MAKERERE UNIVERSITY COLLEGE

Faculty of Agriculture

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PEASANT AGRICULTURE AND THE NEO-LUDDITES

By

Malcolm Hall

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"the opinion expressed by the labouring class, that the employment of machinery is frequently detrimental to their interests, is not founded on prejudice and error but is conformable to the correct principles of political economy" David Ricardo.

1. Introduction

Ricardo's sudden change of philosophy after previous advocation of the benefits of mechanisation has proved to be ill-founded in the context of western economic development. The smashing of machinery by the Luddites in the early ninetheenth century was a temporary phenomenon catalysed by the dismissal of workers as new machines were being introduced and extinguished by rising living standards resulting largely from improvements in technology. Nevertheless a lingering distrust of labour saving inventions may be diagnosed in the current controversy on the dangers of automation.

In developing countries however, leaders have been clamouring for the wholesale adoption of improved technology, much of it being of a labour saving nature. Economists working in these areas have in general counselled a cautious approach to this transfer of techniques developed in countries with a different pattern of resource endowments and their advice has often produced irrational and emotional reactions. In view of the importance of achieving correct inter-sectoral and intra-sectoral allocations of resources it is proposed to examine this question of choice of technique in the context of the economies of the developing countries. A macro-economic examination of the whole economy will endeavour to pinpoint the key factors affecting national level decisions. Decisions at the farm level will then be discussed and an attempt will be made to draw together both ends of the spectrum.

2. Capital and Labour in the Development Process.

Of the many economists who have interested themselves in the question of choice of technique the majority have based their arguments on the model of the dual economy[1] subscribed to by Eckaus[2], Higgins[3] and Lewis[4] who

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1. This 'technological dualism' should not be confused with the earlier dualism concept propounded by Boeke which was a sociological theory refering to the supposed differences in decision-making criteria between eastern and western cultures. See Boeke, J.H., Economics and Economic Policy of Dual Societies. New York 1963.
2. Eckaus, The Factor Proportions Problem in Underdeveloped Areas, American Economic Review. September 1955, pp. 539-65.
3. Higgins Economic Development and Cultural Change, January 1956, pp. 99.
4. W.A. Lewis, Economic Development with unlimited supplies of labour. Manchester School Vol. XXII, May 1954. A Further Note, Jan. 1958.

further developed the concept. The term essentially refers to the dichotomy which is apparent in most developing countries between what Lewis referred to as 'the modern or capitalistic sector and the traditional or subsistence sector.' It is argued that the supply of labour in such economies is abundant and that capital is in short supply. Whatever capital is available should go first to the manufacturing sector which should be given top priority. This allocation of capital to industry would leave a very small amount of capital for agricultural investment but, assuming the normal capital-intensive form of investment in industry, the stock of labour in agriculture will remain very high. This residual capital should therefore be used to create as much employment as possible. In this way the developing countries will make the best use of scarce capital in the early stages of growth.

It is necessary to further examine the facts which lie behind this rather oversimplified description of the mainstream of thought in the area of choice of development policies.[1] One of the basic tenets of the approach is that a labour-surplus situation exists in developing countries and that the marginal product of labour is therefore very low. It was once very popular to talk about a zero marginal product for labour but economists are increasingly sceptical about this.[2] The fact that farm labour is hired at all in these countries has been held to invalidate the theory. This is not necessarily true, as it has been pointed out that since the land - labour ratio varies from farm to farm so must the marginal productivity of labour on these farms and therefore labour could be attracted from farms with labour surplus to those where the return to labour is higher.[3] This process could even take place to some extent in such a relatively overpopulated country as India. Another possible source of confusion arises from the fact that the number of hours worked per adult tends to vary inversely with the size of the family labour force in peasant farming, with land limiting. The marginal product of a person's work could therefore always remain positive when expressed as marginal productivity per man-hour whereas if that person were transferred to another sector, labour inputs of remaining workers would increase and the marginal value product per man-hour (of the original worker) could be regarded as being zero. The seasonal nature of agricultural work is also

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1. In this section the writer is accepting the basic assumption of the two-sector model i.e. agriculture is subsistence oriented, there is no technical progress and that land is a limiting factor.
2. T.W. Schultz, Transforming Traditional Agriculture. Yale University Press 1964. Chapter 4.
3. See A. Mathur, The Anatomy of Disguised Unemployment. Oxford Economic Papers. July 1964.

liable to cause confusion, as the marginal value product of labour will fluctuate throughout the year.

The economists' concept of the theoretical wage rate necessary to attract workers from the 'so-called' subsistence sector into the manufacturing sector is also open to some argument. Lewis placed this rate at the marginal value of subsistence production and others at the level of the average productivity of family labour because all produce is shared amongst the peasant family. Many writers have also pointed out that some sort of premium must be paid on top of this basic level in order to overcome the inertia resulting from religious or social forces. In practice the theoretically assumed level of non-agricultural wages is distorted by the pressure of trade unions and the political force of the more vociferous urban population pushing the wage rates up to ever higher levels. Another factor encouraging the substitution of capital for labour is that, at any given wage rate, a larger number of workers have to be employed to the extent that labour in the developing countries is relatively inefficient because of a low educational level which might frequently be coupled with a poor standard of health. Bhatt[1] has given several examples of the difference in labour productivity between the U.S.A. and India and included the following instance. "For the operation of an electric crane one man is sufficient in America against three in India - - - three men are required to drive a riveting machine (in India) which would be handled by one man in America."

Soaring rates of population growth caused by the combination of falling death rates with steady or slightly rising birth rates and the relatively slow pace of growth of the industrial sector has led to a net increase in the rural populations of the developing countries. This feature reinforces the expectations the two-sector model gives rise to concerning the existence in the rural sectors of the phenomenon described by Nurkse as "disguised unemployment". The situation has been further aggravated by the slowly rising efficiency and stability of the non-agricultural labour force and the tendency of employers to intensify the use of existing capital and to substitute capital for labour in the face of continually rising wage rates. This has led to the paradox of a stagnant wage labour force receiving steady wage increases whilst transfer of labour eager to enter wage employment is blocked by the predictable reactions of employers to rising wages.

