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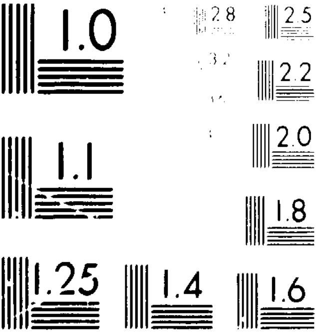
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UNITED NATIONS INDUSTRIAL
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REPUBLIC OF ZAMBIA

FINAL REPORT

STUDY ON THE DEVELOPMENT OF ZAMBIAN AGRICULTURAL MACHINERY AND ON THE POSSIBILITIES OF CREATING A NEW AGRICULTURAL MACHINERY FACTORY[1/]

(SIS/1119/OA 220 ZAM-6)

by

Mr. Barna J. Hajdu
UNIDO Expert

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

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List of abbreviations

t or to	=	metric ton
ha	=	hectare [illegible]
kg	=	kilogramme [illegible]
m	=	metre [illegible]
m^2	=	square metre
m^3	=	cubic metre
mm	=	millimetre
mm^2	=	square millimetre
cm	=	centimetre
cm^2	=	square centimetre
mkg	=	kilogramme[illegible]
h	=	hour
kW	=	kilowatt
%	=	per cent
pc	=	piece [illegible]
km	=	kilometre
$(90)^\circ$	=	(90) degrees
ca	=	circa [illegible]
mo	=	million
K	=	Kwacha [illegible]
Namboard	=	National [illegible] Board
UNIDO	=	United [illegible] Development Organization
A.M.F.	=	Agricultur[illegible]
A.M.D.	=	Agricultural [illegible]

Introduction - The aim of the [illegible]

On the request of the Zambian Government [illegible] or [illegible] United Nations Industrial Development [illegible] gate the possibility of agricultural [illegible] development of local production, in Zambia. A [illegible] objective of my assignment was to see [illegible] tools and machinery production could [illegible] the already existing UNIDO Small-Scale [illegible] that rural artisans could have the [illegible] employment.

The accomplishment of this many- [illegible] task and the preparation of the [illegible] hereafter was effected after careful considera[illegible] factors, during the short [illegible] data (mostly several years old) and [illegible] information obtained from various [illegible] necessary to go and see for myself [illegible] the tools and machinery the farmers [illegible] opinions about the tools and [illegible] their further needs. Should there [illegible] they are due - I believe - to the fact [illegible] almost impossible to verify data and [illegible] from various sources.

Technical development of Zambian [illegible] level of subsistence, emergent and commercial [illegible] only mechanization, but also includes [illegible] agricul- tural production. This is why the [illegible] a fragment of the work to be done in [illegible] with the development, method and [illegible] tools and machinery, giving information [illegible] according to the sphere of UNIDO. [illegible], this study is not intended to give any [illegible] improvement of the methods of agricultural [illegible] the special field of FAO).

The problem of how to ensure the [illegible] factors of agricultural production [illegible] processing, etc.) should be given att[illegible] co-ordinated with proposals and [illegible] on the field of the development of agric[illegible] the higher yield and the proper [illegible] which have a reciprocal effect on each other.

The development of Zambian agriculture [illegible] by the following three main factors:

- quick and cheap supply of [illegible] for the individual subsistence farmers,
- modernization of the [illegible] and sectoral mechanization [illegible];

- the spreading of new, modern techniques.

The effect and reciprocity of these factors will determine jointly the level, directions of development and rate of mechanization, as well as the optimal size of the machines, and purchasing power is also a relevant factor.

On the basis of investigations, as well as economic and trade policy, to be described in more detail later, it is justified by all means that an agricultural machinery factory should be established in Zambia, a part of which would assemble more sophisticated tractor-drawn implements (part of which can be produced locally); water pumps for irrigation, etc.

This factory would decide, for many years to come, on the direction of agricultural development in Zambia. From among the machine industries in the country, the agricultural machine industry will continue to evolve over several years, owing to its special potential. The most suitable machinery for agricultural production in the country will not be known until the first tools and implements have been used during several seasons, which will then make it possible to have an idea of the final modifications necessary. This process cannot be accelerated since the preparation of the soil is done in a certain season only (beginning of rainy season) and the care of plants is connected with the biological characteristics of crop, the growth of the plant, etc.

For this reason, when enumerating those agricultural implements certain parts of which need alteration and also the proposed new ones, I have mentioned their exact names and the agrotechnical process or operation which is being mechanized, as well as possible structural solutions. The final production technology should be developed with far-reaching consideration for these factors (e.g. selection of raw material, formation of cutting-edge, etc.).

