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**Economic Aspects  
of Mechanization  
on Medium-sized  
Farms**



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### THE ECONOMY OF MECHANIZATION ON INTER-MEDIATE-SIZE AND LARGE-SIZE PEASANT FARMS

IN the central Swiss plain and the surrounding hilly country the peasant farms may be divided into those of intermediate-size (from 5 to 29 ha. of cultivated land) and those of large-size (from 30 to 69 ha. of cultivated land). The intermediate-size farms are what are called *Kleegraswirtschaften*, that is to say intensive arable farms with a large proportion of rotational clovers and grasses, producing milk and pigs. This group may be subdivided as follows:

Intermediate-size farms	Hectares	Average livestock	
		horses	cow units
Small	5 to 9	1	6 to 12
Medium	10 to 14	2 to 3	12 to 20
Large	15 to 29	3 to 5	20 to 40

By number and by total area of cultivated land, the intermediate-size peasant farms are the most important group of farms in Switzerland.

TABLE I. *Farms and cultivated land in Switzerland*

(Swiss Farm Survey 1939)

Size of farm (cultivated area)	Number	Total area in ha.
Small farms (3-4 ha.) . . .	36,764	121,007
Intermediate-size farms:		
small (5-9 ha.) . . .	59,044	353,026
medium (10-14 ha.) . . .	23,911	235,088
large (15-29 ha.) . . .	15,492	233,912
Large farms (30-69 ha.) . . .	2,429	64,157
Estates of 70 ha. and over . . .	246	17,091
	<u>137,886</u>	<u>1,024,461</u>

#### *Labour organization on intermediate-size farms*

As the general economy of mechanization cannot be studied apart from the organization of labour, Table 2 has been prepared to show the kind of work that is involved on these farms and the way it is done.

The well known fact that yard work occupies more than half (54 per cent.) of all manual labour, whereas field work only takes 40 per cent.,

TABLE 2. *Proportion of the different kinds of work done on Klee-gras-wirtschaften farms in the Swiss Midlands*

<i>Kind of work</i>	<i>Manual labour per cent.</i>	<i>Draught labour per cent.</i>
Work in the cowshed . . .	24	2
Work in the house . . .	22	..
Work in the yard . . .	6	..
Threshing . . .	2	1
Total work in and around the farm buildings . . .	— 54	— 3
Ploughing and cultivating . . .	3	25
Manuring . . .	4	23
Drilling . . .	1	3
Cleaning and weeding . . .	5	3
Harvesting . . .	20	21
Cutting and carting green fodder (mainly grass). . .	7	17
Total field work . . .	— 40	— 92
Miscellaneous . . .	6	5
Total . . .	100	100

is brought out by the table. Most of the draught labour is used in working the land, manuring and harvesting.

On the farms of the hill-country and the Pre-Alps, where grass farming is predominant, the amount of manual labour inside the farm buildings is even greater, reaching 70 per cent. of all the hours worked. The more dairy cattle kept, the more important is the work to be done in and around the farm buildings.

Particulars about the conditions of labour organization on two typical farms, one of medium size, the other of large size, may be seen in Table 3.

TABLE 3. *Labour input for the dairy herd on two Swiss farms in 1951*

<i>Kind of work</i>	<i>Hours worked by men per cow unit per year</i>	
	<i>'Grundhof'<sup>1</sup></i>	<i>'Rossberg'<sup>1</sup></i>
Work in and around farm buildings . . .	215	192
Hay-making in summer . . .	19	16
in autumn (aftermath) . . .	7	10
Silage-making . . .	9	23
Cutting and carting green fodder . . .	34	27
Spreading liquid manure . . .	11	11
Total hours worked . . .	295	279
Cultivated area . . .	14 ha.	41 ha.
Number of cow units . . .	16	45

<sup>1</sup> Names of farms.

On a pure grass farm all the procuring of fodder—all the labour in the fields and for transport—takes about one-third of the time spent working in and around the farm buildings.