The above discussion suggests that in such circumstances current factor prices are not very reliable guides to the optimum allocation of resources from a national viewpoint, the social cost of additional labour inputs in the controlled wage sector being obviously lower than the wage level. Thus although some economists (e.g. Messrs. Dobbs, Galenson and Leibenstein) use a wage cost criterion for labour allocation purposes

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1. V. Bhatt, Capital Intensity of Industry. 1956.

the modern tendency is to use a rate which reflects the opportunity cost of this labour in the economy as a whole.[1.2.] Others go even further and consider unskilled labour to be free in the context of the economy as a whole.

The above approach to resource allocation will of course favour labour intensive processes in comparison to those demanding large proportions of capital but planners are not always free to follow this course. Many manufacturing processes demand relatively rigid production techniques which are of a capital intensive nature. The development of a steel industry, for instance, is heavily dependent on relatively large injections of capital and many consumer goods demand complex capital intensive production lines in order to produce the desired quality of goods. Since most modern technology has been developed in a high wage environment small quantities of relatively skilled labour are required and this labour must also be imported in many cases thereby adding to the drain on foreign exchange. Capital intensive techniques on industry have also been advocated on the grounds that they avoid economic stagnation and lead to faster long-run growth. The basis of this contention is that urban wage labour has a tendency to spend on consumer goods to such an extent that inflation could result from a switch to labour-intensive manufacturing techniques.[3] Other writers have warned against the use of labour on capital creating projects such as dam building on the grounds that wages are paid, yet no short run increase in production is forthcoming, thereby giving rise to an inflationary situation[4]. To the extent that these warnings are true there would seem to be an area of conflict between techniques which employ labour and maximize immediate output levels and those which veer toward the use of capital and generate more savings for future growth. Apart from the fact that urban wage labour can provide a market for agriculture and in addition, by remittances can be a means of injecting capital into it, this conflict is also limited by discontinuities in the technical co-efficients in much of the manufacturing sector.

The existence of a whole array of criteria used to judge the suitability of techniques has also served to confuse discussions of the problem. The ratio between capital and labour has been advanced as the most important socio-political criterion and the one therefore of most concern to society as a whole. It is obvious, however, that this

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1. K.N. Raj, Economic Aspects of the Bhakra Nangal Project, 1960 Chpt. 2.
2. A.E. Khan. Investment Criteria in Development Programmes. Quarterly Journal of Economics, February 1951.
3. Galenson W. & Leibenstein, H., Investment Criteria, Productivity and Economic Development. Quarterly Journal of Economics, August 1955.
4. Sharman, A.D., The Problem of Factor Proportions in Underdeveloped countries. Indian Journal of Economics, July 1957.

is by no means the only criterion which is considered in practice, as most discussions on technology centre on the incremental capital - output ratio, the usual indicator of the efficiency of capital use. But this can be very misleading unless the circumstances to which it is applied are fully specified. The interaction of diminishing or increasing returns to scale with decreasing returns due to changes in factor proportions is highly complex and constantly changes with the depth and scale of investment. Capital applied to land which is in limited supply, for instance, may soon show an increasing ratio due to diminishing returns resulting from the changing capital - land ratio whereas capital invested in large scale industries may exhibit a very favourable capital - output ratio as it enables the exploitation of scale economies. The most favourable capital-output ratio technique does not necessarily achieve the most labour-absorbing factor mix.

The criterion known as the surplus-capital ratio is also used as it serves as an indicator of the generation of savings by using a particular process, as the surplus is computed by subtracting the wage bill from the value added. Some processes which minimize the capital-labour ratio lead to unfavourable co-efficients for both surplus and gross output[1] and it is conceivable that a choice between alternative technique could result in choosing one having the lower S/K ratio but with a K/O ratio which was relatively unfavourable. Bad maintenance of equipment, defective manufacturing conditions, deficiencies in work methods and poor administrative control tend to lower K/L and raise K/O ratios in the underdeveloped countries. Other factors common to these countries such as shortage of skilled man and general uneconomic size of plant raise both the K/L and the K/O ratios as compared with developed countries.

Since the above criteria are not even positively corellated and as no agreement is forthcoming between economists on the weighting of future growth against immediate output it cannot be claimed that the theory of choice of technique is well defined as far as national-level planning is concerned. Even a well defined theory would be difficult to use as the computation of accounting prices as opposed to market prices is still at a rather unsophisticated and unpractical level. Nevertheless it is generally agreed[2] that developing countries should concentrate on the rapid development of natural resources such as mineral even if this involves the allocation of large quantities of capital and hope that the rest of the economy will be stimulated. Agriculture is recognised as a vital sector but with only a secondary claim on scarce capital. It should not be

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1. A.S. Bhalla, Oxford Economic Papers March 1965. Methods of Milling Rice.

2. W.A. Lewis, Development Planning The Essentials of Economic Policy 1966. Chpt. 2.

allowed to hamper development through inflationary food deficits but the poor export price prospects for most primary commodities have encouraged a continued focus on the development of the industrial sector. This sector is envisaged as the main factor pulling the economy along and agriculture is not expected to push very hard, only to avoid acting as a brake. As many industrial processes demand capital intensive techniques and agriculture has a broader tolerance of differing factor proportions it will continue to be the sector where labour intensive techniques should be favoured in order to reduce the competition for capital, which must go to the faster growing capital-using sector.

3. The Orthodox Approach Reconsidered

A closer look at the conventional wisdom surrounding the question of choice of techniques should pay dividends as a great deal of what has been written is based on the situation found in the densily populated countries of South-East Asia. The land poverty of this area at the current level of agricultural techniques has been largely responsible for the present situation but it has been aggravated by previous planning decisions. The chronic shortage of foreign exchange and the inelastic food supply have been largely brought about by too much concentration on heavy industry and an almost total neglect of agriculture. India is the main example of the effects caused by this approach whereas Japan seems to have avoided them by adopting policies described below. Other parts of the developing world have not yet committed themselves to the development of heavy industry to the exclusion of agricultural development and their resource situations, especially in Africa, reflect a much more favourable land endowment comparative to present population densities. As a result, some of the phenomena described above such as inflation caused by labour intensive capital creation and a slowing down of long run growth rates by employing labour intensive techniques in the industrial sector need not apply. The normative approach of labour intensive techniques employing large number of workers at reduced wage rates has not been considered. It remains, however, a possibility.

The continued existence of export opportunities for raw materials and processed goods derived from agriculture also means that the opportunities of high rates of return are not absent in agriculture as is often assumed. Technical progress in agriculture, increases in the scale of export crops and the development of by-products have usually been overlooked in the writings of economists interested in choice of technique.