I have given proposals - with appropriate reasons - for the alteration of several structural parts, because local production will be mainly concentrated on hand tools and animal-drawn implements and by this means the live labour expenditure can be reduced considerably, which is the main objective of agricultural mechanization.

Another intention is to suggest the introduction of such new implements (roller plough) the use of which is almost completely independent of seasons, climatic conditions, and thus the need for much of the work to be done simultaneously during the high season can be avoided. I am also recommending the use of auxiliary implements (Hydrolift water lifting device) which work without any fuel or attendance.

Details are given to help in choosing, installing and putting into working order, the equipment needed for the small blacksmith's shop and foundry in the proposed factory, as well as for ensuring the right production technology. The forge shop of the factory can start working sooner than the rest of the factory (since there is a complete forge shop in the Zambia Railways Repair Workshop, at Kabwe, almost unused, which can certainly be taken over by the proposed Agricultural Machinery Factory). The forge shop will have the most profitable production and will be able to do commission work for the mines, requiring a large quantity of picks, shovels, etc.

Considering that the Zambian Government is aiming at the intensive development of agriculture, it is of prime importance to improve mechanization in the agricultural sector. This is why I have made a calculation on the profitability of the proposed A.M.F., enabling those competent to do so to discuss my proposal.

One of the objectives of my assignment was to assist Rucom Industries Ltd. in making several prototypes. Since it became evident that agricultural machinery could not be produced by small workshops or artisans only, and a new factory should be set up, no prototype machines could be made by the facilities of a small workshop and the future equipment of the factory proposed is not yet at our disposal.

Summing up in short, the main objectives of the Final Report's proposals are to:

- produce agricultural hand tools and implements locally, at low price and put an end to importations;
- make agricultural production easier;
- ensure continuous working possibilities for rural artisans;
- create new working possibilities in the factory;
- increase food production, thus improving the food supply of inhabitants;
- technical development and creation of the basis of future training.

II. Summary of the actual agricultural development in Zambia and proposals for the creation of the agricultural machinery industry and the development of the agricultural mechanization

A. Summary of agricultural development in Zambia

1. Zambia produces no agricultural machinery herself. Thus the whole requirement of the country (tractors and their equipment, animal drawn implements, scotch carts, hand tools, etc.) has been and is imported mainly from China, South Africa (via Malawi), Mozambique, England, U.S.A., etc. (Name of the Malawi Export Co.: Agrimal, near Blantyre.)

2. The agricultural small machinery prices of South Africa and especially of China are exceptionally favourable (e.g. the 38 kg China plough costs K15, the Malawi (South African) costs K17, which prices cannot even cover their production cost. These prices have, up to now, made it impossible to develop the Zambian industry and produce agricultural machinery locally.)

According to the so called "Lenco Study" on the possibility of producing a few types of agricultural machinery by the Lusaka Engineering Co. (LENCO). the same type of plough (38 kg) would be 40% more expensive than the South African (Malawi) one, and 60% more expensive than the Chinese.

LENCO calculation on animal drawn implements:

Estimation for 1972 in pieces	Denomination	LENCO ex-factory in K	Nambeard selling price	Difference in %
4,000	Plough 8" (single furrow)	25.--	15.15	63
3,000	Cultivator S51	28.50	23.--	23
700	Triangular harrow	15.60	15.60	--
1,500	Heavy zigzag harrow	19.56	19.--	2
1,500	Diamond harrow	13.--	11.30	12
700	Drawbar (2 section)	6.50	4.90	30
100	" 3 "	8.--	7.90	1
2,000	Ridging plough	28.--	23.60	19
13,200				

This price would be much more favourable in an independent Zambian agricultural machinery factory. On the basis of the preliminary calculation the total products of the factory (see separate calculation sheets in Chapter V) would make it possible to achieve a price of K19.56 for the above type and size of plough (38 kg), which price would be 14% higher than the S. African one and 30% hither than the Chinese.

The difference must be remunerated from the profit of those products which are produced with profit. The factory could stay rentable even if it were desired to achieve the actual import price of the Chinese.

Zambian agriculture can be divided into three groups:

a. The so called commercial farming sector (from about 1,000 to 5,000 acres), which is concentrated mainly along the main railway line. Their number is about 550, with an average of 4,000 acres.
The commercial farming sector produces the majority of the agricultural produce and provides almost all the country's agricultural export earnings.

b. The emergent farmers (from about 100 to 1,000 acres) are mainly producing for local marketing.
They are also concentrated along the railway line in Central and Southern Provinces and along some main roads in Eastern Province. The population of these territories is 10 to 40 persons per square kilometre.

c. The small farmers' activity is primarily subsistence (from about 1 to 3 acres by hand and 5 to 20 acres by oxen) - about 450,000 families. They are to be found in Northern, North Western and Western Provinces where the population is 2 to 10 persons per square kilometre.