Despite the great and regular amount of work in looking after cattle, it is still not highly mechanized. Cows require individual attention, and it is much more difficult to mechanize this kind of work than it is to mechanize the growing of plants. As the work in and around the farm buildings is varied, successful rationalization depends less on machines than on many small improvements in labour technique by which productivity in yard work can be improved. Savings of time and effort have to be made wherever possible, these being of a kind that it might frequently be thought not worth while talking about, such as having doors in the right places, and having equipment where it is wanted, and near at hand. These remedies are also at the disposal of small farmers, who can frequently realize them even better than larger farmers can. These remedies have a further advantage in that as a rule they do not cost very much. Dairy farming is, therefore, a common standby of the peasant farmer in respect of labour economy since he can do more by rationalization than by buying machinery.

Progress in the mechanization of field work has been more strongly marked in recent years. Field work has to be done at set times, and if much of it has to be done at once labour peaks are formed, and are often accentuated by bad weather. If they are not overcome there will be loss of both quality and quantity. Fluctuation of labour demand can be diminished but not entirely removed by good farm organization, the final result being determined for the most part by the weather. In earlier times there was a reserve of family labour on peasant farms, but that is so no longer. It has been drawn off by the demands of the professions and of industry, and the gap left on the farms has to be bridged by increased use of machinery. Today it is the rate at which the field work is mechanized that influences the way the peasant farms. It determines the pattern of his production and his labour organization.

The work of animals provides a basis of comparison for the critical examination of the economic effects of mechanization because the labour economy and technical standards when farming with draught animals are well known. It is known for instance that 150 horse hours are required per annum for one hectare of cultivated land on a *Kleegraswirtschaften* farm with good layout in the Midlands; on fragmented farms with poor layout this figure goes up to 200 or 300 horse

hours. On average 400 or 500 hours a year are worked by the men in the fields for each hectare of cultivated land.

The labour techniques involved in mechanization and the economic problems that it raises vary with the size of farm.

Consider first the smaller intermediate-size farms, using as an example a *Kleegraswirtschaften* with 6 ha. of cultivated land.

With customary farming and average layout the yearly requirement of horse labour is on average 1,200 hours. The question then arises how to meet this requirement by means of a machine with the corresponding supplementary tools and implements, and what the results will be. The purchase price for draught power and tools according to present prices is shown in Table 4. It is assumed that the farmer has one horse of his own and that when he requires a team he obtains a second horse by borrowing from his neighbour. The purchase prices of some important tools are given. The second and third columns show the purchase prices of a two- or three-wheeled tractor, and of a light four-wheeled tractor respectively with their corresponding tools.

TABLE 4. *Purchase prices of draught power and tools*

<i>Implements</i>	<i>Team (1 horse)</i>	<i>Two- or three-wheeled tractor</i>	<i>Light four-wheeled tractor</i>
	<i>Fr.<sup>1</sup></i>	<i>Fr.</i>	<i>Fr.</i>
Draught power . . . .	2,300	4,800	9,000
Horse-strappings and horse rug	650	..	..
Plough . . . . .	650	1,000	1,600
Spade harrow . . . . .	700	750	1,600
Mowing machine . . . .	1,000	800	1,500
Swath rake . . . . .	1,250	900	1,300
Potato lifter . . . . .	800	750	950
Total . . . . .	7,350	9,000	15,950

<sup>1</sup> £1 = 12.25 fr. (Swiss) = \$2.80 (approximately) at the beginning of 1954.

Purchase prices for two-wheeled and three-wheeled tractors are between 4,000 and 5,000 fr.; a light four-wheeled tractor costs 8,000 to 10,000 fr. Striking also is the well-known fact that the power-take-off machines for the four-wheeled tractors are much more expensive than the corresponding machines for animal draught. Unfortunately a parity of prices has not been reached up till now. Continuous efforts to standardize the linkages are necessary so that the supplementary tools can be easily exchanged. As a group the implements for the two-wheeled tractors cost nearly as much as those for animal draught, but sometimes individual items are cheaper. The purchase price

quoted for a four-wheeled tractor with its implements is twice as much as when a horse is used. It does not seem very likely that the whole equipment will be renewed at once. The transition to a tractor is in itself a very big investment for a farm, but sooner or later the exchange of implements has to follow. During the transition period the existing implements should be adapted to the tractor by simple expedients.

