....

SAME AS BEFORE/_/ OTHER..

A3.4 THRESHING:

(a) Do you now thresh:

EARLIER/_/If so, why? ....

LATER /_/If so, why? ....

AT THE SAME TIME/_/ OTHER..

(b) Does threshing the same quantity of crop now take:

MORE TIME/_/If so, why? ....

LESS TIME/_/If so, why? ....

SAME AS BEFORE/_/ OTHER..

A3.5 WINNOWING:

(a) Do you now winnow:

EARLIER/_/If so, why? ....

LATER /_/If so, why? ....

AT THE SAME TIME/_/ OTHER..

(b) Does winnowing the same quantity of grain now take:

MORE TIME/_/If so, why? ....

LESS TIME/_/If so, why? ....

SAME AS BEFORE/_/ OTHER..

A3.6 AREA FARMED Do you now cultivate:

A GREATER AREA/_/If so, why? ....

A SMALLER AREA/_/If so, why? ....

SAME AS BEFORE/_/ OTHER..

A3.7 OXEN Do you now use:

MORE OXEN /_/If so, why? ....

FEWER OXEN/_/If so, why? ....

SAME AS BEFORE/_/ OTHER..

HARVESTING= ሃሙ

WINNOWING= ስቢስ፣ ወሊስ

THRESHING= ጟዉ

OXEN= ቆት ዩቷ

A3.8 LABOUR

(a) Do you now find your work, or that of your family, is:

HARDER/ /If so, why? ....

EASIER/ /If so, why? ....

SAME AS BEFORE/ / OTHER...

(b) Do you now need:

MORE MEN / /If so, why? ....

FEWER MEN/ /If so, why? ....

SAME AS BEFORE/ / OTHER...

A3.9 MACHINERY & EQUIPMENT: Have you now started to use:

TRACTORS / /If so, why? ....

COMBINES / /If so, why? ....

CADU THRESHER/ /If so, why? ....

CADU HARROW / /If so, why? ....

CADU PLOUGH / /If so, why? ....

CADU OX-CART / /If so, why? ....

A3.10 CROP AREAS: Have you changed the area under any crop?

YES/ / NO/ / OTHER..

If YES, please give following details, otherwise go to question A3.11

CROP	-- AREA -- Greater	Less	Reason for Change

A3.11 STORAGE Do you find that to store your crop you need:

MORE SPACE/ /If so, why? ....

LESS SPACE/ /If so, why? ....

SAME AS BEFORE/ / OTHER...

HARROW= ቡሊሱ

PLOUGH= ኛና ፊ

OX-CART= ከንከሳታ ዮቶ ዶን አርኪሰን

CROP= ምፕን

STORAGE= ጉምቢ

Text cut off in original

A3.12 MARKETING

(a) Do you now tend to market your crop:

EARLIER IN THE YEAR/_/If so, why? ....

LATER IN THE YEAR /_/If so, why? ....

AT THE SAME TIME/_/ OTHER..

(b) On the whole do you now market:

MORE OF YOUR CROP/_/If so, why? ....

LESS OF YOUR CROP/_/If so, why? ....

SAME AS BEFORE/_/ OTHER..

A4 Do you find that as a result of using fertilizer or CADU seed any farm operations have become too difficult for you to manage comfortably?

OPERATION	YES/NO	If YES, what are the results?
PLOUGHING		
WEEDING		
HARVESTING		
THRESHING		
WINNOWING		
STORING		
TRANSPORTATION		
MARKETING		
OTHER(S)		

A5 If you rent some or all of your land from a landlord:

(a) Has your rent changed as a result of using fertilizer or CADU seed?

INCREASED/_/If so, why? ....

DECREASED/_/If so, why? ....

REMAINED THE SAME/_/ OTHER..

(b) Does your landlord pay all or part of the cost of the fertilizer or CADU seed?

FERTILIZER: NO/_/ YES/_/ OTHER..................................

If YES, what proportion? ....%

CADU SEED NO/_/ YES/_/ OTHER..................................