Economists have also tended to concentrate on manufacturing techniques, thereby neglecting many problems found in the agricultural sector. Here certain factors unique to agricultural production could influence calculations to such an extent that optimum decisions based on criteria development in industry could be incorrect.

The experience of agricultural development in relatively advanced countries with differing factor endowments might also provide some rewarding insights into some of the current problems of agriculture in the developing world. Comparisons and deductions must however be made very carefully as the question of the optimum pattern of tecnhiques is a dynamic one, changing with technological progress, relative factor prices and the general educational level of the community. A quick survey of the way Russia, China, America, United Kingdom and Japan have developed their agriculture does show interesting contrasts, resulting mainly from differing resource endowments although political and social factors have also played a role.

American agriculture in the 1800s suffered from a severe labour shortage as the country was still very thinly settled whereas British agriculture faced a situation where labour was relatively plentiful. The pattern of development was correspondingly different as labour saving devices were developed in America whereas capital investment in British agriculture took the form of land replacing techniques. As a result, the progress of mechanization in American agriculture was extremely rapid and the labour coefficients dropped dramatically for nearly all crops whereas yields remained rather low. The total agricultural output was doubtless maximized in this way as much more land could be cultivated. In the early 1800s corn yields stood at around 25 bushels per acre and one hundred years later they only averaged around 25.9 bushels, whereas labour demand per acre fell from 86 man hours to 38 man hours. With wheat, the picture is similar, yields actually falling from 15 bushels to 13.9 bushels per acre whereas labour demand fell from 56 man hours per acre to 15 man hours in the same hundred year period.[1] In the United Kingdom, on the other hand, capital investment took the form of drainage improvements, land enclosure and the development of new rotations; all these measures being primarily designed to increase returns to land. Little interest was shown in labour-saving devices and there was an incipient feeling against machinery which paralleled the Luddite outlook of many industrial workers. Thus it was said of Jethro Tull in 1840 that he was "wicked enough to construct a machine which - - - beat out the corn without manual labour". It is interesting to note that in present day Britain the attraction of better pay and conditions outside the industry has forced British farmers to save labour by mechanising agricultural

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1. Historical Statistics of U.S. Colonial Times to 1957. Washington D.C., U.S. Census Bureau 1960 series K 86-97.

operations at a speed which can hardly have been matched anywhere else in the world.

Russian agriculture has mechanized to a tremendous extent during the present century, largely owing to the determination of the post-revolutionary government to develop a heavy industrial sector. This development strategy was however based partly on Marxist theory and partly on the need to develop a defence manufacturing potential as quickly as possible, the agricultural machinery was as it were a by-product of these actions. Large scale mechanized farming was seen as the answer to the poor performance of the agricultural sector which was mainly caused by the abolition of free market prices and the system of compulsory deliveries. The opening up of virgin lands to agriculture was chosen as the alternative to structural and institutional reforms although these latter alternative would probably have been more successful. The mechanized sector of Russian agriculture has never quite solved its organisational difficulties and the economy still depends heavily on supplies of vegetables and livestock products raised under labour intensive conditions on the small plots adjoining the huge collective farms. The other large communist country, China has based its development on labour intensive cultivation methods and capital is created in the rural sector by organising huge work groups using simple tools, carrying baskets etc. She has also based her defensive capacity on a labour intensive basis, relying on large numbers of troops rather than technically sohpisticated weapons.

Japan has achieved a phenomenal rate of industrialization largely as a result of the benefits of increased agricultural productivity. The country was densely populated even when it began its period of rapid development in the late nineteenth century yet more food production was needed at the same time as labour was flowing to the non-agricultural sectors of the economy. What capital could be spared for agriculture was therefore used in both land-saving and labour-saving investments. As a result agricultural output increased by 77% during the thirty years between 1881-90 and 1911-20, while the area under cultivation increased by only 21% as compared with 46% rise in yields; and the labour force in agriculture fell by about 14%. This was achieved on farms of an average size of around 2-3 acres mainly by the use of improved husbandry methods and with comparatively modest inputs of capital mainly in the form of fertilizers. The change was also largely powered by a massive build up of research and education facilities.

The experience of the wide range of countries above has been considered in macro-economic terms but the concept of land and labour-saving investments will be of use in a further micro-examination of the problem of capital intensity. The two types of investment are not clear cut, for

instance the mechanization of crop cultivations is mainly labour-saving but the improved quality of work could raise yields by land-saving. Labour-saving investments, mainly in the form of machinery are usually assumed in most discussions of capital injection into agriculture and the whole spectrum of alternative inputs which are mainly designed to raise yields often ignored. It is this class of inputs however, which is of most importance to the development of agriculture in many countries. Improved seeds, insecticides, and fertilizers could give very high returns to capital invested in them and it could be argued that if investment in the rural infrastructure and the agricultural extension service is treated in the same way as power and educational investments are so regarded for industry, the K/O ratio of investments of this type would be very favourable compared with industry. It is only in circumstances where production is not backed up with a suitable infrastructure and institutional arrangements are poor that low returns are obtained from this type of investment. Other constraints which will be dicussed later also ensure that heavy investment in labour-saving techniques will in most cases lead to a high K/O ratio.

Agricultural firms differ markedly from most others in their very large range of sizes. This range is wider, if anything, in the developing countries and it is further increased by the variation of family size which is not corellated with acreage owned. This means that the labour-land ratio varies tremendously even in peasant farming areas where land is in relatively short supply. The result of this heterogeneity is that one or two optimum techniques which will cover the whole range of factor situations cannot be formulated for agriculture as they can for most manufacturing industries where there is more control over factor proportions.

The seasonality of production in agriculture also presents problems as the marginal productivity of labour varies at different times of the year depending on climatic conditions and the crop mix and sometimes the only alternative to work on a particular crop might be to take more leisure. Husbandry standards at all stages of the production process will affect the quality and quantity of the final product however and it is therefore very difficult to guage labour productivity at different times of the year. The seasonality of production combined with the range of discrete operations necessary, means that either multipurpose machinery must be used or a whole range of machines must be available. The large range of crops grown on most peasant farms, because of rotational and risk-sharing considerations, coupled with the general small size of these farms further reduces the opportunity of securing economies of scale by the use of machinery in peasant agriculture.