If the yearly costs for the three cases quoted above are calculated on the basis of their purchase prices, the following results emerge (Table 5).

TABLE 5. *Expenses per year of draught-work calculated for a Kleegraswirtschaften farm of 6 ha. cultivated land*

	<i>Team (1 horse)</i>	<i>Two- or three-wheeled tractor</i>	<i>Light four-wheeled tractor</i>
	<i>Fr.</i>	<i>Fr.</i>	<i>Fr.</i>
Draught power . . . .	1,200	1,805	2,326
Cost of attendance . . . .	450	90	60
Horseman or driver . . . .	1,350	900	600
Cost of implements . . . .	733	754	949
<b>Total cost . . . .</b>	<b>3,733</b>	<b>3,549</b>	<b>3,935</b>

*Basis of the calculation:*

4 per cent. interest on two-thirds of the invested capital; amortization of the horse at 10 per cent. and of the tractor at 8 per cent. Operating expenses are calculated for a consumption of 2.5 lit.<sup>1</sup> of petrol per hour for the smaller tractor, and 4 lit. per hour for the light four-wheeled tractor.

The cost of the care and attendance of the draught power is calculated on the basis of 300 man hours for one horse per year, and for the tractor at one-tenth of the number of hours worked.

The costs for the draught-power unit are lowest for the horse and highest for the four-wheeled tractor. The tractor is also expected to reduce the necessary labour for attendance, especially when doing team work. According to our investigations, the hours worked by horses on peasant farms are divided approximately equally between work done with only one horse, and with two horses. The expense of work is therefore for a horseman doing nearly 900 man hours. Using full mechanization, one hour worked with a two-wheeled tractor equals two hours with a horse, and one hour worked with a four-wheeled tractor equals three hours with a horse. In the example, therefore, 600 hours are worked by the two-wheeled tractor, and 400 hours by the light four-wheeled tractor. Full mechanization thus

<sup>1</sup> 1 litre = 0.22 Imperial gallon.

reduces the expense of work for attendance and of the horseman to roughly one-half. The charges for implements for a mechanized farm are higher because the tools are more expensive to buy and deteriorate more quickly.

From Table 5 it will be seen that the two-wheeled tractor is cheaper than the horse, but the four-wheeled tractor is more expensive. More important, however, than the difference in total cost is the variation between the groups for different items.

The saving of labour through mechanization may become necessary when there is a shortage of labour on the farm. If labour is in short supply, mechanization is essential, despite an increase in capital costs. If only the costs of draught power and the associated implements are considered, the costs for a horse are very much cheaper than for a tractor. In some small intermediate-size peasant farms the income can be increased by using the reserve of labour, where there is any, and spending less money on machinery. When a farmer is working with horses his output per hour is less. He therefore has to work more hours a day to get his work done, and his return per hour of labour is smaller, but the intensity of the farm is no greater than if he were working shorter hours with a tractor. This was confirmed by J. Petrićević<sup>1</sup> in his study of some of the accounts sent in to the Swiss Farmers Union. From this it can be deduced that, in principle, the time saved by using a tractor must be used for increasing output so as to bring in more money and pay for the machinery. Otherwise no improvement can be expected.