If YES, what proportion? ....%

MARKETING= [illegible]
WEEDING= [illegible]
THRESHING= [illegible]
STORAGE= [illegible]

PLOUGHING= [illegible]
HARVESTING= [illegible]
WINNOWING= [illegible]
TRANSPORTATION= [illegible]

A6 What, in your opinion, are the main advantages of using

(a) FERTILIZER: 1...
(list in order) 2...
3...

(b) CADU SEED 1...
(list in order) 2...
3...

A7 What, in your opinion, are the main disadvantages of using

(a) FERTILIZER: 1...
(list in order) 2...
3...

(b) CADU SEED 1...
(list in order) 2...
3...

A8 Do you intend to continue or stop using fertilizer or CADU seed?

WILL CONTINUE USING FERTILIZER/ /

WILL STOP USING FERTILIZER/ /If so, why?.............................
....

OTHER................ ....

WILL CONTINUE USING CADU SEED/ /

WILL STOP USING CADU SEED/ /If so, why?.............................
....

OTHER................ ....

(GO TO SECTION B, page 7)

A9 (For farmers who have never used fertilizer or CADU seed.)

How do you think fertilizer and CADU seed would affect crop yields if you used them on your farm?

WOULD INCREASE THEM/ / WOULD DECREASE THEM/ /

WOULD NOT AFFECT THEM/ / OTHER.....................................

E9.1 If DECREASE, could you say why?.....................................

E9.2 If INCREASE, why don't you use them? ....
....

SECTION B: GENERAL FARMING CONDITIONS

B1 LAND TENURE

B1.1 How much land do you farm in total? (state units)..............

B1.2 How much land do you rent from a landlord(units?)?..............

If NO land is rented, go to question B1.5 below

If ANY land is rented, please state:

B1.3 From how many different landlords do you rent land?............

B1.4 LEASE DETAILS:

	LEASE #1	LEASE #2	LEASE #3
AREA			
RENT (specify amount paid, cash, share or other)			
DO YOU PAY 'ASRAT'?(yes/no)			
DO YOU PROVIDE ANY OTHER SERVICES TO THE LANDLORD APART FROM RENT (EG. working for him or transporting the crop rent) - Give Details			
DOES THE LANDLORD PROVIDE: (yes/no) SEED? ... (yes/no) OXEN? ...	....	....	....

B1.5 Do you rent out any of your own land for others to farm?

YES/_7 NO/_7 OTHER..

-If YES, why do you not farm this land yourself? ....

....

B2 Do you try to practice crop rotation?

YES/_7 NO/_7 OTHER..

If NO, go to question B3 , page 8.

If YES,

B2.1 What would be the normal crop rotation on your farm? (include fallows)

YEAR	CROP	YEAR	CROP
1	______	5	______
2	______	6	______
3	______	7	______
4	______	8	______

FALLOW= ገበሶ

LANDLORD= ባለርስ

B3 Do you burn your soil at certain times of the year?

YES /_/ NO /_/ OTHER..

B4 Do you clean your seed. (to remove weed seeds) before planting?

YES /_/ NO /_/ OTHER..

-If NO, why not? ....

....

B5 CROP INFORMATION (1974 season)

CROP OR VARIETY	TOTAL AREA (unit?)	TOTAL AMOUNT PRODUCED (unit?)	WAS SEED BOUGHT IN 1974 OR GROWN ON THIS FARM? BOUGHT	GROWN	APPROX. %age MARKETED
WHEAT, local					
WHEAT, CADU					
BARLEY, local					
BARLEY, CADU					
TEFF, local					
TEFF, CADU					
HARICOT BEANS, local					
HARICOT BEANS, CADU					
RAPE, local					
RAPE, CADU					
HORSEBEANS					
FIELD PEAS					
LENTILS					
MAIZE					
SORGHUM					
LINSEED					
POTATOES					
VEGETABLES					
FODDER CROPS					
OTHERS:.......					
....					
....					
....					
....					