In general the necessary level of skill to use and maintain anything but the simplest tools is absent in developing agriculture but this situation may change rapidly as more resources are poured into education. In the meantime any large scale farm mechanization effort involves the hiring of expensive expatriate technicians and engineers.

Some developing countries have already experienced rising food prices and resulting inflation because of their neglect of agriculture but it is extremely doubtfull whether mechanization is the answer to their problems even though some form of capital injection appears necessary.

4. The Agricultural Situation in East Africa

The question of the optimum degree of mechanization for East African conditions cannot be easily answered because of the variety of types and structure of agricultural firms in the area. Some districts have very good ecological conditions for most types of agriculture whereas others are only suitable for stock rearing. Population densities vary greatly and the highest pressures do not always coincide with the best agricultural land. Many of these areas are associated with perennial crops and steep slopes where any type of mechanization is hard to envisage.

The majority of farms are peasant owned but estates make an important contribution to the total output of cash crops and the incidence of large scale, government initiated, mechanized schemes is increasing. To achieve the necessary economies of scale in the peasant sector it is necessary to arrange hire services where machinery pools serve large numbers of farmers. Estates and large farms are able to avoid the organisational complications of hiring as they are large enough to utilize whole units of machinery. Most estates, however, grow perennial crops where the scope for mechanization is extremely limited and except for sugar plantations, machinery is confined to processing and transport activities.

Even among the arable crops the desirability of introducing capital intensive techniques varies. Crops which are grown on large acreages and which can be fully mechanized over the whole production process offer opportunities for reducing the labour force and obtaining lower production costs by using a limited range of machinery very intensively. Most crops, however, can only be partly mechanized and capital cannot be utilized for a large part of the year. This is acceptable if a restricted use can cut production costs or raise revenue to a greater extent than added mechanisation costs, but overheads are usually too high to allow this under these circumstances.

The wage labour force is stagnant over most of East Africa and populations are rising rapidly. The number of unemployed school leavers rises each year exerting a downward pressure on wage increases and it can fairly be concluded that industrial wages are unlikely to go on rising as they have in the recent past. Rural hired labour is therefore likely to remain at low wage rates whereas the quality of individual workers is liable to

rise, This means that manual labour will remain relatively cheap, but on the other hand the numbers of farmers and even farm workers able to handle and maintain machinery will also rise thereby cutting down mechanization costs. The social cost of agricultural labour will also remain very low. Although this and population absorption considerations need not concern the individual farmer when making technique decisions they should influence government credit, subsidy and ex- ion policies and the future growth and policy of government schemes.

Farm level decisions are concerned with the effect of choice of techniques on the level of costs and their possible effect on production. Land-saving techniques are generally of a labour absorbing nature, although the possibili- /yieldsty or better quality and/ has been previously mentioned as a by-product of some essentially labour-saving innovations. The displacement of animal power by motorized processes can also be claimed as a land-saving change as land previously set aside to provide fodder can be utilized for cash enterprises. Increased yields can result from the adoption of techniques which are primarily labour-saving owing to improvements in timeliness (sowing dates), speed (harvesting in brief dry spells) and increased efficiency (optimum plant populations and spacing, more efficient spray and fertilizer application) In areas of excess land, mechanization might also enable total cultivated area to be raised. These potential benefits are however, often unrealised in East Africa because of partial mechanization of the production process. If seedbed preparation is mechanized, for instance, the benefit of early planting might be lost due to poor spacing and weeding carried out by hand. Even if these operations are carried out adequately, a poor variety of seed will prevent a full return from the improved inputs,as good husbandry must be practiced throughout the production process. Failure to mechanise all operations in the production process might also lead to the replacement of one bottleneck by another[1]. A mechanized seedbed preparation could simply mean that weeding labour becomes the limiting factor. Mechanisation of this operation means an increase in production costs as labour,often family labour with a low opportunity cost, must be replaced by money outlays and assumes that row cropping is practised. Even though increased acreage could increase net output, land shortage on the individual farm or short run cash constraints could prevent the realization of this potential. Figure I, illustrates one aspect of the problem in a diagramatic form. The production possibility surface can

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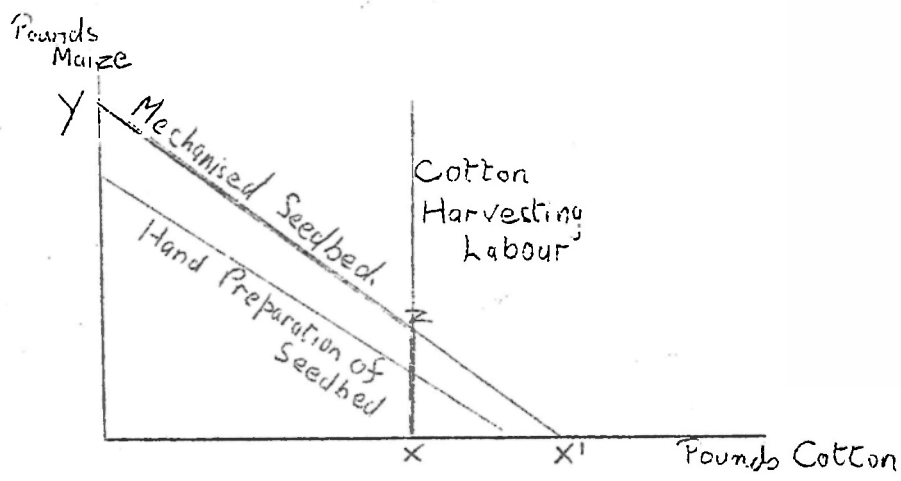
1. M. Okai, Some Aspects of Labour Use in Lango District, R.D.R. 25.

be extended outwards by mechanising seedbed preparation but the harvesting bottleneck ensures that the realisable curve is only YZX thereby preventing full returns to the mechanized operation represented by curve YZX[1]