Our calculations show that the two-wheeled tractor costs less than the horse or a four-wheeled tractor up to a total of 1,500 horse hours a year. (This corresponds to a farm with about 7.5 ha. of cultivated land in the Midlands.) This calculation is true only so long as the purchase price of a new two-wheeled tractor is less than 60 per cent. of the purchase price of a four-wheeled tractor. Price, however, is not the only factor since it is essential that mechanization be complete and that horses be no longer required for any operation. This stage has by no means yet been reached everywhere in Switzerland. It is especially difficult to have full mechanization in the hilly areas where horses are still used instead of tractors because of the steep slopes, the higher rainfall, and the long winters with snow. In the ley farming of

<sup>1</sup> J. Petrićević, *Der Traktor im schweizerischen Mittelbauernbetrieb*. Nr. 19 der betriebswirtschaftl. und buchhaltungstatistischen Beiträge des Schweiz. Bauernsekretariates, Brugg, 1949.



the Midlands, mechanization with a two-wheeled tractor is possible where the surface is such that a tractor can do all the tasks. When using a light four-wheeled tractor drilling seed and cultivating for roots is not always easy, but it can be said that between 80 and 90 per cent. of the total amount of draught power required can be done by this kind of tractor. As for the rest, it can generally be done by borrowing horses from a neighbour in return for some tractor work.

Turning now to the middle group of the intermediate-size farms—those with a requirement of 2,000 horse hours a year and up to 10 ha. of cultivated land—it appears that if the whole of the 2,000 hours of horse work can be done by horses (by means of borrowing a horse from a neighbour when required) it is much cheaper than if some of the work is done by tractor. For this size of farm the cost of a two-wheeled or a light four-wheeled tractor would be about the same.

Even today horses which are fully employed are still cheaper than a tractor. The practical difficulty, however, is for a farm which only has horses to complete all the work on time. As a rule the horse requirements of such a farm are above the average, and the farmer must make sure that he has enough horses. Because of this the amount of work done by each horse is less, possibly only 1,200 hours or even less per year. The horses which are most fully employed are found on farms which are only partly mechanized, because there the peaks are broken by the mechanized equipment whereas the horse numbers are fixed according to the average requirements. This combined use of horses and tractors is really suitable only for large farms.

On a farm with an annual requirement of about 2,000 horse hours and with 10 ha. the solution must be found in the interchange of tractors and horses between neighbours. The choice between a two-wheeled and a four-wheeled tractor depends on the individual farmer.

The larger intermediate-size farms consist of those where the annual requirement is about 3,000 horse hours a year and where there are about 15 ha. of cultivated land. To meet this requirement two horses are necessary; as to the tractor, a medium or heavy four-wheeled diesel tractor would usually be chosen. The following table shows the costs.

To start mechanizing a farm in this category involves a very high investment cost because of the need to buy a diesel tractor; also the tools are much more expensive than those for horses, owing to their being tractor-driven rather than having self-drive mechanism. The

TABLE 6. *Purchase cost of draught power and tools*

Item	Team 2 horses	Medium-powered diesel tractor
	Fr.	Fr.
Draught power . . . . .	4,600	12,000
Horse-strappings and horse rug . . . . .	1,300	..
Plough . . . . .	650	1,600
Spade harrow . . . . .	700	1,600
Mowing machine . . . . .	1,000	1,500
Swath rake . . . . .	1,250	1,300
Potato lifter . . . . .	800	950
Total . . . . .	<u>10,300</u>	<u>18,950</u>

purchase price of a tractor and its implements is very high, but a glance at the operating costs for a year shows the position to be radically different (Table 7).

TABLE 7. *Expenses per year of draught work calculated for a Kleegraswirtschaften farm of 15 ha. of cultivated land (assuming 3,000 horse hours per year)*

Item	Two horses	Medium-powered diesel tractor
	Fr.	Fr.
Draught power . . . . .	2,400	3,830
Cost of attendance . . . . .	900	135
Horseman or driver . . . . .	3,375	1,350
Cost of implements . . . . .	909	1,088
Total . . . . .	<u>7,584</u>	<u>6,403</u>