WEED= አረም
BARLEY= ገብስ
RAPE= [illegible]
MAIZE= በቆሎ

SEED= [illegible]
TEFF= ጤፍ
FIELD PEAS= አተር
SORGHUM= [illegible]

WHEAT= [illegible]
HARICOT BEANS= [illegible]
LENTILS= ምስር
LINSEED= ተልባ

B6 How do you sow your seed? (List Crops)

BROADCAST	ROWPLANT (If so, please state reasons for rowplanting.)

B7 How much time would the following operations normally take you for ONE TIMAD of land?

OPERATION		LENGTH OF TIME TAKEN (state unit)	METHOD USED (eg oxen, tractor, etc)
FIRST PLOUGHING			
SECOND PLOUGHING/HARROWING			
THIRD PLOUGHING/HARROWING			
FOURTH PLOUGHING/HARROWING			
SOWING SEED	(i) BROADCASTING		
	(ii) ROWPLANTING		
SEED COVERING			
FIRST WEEDING (if any)			
SECOND WEEDING (if any)			
THIRD WEEDING (if any)			
HARVESTING	LOCAL WHEAT		
	CADU WHEAT		
	LOCAL BARLEY		
	CADU BARLEY		
	LOCAL TEFF		
	CADU TEFF		
THRESHING	LOCAL WHEAT		
	CADU WHEAT		
	LOCAL BARLEY		
	CADU BARLEY		
	LOCAL TEFF		
	CADU TEFF		

BROADCAST= ቢትምሱ፣ ፋጫሱ ROWPLANT= ተረን ዷቡ PLOUGHING= ቆና
WEEDING= አረሙ HARVESTING= ሃሙ THRESHING= ዷው
WHEAT= ቃሙዲ BARLEY= ገርቡ TEFF= ጣፊ
SEED COVERING= ቢዬ ሰኚ ኡፊሱ

B8 FARMING PRACTICES: Please give the following information:

CROP OR VARIETY	SEEDING RATE (state units)	USUAL DATE OPERATION BEGINS* FIRST PLOUGHING	SECOND PLOUGHING/HARROWING	THIRD PLOUGHING/HARROWING	FOURTH PLOUGHING/HARROWING	SOWING OR PLANTING	FIRST WEEDING (if any)	SECOND WEEDING (if any)	THIRD WEEDING (if any)	HARVEST
WHEAT, local										
WHEAT, CADU										
BARLEY, local										
BARLEY, CADU										
TEFF local										
TEFF, CADU										
HARICOT BEANS, local										
HARICOT BEANS, CADU										
RAPE, local										
RAPE, CADU										
HORSEBEANS										
FIELD PEAS										
LENTILS										
MAIZE										
SORGHUM										
LINSEED										
POTATOES										
VEGETABLES										
FODDER CROPS										
others......										
....										
....										

*DATES: Approximate dates will suffice: eg, "early February", "before first rains", etc.

WHEAT = ስንዴ
TEFF = ጤፍ
LENTILS = ምስር
BARLEY = ገብስ
RAPE = ምጃን ራፏ
MAIZE = በቆሎ
HARICOT BEANS = አደንጓሬ፣ ቦሎቄ
FIELD PEAS = አተር
SORGHUM = ምበገጓ

SECTION C: FARM LABOUR FORCE

C1 MEMBERS OF FARM FAMILY.(ie those relatives who live with the farmer and work on the farm, but do not receive a daily, weekly, monthly or yearly salary)

C1.1 How many of the following live in the farm household?

	TOTAL NO.	NO. ABLE TO READ	NO. ATTENDING SCHOOL
ADULT MEN			X
ADULT WOMEN			X
CHILDREN			

C1.2 Please state how many adult men, adult women and children from the above list (C1.1) are able to perform the following tasks

	ADULT MEN	ADULT WOMEN	CHILDREN
PLOUGHING			
SOWING			
WEEDING			
HARVESTING			
THRESHING			
WINNOWING			
MARKETING			
HERDING CATTLE			

C1.3 Are there any members of your family who live away from home, but return at certain times to help work on the farm?

YES/_/ NO/_/ OTHER.......................................

If YES, please give details: How many?..........................

Type of Work...