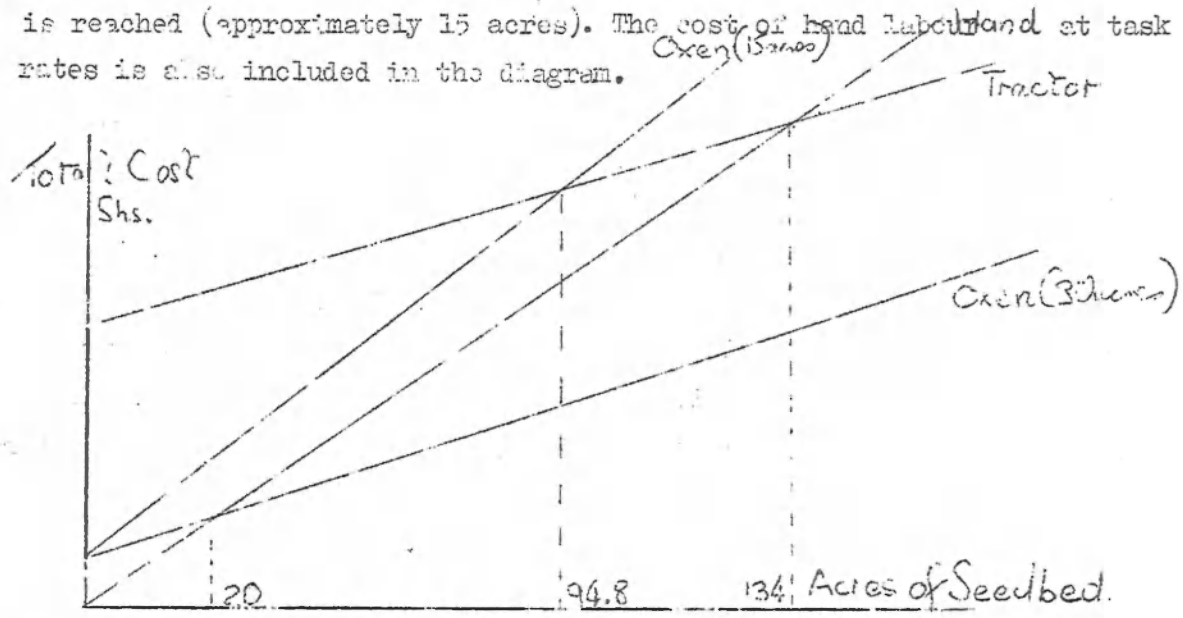


One other aspect to labour saving techniques is the ability of many of these techniques to reduce drudgery and to create more pleasant working conditions. This may be of importance in peasant agriculture where many workers are chronically ill or malnourished and may be enabled to work longer hours using the more capital intensive techniques. As labour productivity is raised by such techniques the marginal value product of an hours work must also be raised. This will have the effect of raising labour inputs in a farm family labour context where the return to an hours extra labour may be equated with the utility derived from one more hour of leisure.

5. Optimum Techniques for Various Types of Operation .

The most common technique used to decide the optimum method of carrying out a particular operation is the calculation of the break-even point. This involves the calculation of that scale of production, (most commonly expressed in terms of the production unit e.g. per cow of per acre) above which the total cost of production becomes less if the more capital intensive technique displaces the labour intensive alternative. The calculation involves dividing costs into their fixed and variable components. Fixed costs comprising depreciation, taxes, insurances and usually the machine operators' wages, and variable costs being made up of the direct costs of the operation such as fuel and repairs. The more capital intensive techniques have, of course, higher fixed costs but their variable costs rise more slowly and at a certain output these techniques may result in a lower total cost than labour intensive methods. The costs of a 35 h.p. tractor plus the conventional implements for preparing a seedbed are given in Appendix One in a form which indicates the fixed and variable cost elements. This equipment should be capable of preparing one acre of seedbed in four hours at a total variable cost of Sh 36/-

An ox-team with a plough and harrows would have a much slower rate of work (approximately ½ acre per day) and virtually no variable costs so that total cost[1] would only rise as more ox-teams were created. Figure 2 shows the break-even acreage assuming the above cost structure(if the tractor was used for other operations its costs would be lowered) A similar quality of work is assumed using the two techniques and a two month seedbed preparation season necessitates the use of more than one ox team after a given acreage is reached (approximately 15 acres). The cost of hand labour and at task rates is also included in the diagram.



The break even point can also be calculated by an arithmetic method by solving the equation which represents the cost functions of the competing techniques.(n.b. the total cost of ox-cultivation should strictly be shown with a step-like function.)

For Technique 1 $T_1 = F_1 + V_1U$

For Technique 2 $T_2 = F_2 + V_2U$

For Techrique 3 $T_3 = F_3 + V_3U$

Where:-

T represents total costs

F represents fixed costs

V represents variable costs

U represents output level

There is only one output level where

$$T_1 = T_2$$

or $$T_1 = T_3$$

or $$T_2 = T_3$$

The break-even point between techniques 1 and 2 will occur at output levels U_1 at which level

$$F_1 + V_1U = F_2 + V_2U \quad \text{and} \quad \therefore U = \frac{F_2 - F_1}{V_1 - V_2}$$

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1. See Appendix One for assumptions on ox-ploughing costs and hand-labour details.

The break even point for the above example is therefore $\frac{1222 - 442}{98 - 36} = 94.8$ acres if the fixed costs of one ox-team are converted into variable costs per acre of seedbed prepared.[1] The costs of seedbed preparation by hand are also also given in Appendix 1 and it is interesting to note that under the given assumptions it is always cheaper than ox-cultivation. If there are two planting seasons however, ox-cultivation costs go up in steps of 30 acres and it becomes cheaper than hand cultivation at below 20 acres and tractor cultivation only becomes economic at 556 acres./ Since the majority of peasant farms are far smaller than this , or even 50% of this assuming two growing seasons, private tractor ownership in the majority of cases, can only be profitable if hire work is pursued. The heavily subsidized government hire services, however, prevent private owners from being successful hirers unless efficiency is extremely high and government services are not available. At present market prices, therefore, it pays the majority of farmers to prepare their seedbed either by hand or by oxen. Tractor costs can be spread if other operations are mechanized but the difficulties of profitably achieving this are described elsewhere. If ex-ante evaluation was carried out using relevant accounting prices, tractors would indeed be a rare sight in East Africa and even using market prices profitable circumstances are few and far between.

Wage labour costs in the peasant farming sector of the East African economy are not subject to government control and are therefore much lower than those in the manufacturing sector or on institutional farms. They range between 50 cents to one shilling per hour or 30/- to 60/- per month, as this class of worker often receive non-monetary benefits in addition to wages. The wage which should be attributed to farm family labour is notoriously difficult to compute as it is best reckoned in terms of the highly variable opportunity cost of the labour. When calculating the least cost technique it is therefore important to know whether the labour associated with it has to be hired or if it is to be provided by the family, the alternative use for the labour must also be clearly formulated. To avoid this difficulty any calculations made in this paper will assume that all labour is hired at sixty shillings per month unless there is a statement to the contrary as in the case of workers possessing special skills.