Working two horses for 1,500 hours a year each is quite reasonable, and about 2,250 man hours are required to match the 3,000 horse hours; add to this the hours required attending to the horses and the full time of one man is taken up. The tractor can do the equivalent of 3,000 horse hours in about 900 hours (ratio of one tractor hour to 3.3 horse hours). It is important for making the comparison that the cost of diesel fuel should be cheap and that far fewer hours are required for attending to the tractor. On a farm of 15 ha. it is more common to have non-family workers, so having a tractor may lead to a saving of labour costs, though the difficulty remains that about 300 to 500 hours of horse labour are still needed if good quality work is to be done on the arable land. With two horses the farmer has been able up to now to do all the work which required horse labour on his own, but nowadays because mechanization is progressing, a team of

two horses is not always sufficient (e.g. for a combine-harvester). As a consequence some combination of horses and tractors has to be accepted. So far as this size of farm is concerned it follows that one or even two horses have to be kept on when changing over to a tractor. In this case either the horses are hardly ever used or the tractor is used only at times of peak labour requirements. From the economic standpoint this joint use of horses and tractors is bad since both need time spent in attending to them and two sets of implements are required.

### *Problems and costs of mechanization on large farms*

The bigger the farm and the greater the number of hours of draught power required per year, the easier it is to fit draught-power supplies to requirements. On a large farm where there is a full team of horses as well as a tractor, it is a good plan to use the team to the full extent of its time, and to use the tractor for those tasks which correspond with its capacity. For instance, the tractor can do some jobs in one hour which would take horses from four to six hours, while the horses can be left to do those tasks which are best suited to them—for example, cultivation of roots, light carting, and work in the forests. In such circumstances full mechanization is not important, the tractor replacing horses which were not fully used before.

This part-mechanization is common today on most of the large farms. Where full mechanization is the ultimate aim, part mechanization is only a temporary arrangement which makes it possible to buy new implements and tools one at a time. Meanwhile the farmer can use the implements which he already has until they are worn out. The degree of mechanization varies from farm to farm.

Since the war not only is the classical four-wheeled tractor used for root hoeing, but also the light four-wheeled, or even a two-wheeled, tractor. The last mentioned is already very common on medium-size and large-size farms and is used particularly for cutting green fodder and for forming a swath, jobs which were previously done by hand with a scythe.

The economy of mechanization on large farms depends on the correct choice and co-ordination of the different kinds of draught power. At the lower limit of this size group where the annual draught-power requirement is about 6,000 horse hours, a medium-powered diesel tractor would be chosen. In addition, horses and a two-wheeled tractor would be used. Generally one horse would not be enough, but

if two horses were needed to make a team and each horse were used for about 1,800 hours, there would be only about 500 hours of work for the tractor. If a two-wheeled tractor were chosen instead of horses, then normally a diesel tractor would be used for 1,000 or 1,200 hours, and the rest of the work would be done by a two-wheeled tractor in about 500 hours.

Based on annual cost, full mechanization is cheaper than using horses, but it is not entirely a question of cost because on certain farms horses are preferred for particular jobs.

If the annual requirements of draught power are even larger than before, then a horse team can be used to its full extent. If, for instance, the annual requirements of draught power are from 8,000 to 10,000 hours, the horse team kept in addition to the diesel tractor is fully used and can therefore compete economically with a second tractor. If the annual requirements are greater than this, the possible variation as regards draught power and implements is even greater. This means that for bigger farms no single solution is possible, the solution varying from one farm to another. Moreover, the calculation is based on the technical standards of today, whereas progress is continuous. With technical progress new machines are developed, new possibilities of mechanization arise and fresh calculations are necessary. Each farmer cannot follow every technical improvement, but has to invest at different stages of development and sometimes may even make a wrong investment. When a farmer buys a new implement he does not get rid of the old, but has the new in addition. A farm which is very up to date in its machinery nearly always has too much draught power and too many implements. This excess of draught power and implements is due also to the desire of the farmer to have a reserve. It is difficult to measure the effect of this over-investment in draught power and machinery, but in any case it is not possible to judge the economy of mechanization on large-size farms solely by cost.