C2 HIRED WORKERS (Do NOT include mutual help; refers to workers paid a daily, weekly, monthly or yearly wage)

C2.1 Do you usually hire any workers on a permanent or temporary basis?

TEMPORARY ONLY/_/ PERMANENT ONLY/_/ BOTH/_/ NEITHER/_/

If NEITHER, go to question C3, page 12

If TEMPORARY ONLY, go to question C2.3, page 12

If PERMANENT or BOTH, go to question C2.2, page 12.

C2.2 PERMANENT WORKERS Please give details of those employed:

WORKER	WAGE (state units)	DO YOU PROVIDE (YES/NO) FOOD?	LODGING?	CLOTHING?	TYPE OF WORK DONE
1					
2					
3					
4					
5					

- CONTINUE OVERLEAF IF NECESSARY -

C2.3 TEMPORARY WORKERS: Please give details of those employed (nb: Do NOT include mutual labour exchange). Details for 1974 season.

WORKER	WAGE (state units)	DO YOU PROVIDE FOOD?	LODGING?	IN WHICH MONTHS EMPLOYED	HOW MANY DAYS?	TYPE OF WORK DONE
1						
2						
3						
4						
5						
6						
7						
8						

- CONTINUE OVERLEAF IF NECESSARY -

C3 Did you participate in mutual labour exchange during 1974?

YES/ _7 NO/ _7 OTHER...

If NO, go to question C4, page 13

If YES, please give details:

C3.1 WORK DONE BY PEOPLE FROM THIS FARM ON SOMEONE ELSE'S FARM IN 1974

(a) No. of men from this farm.......................................

(b) No. of days each worked(state months)...................

C3.2 WORK DONE BY PEOPLE FROM OTHER FARMS ON THIS FARM IN 1974

(a) No of men who worked here....................................

(b) No of days each worked (state months)...........................

(c) Did they supply oxen?..

(d) Type of work done..

(e) Were food and drink provided?..................................

C4 Did people from this farm spend time on occupations other than farming on this farm during 1974? (Do NOT include mutual labour exchange)

YES/ / NO/ / OTHER..

If NO, go to question C5 below
If YES, please give details:

C4.1 (a) Nature of the work...

(b) Number of days last year in total..........................

(If more than one person was involved, give further details overleaf)

C5 HOLIDAYS.

C5.1 Do you work on your farm on FRIDAYS?

USUALLY/ / OCCASIONALLY/ / NEVER/ / OTHER.................

If NEVER, is this for religious reasons? ....

C5.2 Do you work on your farm on SATURDAYS?

USUALLY/ / OCCASIONALLY/ / NEVER/ / OTHER...............

If NEVER, is this for religious reasons?.........................

C5.3 Do you work on your farm on SUNDAYS?

USUALLY/ / OCCASIONALLY/ / NEVER/ / OTHER...............

If NEVER, is this for religious reasons?........................

C5.4 MONTHLY SAINTS' DAYS: On which of the following monthly saints' days do you NEVER work on the farm? (List by month.)

DAY	FEAST	MONTH (Ethiopian Calendar) 1	2	3	4	5	6	7	8	9	10	11	12	13
1st	LEDETA													
3rd	BAHATA													
5th	ABO													
6th	EGRESUS													
7th	SELLASSIE													
11th	KIDIST HANNA													
12th	KUDUS MIKAEL													
15th	CHERKOS													
16th	KEDANE MEHRET													
19th	KUDUS GABRIEL													
21st	KIDIST MARIAM													
23rd	KUDUS GIORGHIS													
24th	TEKLE HAIMENOT													
27th	MEDHANE ALEM													
29th	BE'ALE EGZIABHER													

C5.5 How many days holiday do you normally take for each of the following religious feasts? (If none, enter 0; otherwise enter actual number.)

CHRISTIAN

Kudus Yohannes....
Maskal............
Genna.............
Timkat............
Kudûs Mikael......
Siklet............
Tinsaea...........
Filsetta..........

MUSLIM

1st Muharam (New Year)...........
Ashura...........................
Maulud (Prophet's Birthday)......
Mehraj...........................
Id el Fitre......................
Id el Adaha (Arafa)..............
Shek Husen.......................