Boon[2] has attempted to apply modified accounting prices to farm level decisions with some very interesting results. He computed the costs of various types of labour by considering training costs in terms

/much greater than tractor capacity

1. See Appendix 1 for details.
2. Boon, G.K., Economic Choice of Human and Physical Factors in Production, 1969. Chpt. 1.

of total capital invested in the training of workers with five different levels of education; the more capital intensive agricultural processes require workers with higher degrees of skills. The concept of accounting prices was also applied to capital inputs and the series used was considered to be applicable to the developing countries as a group. Break-even calculations were also made using Dutch market prices for labour and capital Boon compared eight different methods of ploughing ranging from a Burmese ox-plough to a trailed eight furrow plough pulled by a 55 h.p. track laying tractor.

Table 1. Alternative Methods of Ploughing[1]

Code No.	Type of implement	Type of pulling
1A	Burmese indigenous plough	Pair of oxen
1B	'Eberhard ST 30' plough	Pair of oxen
1C	'Eberhard KK 30' plough	Pair of oxen
1D	'Eberhard KK 30' plough	Pair of horses
2	Trailed 3-furrow	Wheel tractor 28.5 h.p.
3	Trailed 4-furrow	Track layer 26 h.p.
4	Trailed 6-furrow	Track layer 40 h.p.
5	Trailed 8-furrow	Track layer 55 h.p.

It was found that when the system of accounting prices was used, the simple ox-ploughing method (1A) was optimal up to 135 acres. Above this acreage method 2 became cheaper and remained so for any subsequent acreage. The most highly capitalized ploughing methods would not find a place in the agriculture of the developing countries if Boon's assumptions are correct. In contrast, the results derived from the use of Dutch market prices indicated more intensive capital choice at equivalent acreages, this is indicated in Table 2.

Table 2 The Optimal Pattern of Ploughing Methods Using Market Prices

Ploughing Method	Optimal Range in Acres
1A	0 - 0.3
1B	-
1C	-
1D	0.3 - 0.6
2	0.6 - 120.0
3	120.0 - 150.0
4	150.0 - 500.0
5	500.0 -

1. op. cit. Chpt. 5.

Similar indications were obtained when a range of techniques was considered for the remaining operations concerned with grain production and Boon concluded "The analysis proves that for the first type of country (the underdeveloped countries) the mechanization of the agricultural processes is not justified - - -".

If these conclusions are correct we must investigate the reasons for the existence of mechanized cereal production in East Africa. Are the producers using those techniques losing money through their wrong production decisions?; the answer to this problem highlights a weakness in Boon's approach. Because of price protection, cereals are a highly profitable type of crop to grow in suitable areas, in comparison to existing alternatives. This means that farmers have the incentive to maximize cereal acreage, yet planting periods are restricted and speed of harvesting is important if cereal quality is to be maintained and the installation of expensive drying facilities avoided. It is extremely inconvenient, and in many cases impossible, to recruit the very large numbers of workers which would be seasonally demanded if cereal farming is to be carried out on a large scale using labour intensive methods.

In these circumstances cereal farmers are forced to mechanise if they are to take full advantage of this lucrative enterprise. It is very important not to overlook those aspects of capital intensive methods which enable larger acreages of the more profitable crops to be grown than would otherwise be the case.

Machines specifically designed for small farms have so far not met with much success in East Africa, partly because of complexity, poor maintenance standards and poor service facilities but mainly because they did not offer a cheaper alternative to hand labour on the acreages for which they were designed. The walking tractor type of machine with a rotovator attached was advocated for weeding purposes in smallholding coffee but very few of the original purchasers continue to use them and most have gone back to hand weeding methods.[1] The calculation of the break even acreage of machine weeding[2] (assuming four operations per annum and similar quality of work between hand and machine weeding) illustrates why this reaction has occured as the mean farm size in the area in question is around five acres and the farmers are individualistic averse to sharing capital possessions with their neighbours.

Assumptions

Hours per single rotavation per acre using a single axle walking tractor	6.0 hours
Man hours needed to weed one acre once by jembe	35.0
Cost of tractor plus rotavator	Sh 2,600

1. D. Hunt, Some Aspects of Agricultural Credit in Uganda, E.D.R.P. 105.
2. For further details see W.H. Bosloff and D. Innes.

Annual depreciation assuming a 5 year life	Sh 520 per annum
Variable costs of one tractor weeding assuming operator hired by the hour and fuel costs of Sh 11 per acre and Sh 12 per acre for spares and repairs	Sh 29 per acre
Variable costs per acre (4 weedings)	Sh 116.0 per acre
Hand weeding costs per acre (4x35/-)	Sh 140.0

Break-even acreage $\frac{F_2 - F_1}{V_1 - V_2} = \frac{520}{140 - 116} = \frac{520}{24} = 21.1$ acres

If a permanent worker had to be hired at Sh 60 per month the machine weeding would be cheaper if total acreage weeded was over 25 acres. In practice, however, the economic working of the machine depends as much on maintenance skill, the hiring of a worker who will not sabotage the machine because of the hard work it entails and the possession of enough working capital to meet fuel and repair bills. bills

The adoption of harvesting machinery, apart from combined cereal harvesters, has been almost completely neglected in East Africa. Many of the large production units specialize in perennial crops which cannot be easily mechanised without damaging quality e.g. tea so that potential economies of scale remain unrealised. Even with sugar harvesting, where of the quality consideration does not apply, it is still cheaper to harvest by hand although new estates contemplating the cost of workers' housing welfare services and supervision might be tempted to import cane harvesting machinery. The mechanization of cotton harvesting would enable vast acreages to be grown in sparsely populated areas, but the necessity of introducing new varieties, different methods of husbandry and investment in specialized ginning equipment has proved to be prohibitive.

The processing of crops, on the other hand is usually mechanised as the quality of the finished product can be raised in this way and the increased productivity compared with labour intensive methods makes it a profitable investment. Nevertheless there would appear to be plenty of scope for the introduction of hand processing equipment on small farms to reduce the labour and drudgery of food preparation in the rural areas and to free labour for directly productive activities.