C5.6 (FOR MUSLIMS ONLY) Do you normally work less than a full working day during the month of RAMADHAN?

LESS THAN FULL DAY/ / FULL DAY/ / OTHER................

---If LESS THAN FULL DAY :
(i) What fraction of a day do you work?...................
(ii) Why do you work less than usual?...................
....

SECTION D: WORKSTOCK

D1 How many of each of the following animals do you OWN ?

WORKING OXEN..... DONKEYS...... MULES...... HORSES......

D2 Do you ever HIRE any oxen, donkeys, mules or horses to work on your farm? (Do NOT include those brought under mutual exchange.)

YES/ / NO/ / OTHER...

If NO, go to question D3 below.
If YES, please give the following details:

D2.1 How many of the following animals did you hire during 1974?

ANIMAL	TOTAL NUMBER HIRED	TOTAL NUMBER OF DAYS	AMOUNT PAID (State Unit)	PURPOSE
OXEN				
DONKEYS				
MULES				
HORSES				

D3 Do you ever hire out any of your own working animals to work for others? (Do NOT include mutual exchange.)

YES/ / NO/ / OTHER...

If NO, go to question D4 , page 15
If YES, go to question D3.1, page 15

D3.1 How many of the following animals did you hire out (ie to work for others) during 1974?

ANIMAL	TOTAL NUMBER HIRED	TOTAL NUMBER OF DAYS	AMOUNT PAID (state unit)	PURPOSE
OXEN				
DONKEYS				
MULES				
HORSES				

D4 Could you give the following information about working animals:

ANIMAL	AVERAGE WORKING LIFE (yrs)	DO YOU PRACTICE "GODANTU"?	DO YOU FEED THESE ANIMALS ON:				
			GRAZING	GRAIN	CUT STRAW	FODDER CROPS	STUBBLE
OXEN							
DONKEYS							
MULES							
HORSES							

SECTION E: IMPLEMENTS AND EQUIPMENT

E1 Details of implements owned (DO NOT include CADU-designed implements.)

IMPLEMENT		TOTAL NUMBER OWNED	BOUGHT (B) OR HOME-MADE (H)	IF BOUGHT STATE PRICE	NORMAL LIFE (in years)
(INCLUDE COMPLETE PLOUGHS)	PLOUGH TIP (METAL)				
	PLOUGH HANDLE				
	PLOUGH BEAM				
	PLOUGH "WINGS"				
	PLOUGH HOOK (METAL)				
YOKE					
HOE, LOCALLY MADE					
HOE, FACTORY MADE					
PICKAXE LOCALLY MADE					
PICKAXE FACTORY MADE					
AXE, LOCALLY MADE					
AXE, FACTORY MADE					
SICKLE, LOCALLY MADE					
SICKLE FACTORY MADE					
THRESHING FORK, LOCALLY MADE					
THRESHING FORK, FACTORY MADE					
WINNOWING SHOVEL, WOODEN					
TRADITIONAL OX-SLED					

GRAZING = ግጦሽ PLOUGH "WINGS" = [illegible] AXE = [illegible]
GRAIN [illegible] PLOUGH HANDLE [illegible] WINNOWING SHOVEL = [illegible]

E2 TRACTOR USE Have you ever used a tractor on your farm (whether your own or someone else's.)

YES/ / NO/ / OTHER..

If NO, go to question E3, page 17

If YES, please give the following details:

E2.1 When did you first use a tractor? ....(EC)

E2.2 What is the SMALLEST size of field on which you have used a tractor? ....(state unit)

E2.3 Did you still use a tractor in 1974?

YES/ / NO/ / OTHER......................................

If NO, go to question E2.8 below
If YES, please give details (below) for what crop season:

E2.4 For which operations did you use the tractor? (Circle more than one if necessary.)

1 PLOUGHING 2 HARROWING 3 TRANSPORTATION

OTHER (specify)..

E2.5 For which crops did you use the tractor?

PLOUGHING ....

HARROWING ....

TRANSPORTATION ....

OTHER ....

E2.6 Was the tractor you used your own or rented?

OWN/ / RENTED/ / OTHER ....

If OWN, go to question E2.8 below

If RENTED, please give the following details:

E2.7 How many tractor-hours did you rent in 1974 for each of the following operations

OPERATION	TOTAL NUMBER OF HOURS RENTED	AMOUNT PAID $ per ..... (state unit)	DOES CHARGE INCLUDE DRIVER'S WAGES?	DOES CHARGE INCLUDE FUEL COST?
PLOUGHING				
HARROWING				
TRANSPORTATION				
OTHER.........				

E2.8 What, in your opinion, are the main advantages of tractors over traditional methods? (List in order of importance.)

1 ....

2 ....

3 ....

E2.9 What, in your opinion, are the main disadvantages of tractors compared with traditional methods? (List in order of importance.)

1 ....

2 ....

E2.10 FOR FARMERS WHO HAVE STOPPED USING TRACTORS:

Why did you stop using them? ....

....

....

E3 USE OF COMBINE HARVESTERS: Have you ever used a combine harvester on your farm? (Whether your own or rented, whether combine harvesting or stationary threshing.)

YES/ /   NO/ /   OTHER...

If NO, go to question E4, page 18.

If YES, please give the following details:

E3.1 When did you first use a combine? ....(EC)

E3.2 Did you still use a combine in 1974?

YES/ /   NO/ /   OTHER...

If NO, go to question E3.8 below

If YES, please give details (below) for that crop season:

E3.3 Did you use the combine f... harvesting and threshing or for stationary threshing only?

HARVESTING + THRESHING/ /   STATIONARY THRESHING ONLY/ /

OTHER ....

If STATIONARY THRESHING ONLY, go to question E3.5 below.

If HARVESTING + THRESHING, please specify:

E3.4 What is the smallest size of field in which you have used a combine?.................................(state unit)

E3.5 Which crops did you thresh by combine in 1974?

WHEAT/ /   BARLEY/ /   OTHERS ....

E3.6 Was the combine you used your own or rented?

OWN/ /   RENTED/ /   OTHER.................................

If OWN, go the question E3.8 below.

If RENTED, please give the following details:

E3.7 (a) Total number of combine hours rented in 1974.............

(b) Amount paid (state unit) $........per.....................

(c) Does charge include (i) Operator's Wages? ....

(ii) Fuel Costs? ....

(d) Total number of quintals threshed (i) WHEAT..............

(ii) BARLEY............

(iii)OTHER....... ....

E3.8 What, in your opinion, are the main advantages of combines over traditional methods? (List in order of importance.)

1 ....

2 ....

3 ....

E3.9 What, in your opinion, are the main disadvantages of combines compared with traditional methods? (List in order of importance.)

1 ....

2 ....

3 ....

E3.10 FOR FARMERS WHO HAVE STOPPED USING COMBINES:

Why did you stop using them? ....

....

....

E4 CADU PLOUGH: Have you ever used a CADU plough on your farm? (Whether your own or rented.)

YES/ / NO/ / OTHER..

If NO, go to question E4.10, page 19.

If YES, please give the following details:

E4.1 Do you still use the CADU plough?

YES/ / NO/ / OTHER..

If NO, go to question E4.7 below

If YES, please give the following details:

E4.2 Do you own the CADU plough or rent it?

OWN/ / RENT/ / OTHER..

If RENTED, go to question E4.6 below

If OWN, please state

E4.3 (a) Year of Purchase ....(EC)

(b) Cash or Credit? CASH/ / CREDIT/ / OTHER............

E4.4 Has your plough ever broken down since you bought it?

YES/ / NO/ / OTHER..

-----If YES, could you state (a) No of Times...................

(b) Cause of breakdown ....

....

(c) Cost of Repairs(total).......

E4.5 Have you ever hired out your plough for use by other farmers?

YES/ / NO/ / OTHER..

If NO, go to question E4.7 below

If YES, please state

E4.6 (a) Average number of days hired per year.....................

(b) Amount charged (state both units) ....per.........