Most of the milking machines found in the area are on large institutional farms where wages are relatively high and the commercial farmers who have adopted mechanised milking would appear to place a very high value on the time gained by the resulting decrease in welfare and supervisory responsibilities. An Indian experiment on the effects of different milking techniques[1] has provided useful facts concerning the competitive position of hand milking as opposed to machine milking. One group

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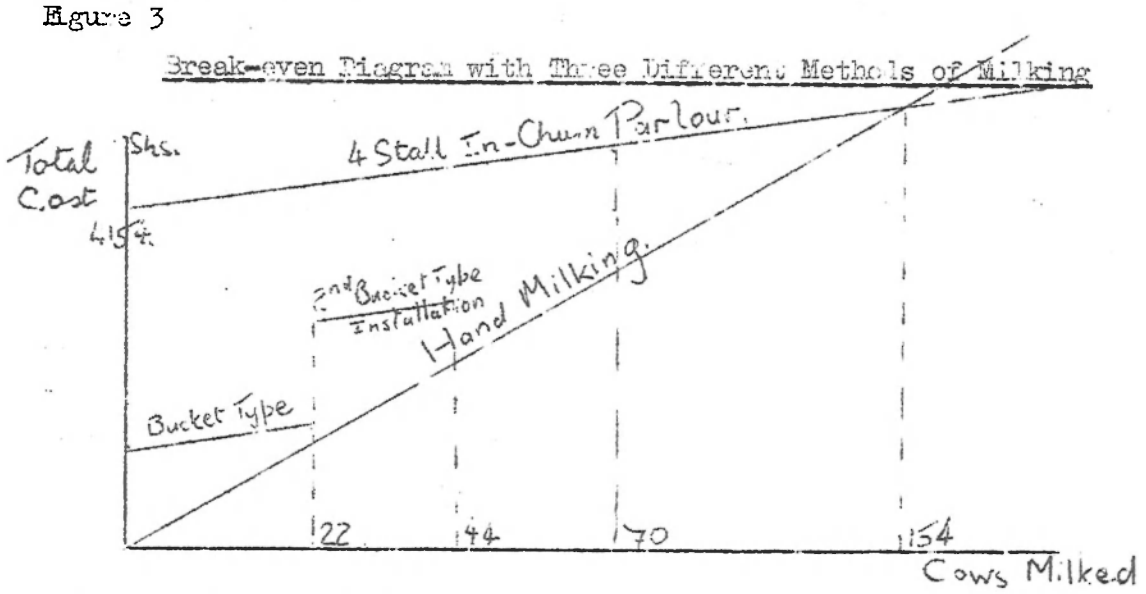
1. Sundaresan, Malik and Tiwari, Milking by machine under Indian Farm Conditions. Indian Journal of Dairy Science. March 1964.

of 40 high yielding cows was milked by machine methods and the other 39, remaining after the initial random selection, were milked by hand. Both groups were milked three times a day, the machine milked cows by two men while three others did the hand milking at a rate of 8-10 cows per hour and 12-13 cows per milker. Total labour in man hours for machine milking was 56% of that taken to complete the hand milked group (9.6 man hours per day as opposed to 16.9 man hours) but the keeping quality of the milk from the two groups was not significantly different and the yields from the hand milked groups were better maintained. A break-even calculation was not performed by the authors but one has been attempted below using physical data and market prices likely to apply to East African conditions.[1] Wages will again be assumed to be those commonly encountered i.e. Sh 60 per month although it is likely that the milking machine operators would have to be paid more and any accounting prices derived using Bean's approach would definitely accord them a higher wage and further militate against the selection of mechanised arrangements.

Figure 3

Break-even Diagram with Three Different Methods of Milking



Technique A (hand milking) is cheaper that Technique B at all levels of production and cheaper than technique C up to around 154 cows. This throughput is beyond the capacity of the set-up and cannot be achieved without expanding the installation and therefore increasing the break-even number of cows milked. Given the validity of the assumptions made, there does not seem to be a case for machine milking at present although the numbers of milkers needed to handle very large herds may cause an efficient machine arrangement to become economic if the housing and supervisory costs of hand milkers are considered.. It has been observed that on those farms where milking machinery has been installed the hoped for reduction in labour has seldom been achieved owing to the general low level of technical skills available and even the maintenance of low levels of mastitis and clean milk demands a relatively high level of supervision. It is likely that only the most efficient

1. See Appendix 2 for details of the costs of the different milking techniques, their capacities, and the break-even calculation.

and easily maintain equipment will give anything like the possible throughput and labour productivity through the employment of a minimum number of highly trained and well paid milkers. The higher wage demanded by this class of worker may however prevent any reduction in total wage payments while involving heavy investments in buildings and equipment. Unlike many other forms of labour saving machinery, milking machines do not offer opportunities for raising yields except in the case of very high milkers where the faster milking rate achieveable by machine enables the complete milking to take place during the limited time which is optimum for milk let-down.

Conclusion

Many production processes in the industrial sector of developing countries are capital demanding and this sector will therefore absorb the greater part of their available development capital and foreign exchange resources. Although most of the currently developed countries have achieved their present status by exploiting agriculture in order to finance industrial development there is a danger that too much neglect of agriculture will limit the market for the new manufactured products and may even lead to inflationary food shortages. The Japanese[1] example of development would appear to be desirable as in this case productivity rises led to cheap food and the release of workers for industry. Other countries could emulate this approach and increase their agricultural exports simultaneously. Attempts to introduce labour saving machinery have been generally unsuccessful in developing countries as the potential benefits of yield increase have been frustrated by poor husbandry practices in the non-mechanized operations and the possibilities of bringing more land into production have not been fully realised owing to non-mechanised bottlenecks in other parts of the production cycle. To obtain low production costs using mechanized methods, these bottlenecks must somehow be eliminated and farming must be carried out on a large enough scale to obtain the economies of scale resulting from the spread of overhead costs. The time, effort and resources required to bring about large structural changes in peasant agriculture has generally been seriously underestimated, however, while the development possibilities of quite small capital injections in the form of improved seeds fertilizer insecticides, and pesticides, have been neglected. This is regretable as this type of investment will often increase returns to labour as well as land and at the same time absorb more labour. Even if larger amounts of capital were forthcoming it is likely that higher returns could be obtained by investments in the rural infrastructure, the extension services and research facilities.

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1. S. Ohkita, Choice of Techniques: Japan's Experience and its Implications in Economic Development with Special Reference to East Asia, edited by K. Berrill 1964.

In the areas where there are seasonal labour shortages owing to a land plenty situation the problem can often be greatly improved by the formulation of new rotations, the teaching of more efficient work techniques and the introduction of improved hand tools. A simple and robust hand seeder together with a pulling-type weeding hoe could greatly increase agricultural production on many small farms in arable crop areas of East Africa and the spread of ox-cultivation on larger farms would achieve the same effect. The possibilities of settling people from densely populated areas into areas of plentifull land should also be considered as a serious alternative to large scale mechanized farms in these areas.

Many of the economic problems of underdeveloped countries have their root in the divergence existing between market and accounting prices. In any country where many decisions are taken by private entrepreneurs this difficultly will exist and in many developing countries it is compounded by the determination of ill-informed individuals to aquire the latest technological innovations irrespective of the economic considerations surrounding the decision. Government fiscal policies could be designed to bring market prices into line with accounting prices. Subsidies could be paid for use of unskilled labour and capital goods could be taxed more heavily in order to bring the ruling prices into a true equilibrum. Before such policies are decided upon, however, the national aims must be clarified, governments must decide whether the primary target for economic development is long run national growth, short run labour absorbtion and maximization of output or some intermediate goal. While the writer does not advocate a Luddite revival in the developing world, it is hoped that some of the considerations which have been raised will illustrate the importance of questioning the widespread acceptance of the latest western technology into a totally alien resource situation.

Appendix One

A. Annual fixed costs of a Super Dexta and Cultivation Equipment

(depreciating to zero value over six years)

(N.B. This example shows a write-off after six years but this is only a book-keeping concept. Depreciation to Ks 1000/- after 8 years or to Ks 4000/- after 5 years might be better.

		Ks
Tractor Depreciation		2983.00
Drivers' wages (200/per month)		2400.00
Vehicle Tax & Insurance		150.00
Disc Plough (5 years)		660.00
Disc Harrows (5 years)		660.00
Tipping Trailer (10 years)		500.00
Total fixed costs	Ks	7353.00

(Overheads resulting from buildings, fuel installation and mechanics are ignored but to some extent they are taken care of in the repair charges included with variable cost calculations).

Variable Costs per Hour (Tractor only)

Repairs (averaged over life of tractor)	3.00
Deisel Fuel @ 4/50 gal. @ 1.25 Gal/hour	5.40
Lubricating oil and grease	0.54
Total variable costs/hour =	9.00

B. Cost of Ox-Cultivation Equipment

1 pair of oxen	1,200
Plough and harness	200
Ox-harrow	150
Total cost	1,550

If the unfavourable assumption is made that the oxen and equipment depreciate to zero value in ten years (oxen in fact may appreciate as they become heavier as they get older) fixed costs per annum = Ks 155
The oxen can usually maintain themselves on swamp edge grazing or or communal pasture but another unfavourable assumption will be made, that the oxen prevent two acres of land being utilized for arable crops and therefore have an opportunity cost of grazing of Ks 300 per acre, a total grazing charge of Ks 600 per annum.

One ox-porter is paid Sh 60 per month looks after the oxen and he is retained throughout the year at a total wage of Sh 720 (he would be available for other work but in this simple illustration this is ignored as the tractor driver would be similarly available).

Total annual fixed cost of an ox-team, equipment and porter is therefore Sh 1475 (or Sh 98 per acre if expressed as a variable cost).

Cost of seedbed preparation by hand (task rates are taken from information obtained in Buganda Region)

First Digging

A one shilling task is approximately 125 sq. yds. i.e. Sh 38 per acre.

Second Digging

This is the final preperation of the seedbed and the work is slower and more painstaking, a task being around 90 sq. yds. i.e. Sh 54 per acre. Total cost of a hand prepared seedbed using a chopping hoe is therefore approximately Sh 92 per acre.

Appendix Two

Milking Costs and Capacities

It is assumed that each milking should not last over 2 hours and the capacity of the two machine arrangements is therefore limited to their throughput in this time period. Medium yielding cows are also assumed. Milkers are paid at the rate of 60/- per month and no interest is charged on capital locked up in equipment.

1. Hand Milking:

One man can milk 8-10 cows per hour, or approximately 15 per two hour period.

Cost of simple building (Sh 1,000) depreciated over 10 years is Sh 100 per annum a bucket and detergent costs Sh 30/- per annum. Wages = Sh720 per annum. Therefore Fixed costs of Hand Milking = Sh 850 per annum, or if expressed in 'variable' costs per cow in order to facilitate arithmetic calculations

$\frac{850}{15}$ = Sh 57/per cow.

2. Bucket Type 2-stall Single Unit

	Sh
Stalls	680
Milking Unit	640
Extra Pail	160
Pump and Accessories	900
Engine	400
Installation	600
Simple Building	1,000
Total Equipment Sh	4,380

Depreciated over 10 years Sh438 per annum

Replacement liners, machine maintenance, detergents etc. Sh150 per annum

Wage for 1/2 milker Sh720

Total Fixed Costs Sh1,308 per annum

Variable Costs per Cow (30 units of electricity) Sh30 per annum

Capacity 11 cows per hour or 22 in 2 hours

Therefore cost per cow is Sh 89 per cow if the equipment is fully utilized.

N.B. A 2 unit arrangement of a similar type could achieve a throughput of 25 cows in two hours with one man milking and little extra investment in equipment. It would therefore be a more economic choice than the single unit arrangement.

3. In churn 4-stall abreast type parlour

Building and Equipment Costs	Sh
Milking shed and Dairy	5,000
4-stall tubular steel	1,650
4 feed hoppers	1,040
In churn milking machine (2 points)	3,240
Electronic pulsator	360
Engine (or motor)	600

Milk room equipment	1,000
In-churn cooler head	250
Cold flow cooler	6,000
	£ 22,340

Depreciated over 10 years £ 2,234 per annum

Replacements, maintenance, detergents 500 per annum

Labour 1420 per annum

Total Fixed Costs £ 4154 per annum

Variable Costs per Cow £ 30 per annum.

Throughput 35 cows per hour

70 cows per milking of two hours.

Break-even point for hand milking with 4 Stall abreast-type parlour

$$\frac{4154}{57-30} = 154 \text{ cows.}$$