E4.7 What, in your opinion, are the main advantages of the CADU plough over the traditional plough? (List in order of importance.)

1 ....

2 ....

3 ....

E4.8 What, in your opinion, are the main disadvantages of the CADU plough compared with the traditional plough? (List in order.)

1 ....

2 ....

3 ....

E4.9 FOR FARMERS WHO HAVE STOPPED USING THE CADU PLOUGH

Why did you stop using it? ....

....

....

E4.10 FOR FARMERS WHO HAVE NEVER USED THE CADU PLOUGH

(a) How do you think CADU ploughs compare with traditional ones?

Cadu ploughs are: BETTER/ / WORSE/ / OTHER...........

(b) If BETTER or WORSE, give reasons.........................

....

(c) If BETTER, why don't you use one?........................

....

E5 CADU SPIKE-TOOTH HARROW: Have you ever used a CADU harrow on your farm? (Whether your own or rented.)

YES/ / NO/ / OTHER...

If NO, go to question E5.10, page 20

If YES, please give the following details:

E5.1 Do you still use the CADU harrow?

YES/ / NO/ / OTHER.......................................

If NO, go to question E5.7, page 20

If YES, please give the following details:

E5.2 Do you own the CADU harrow or rent it?

OWN/ / RENT/ / OTHER....................................

If RENTED, go to question E5.6, page 20

If OWN, please state

E5.3 (a) Year of Purchase..................................(EC)

(b) Cash or Credit? CASH/ / CREDIT/ / OTHER...........

E5.4 Has your harrow ever broken down since you bought it?

YES/ / NO/ / OTHER.......................................

-----If YES, could you state(a) No of times..................

(b) Cause of Breakdown..........

....

(c) Cost of Repairs(total).......

E5.5 Have you ever hired out your harrow for use by other farmers?

YES/ / NO/ / OTHER.......................................

If NO . go to question E5.7, page 20

E5.6 (a) Average number of days hired per year....................

(b) Amount charged (state both units)...........per..........

E5.7 What, in your opinion, are the main advantages of the CADU harrow over the traditional alternative? (List in order of importance.)

1 ....

2 ....

3 ....

E5.8 What, in your opinion, are the main disadvantages of the CADU harrow compared with the traditional alternative? (List in order of importance.)

1 ....

2 ....

3 ....

E5.9 FOR FARMERS WHO HAVE STOPPED USING THE CADU HARROW

Why did you stop using it?.....................................

....

....

E5.10 FOR FARMERS WHO HAVE NEVER USED THE CADU HARROW

(a) How do you think CADU harrows compare with traditional methods?

Cadu harrows are: BETTER/ / WORSE/ / OTHER............

(b) If BETTER or WORSE, give reasons.........................

....

(c) If BETTER, why don't you use one?.........................

....

E6 CADU OX-CART: Have you ever used a CADU ox-cart on your farm? (Whether your own or rented.)

YES/ / NO/ / OTHER.......................................

If NO, go to question E6.10, page 21

If YES, please give the following details:

E6.1 Do you still use the CADU ox-cart?

YES/ / NO/ / OTHER.................................

If NO, go to question E6.7, page 21

If YES, please give the following details:

E6.2 Do you own the CADU ox-cart or rent it?

OWN/ / RENT/ / OTHER................................

If RENTED, go to question E6.6, page 21

If OWN, please state:

E6.3 (a) Year of Purchase..................................(EC)

(b) Cash or Credit? CASH/ / CREDIT/ / OTHER.........

E6.4 Has your ox-cart ever broken down since you bought it?

YES/ / NO/ / OTHER...

-----If YES, could you state (a)No of Times..................

(b)Cause of Breakdown...........

....

(c)Cost of Repairs(total).......

E6.5 Have you ever hired out your ox-cart for use by others?

YES/ / NO/ / OTHER...

If NO, go to question E6.7 below

If. YES, please state:

E6.6 (a) Average number of days hired per year....................

(b) Amount charged (state both units)...........per..........

E6.7 What, in your opinion, are the main advantages of the CADU ox-cart over the traditional alternative? (List in order of importance.)

1 ....

2 ....

3 ....

E6.8 What, in your opinion, are the main disadvantages of the CADU ox-cart compared with the traditional alternative? (List in order of importance.)

1 ....

2 ....

3 ....

E6.9 FOR FARMERS WHO HAVE STOPPED USING THE CADU OX-CART

Why did you stop using it?................................

....

....

E6.10 FOR FARMERS WHO HAVE NEVER USED THE CADU OX-CART

(a) How do you think the CADU ox-cart compares with traditional methods of transportation?

CADU ox-carts are: BETTER/ / WORSE/ / OTHER.......

(b) If BETTER or WORSE, give reasons.......................

....

(c) If BETTER, why don't you use one?.......................

....

E7 CADU (STATIONARY) THRESHING SERVICE: Have you ever made use of the CADU threshing service?

YES/ / NO/ / OTHER...

If NO, go to question E7.6, page 22

If YES, please give the following details: (OVER)

E7.1 When did you:

(a) First use the CADU threshing service?................(EC)

(b) Last use the CADU threshing service?.................(EC)

E7.2 Do you intend to use the CADU threshing service next season if it is available on the same terms as before?

YES/_7 NO/_7 OTHER.......................................

-----If NO, why not?...

....

E7.3 PLEASE GIVE THE FOLLOWING INFORMATION WITH RESPECT TO THE LAST TIME YOU USED THE CADU THRESHING SERVICE

How much of the following grains did you thresh and by what method?

THRESHING METHOD	QUANTITY THRESHED WHEAT (state unit)	BARLEY (state unit)	TEFF (state unit)
CADU THRESHER			
OXEN			
COMBINE: COMBINING			
COMBINE: STATIONARY			

E7.4 What, in your opinion, are the main advantages of the CADU threshing service over the traditional alternative? (List in order of importance.)

1 ....

2 ....

3 ....

E7.5 What, in your opinion, are the main disadvantages of the CADU threshing compared with the traditional alternative? (List in order of importance.)

1 ....

2 ....

3 ....

E7.6 FOR FARMERS WHO HAVE NEVER USED THE CADU THRESHING SERVICE

(a) How do you think the CADU thresher compares with traditional methods of threshing?

CADU thresher is: BETTER/_7 WORSE/_7 OTHER........

(b) If BETTER or WORSE, give reasons............................

....

(c) If BETTER, why don't you use it?............................

....

SECTION F: CREDIT CONDITIONS

F1 Did you borrow (money, food, seed, fertilizer, etc) during the past two years?

YES/_/ NO/_/ OTHERS..

If NO, go to question F2 below

If YES, please give the following details:

F1.1 Loan details for 1973 and 1974:

LOAN NO.	AMOUNT BORROWED (state unit)	WHEN BORROWED (month & year)	AMOUNT (TO BE) REPAID (OR RATE OF INTEREST)	WHEN (TO BE) REPAID (month & year)	WHO WAS LENDER (see codes* below)	PURPOSE OF LOAN (see codes** below)
1						
2						
3						
4						
5						
6						

CODES *LENDER: 1 = CADU; 2 = bank; 3 = neighbour, relative or friend; 4 = trader or moneylender; 5 = ekub or similar traditional organization; 6 = non-traditional co-operative society; 7 = landlord. IF OTHER, PLEASE SPECIFY

**PURPOSE 1 = food; 2 = seed; 3 = fertilizer; 4 = celebration; 5 = to pay rent; 6 = equipment; 7 = taxes. IF OTHER PLEASE SPECIF

F1.2 Have you ever been unable to repay a loan on time?

YES/_/ NO/_/ OTHER..

-----If YES, what was the result?..............................

....

GO TO QUESTION F3 BELOW

F2 FOR THOSE WHO DID NOT BORROW IN THE PAST TWO YEARS

Have you ever borrowed (money, food, seed, fertilizer, etc) ?

YES/_/ NO/_/ OTHER..

F3 What, in your opinion, are the main advantages of borrowing?

1 ....

2 ....

3 ....

F4 What, in your opinion, are the main disadvantages of borrowing?

1 ....

2 ....