It can be found that the size of the commercial farming sector is decreasing. At the same time the size of the non-commercial sector is increasing and this tendency will probably last in the future.

The development of these agricultural farming sectors and their influence on each other will decide on the level, direction and rate of development of agricultural mechanization as well as on the rational and economical size of the commercial and non-commercial sectors.

3. The demand for agricultural small machinery and hand tools is high enough (e.g. ploughs, harrows, cultivators, 12,000 pieces/year, hand hoes 500,000 pieces/year) to create an agricultural machinery factory in Zambia but one must, naturally, take into consideration these findings enumerated in the previous paragraph.

4. One of the main imperfections of the actual supply in agricultural machinery (both tractor and animal drawn) is the shortage of spare parts, which is often catastrophic (e.g. one farmer near Kabwe, (Mr Moresby-White) had to buy several new tractors, owing to lack of spare parts for the old ones; at the Kafubu Resettlement Scheme, run by the Isralis, a tractor is disassembled whenever a spare part is needed for the others, etc.) and there are no sufficient maintenance and service possibilities either.

The very limited number of repair or service workshops, dealing with agricultural machinery are either not reliable owing to their technical inability, or they are much too expensive. Those who know their job and have favourable prices, have insufficient capacity to meet all the requirements and one has to wait even half a year to have the machines repaired.

Owing to these insufficiencies there is, in every working season, a large quantity of machinery which is out of use and therefore the yield is less than expected, which is a significant loss for the country.

5. The small-scale industrial workshops of Rucom Industries Ltd. are situated in the rural areas. These workshops which have a mechanical repair shop - at Choma, Mongu, Zambezi, Solwezi, Mansa, Mwambwe, Kasama, Chipata, Petauke (see sketch map) - could take part in the assembly, repair and maintenance of agricultural machinery if they were sufficiently equipped and the tenants of the workshops were properly trained. In this way these workshops could participate in the activity of the proposed Kabwe Agricultural Machinery Factory.

It is only a matter of organization for the central Kabwe Factory to supply the small-scale industrial workshops with the more sophisticated parts (forged and cast pieces) which could not be made in these small workshops. Then, a certain number of small machines would be finished in the rural workshops, on the basis of the factory's drawings.

This kind of division of labour would assure the permanent possibility of work for these workshops and the factory would promote their technical development effectively. On the other hand this solution would create a possibility of developing on a countrywide scale, a repair and maintenance network.

6. The Zambian Ministry of Rural Development and other organizations do not have a well organized, effective publicity team. Publicising has been taking place since 1966 but not efficiently enough, as by 1971 only 20% of the population had been trained and helped to some extent.

The Agricultural Officers in the provinces do not function in this sphere, although instruction on the use of animal-drawn implements would be the easiest to do by direct means, among the inhabitants of the villages. This is the first and most important step for the approximately 450,000 rural subsistence farmer families, to replace the use of human physical energy by the use of machines.

This would be a way of realizing the call to the public by Dr K. Kaunda, President of the Zambian Republic, in 1969, aiming at the most intensive rural development and at a higher standard of life and better yield of the subsistence farmers, so that they, too, can sell part of their products.

7. The Ministry of Rural Development and other organizations are not in possession of suitable market research organizations able to determine the changing market demand. Therefore the market demand cannot be determined exactly. This is why it happened that different types of machines were imported (e.g.

implements which do not match the types of tractors used in this country and so they have been kept in the Namboard depots for several years) and cannot be used.

8. The quality and the selection of goods imported are sometimes questionable. The material of the Chinese plough is weak, they easily get deformed, the ploughshare does not keep its edge for long enough. The rural farmers have no possibility of sharpening it regularly and, unfortunately, they are unaware of the importance of working with a sharp ploughshare.

The quality of the hand hoes is also inferior. In 3-4 years they are worn out (see photos. 2 and 4 years resp.)

9. Many more types of hand hoes could be used. There is only one type of hand tool available all over the country and that is the hand hoe of 1.60 kg. This is too heavy for weed hoeing. It is also difficult to cut deeper in the soil than 5-7 cms because the use of this type of hoe in the hard soil requires hard physical work and thus only a smaller area can be cultivated.

Sometimes the agricultural machinery and tools are not distributed according to the requirements of certain areas, the local conditions and the quality of the soil; if they are used then, they cannot work efficiently from the agro-technical point of view.

Imported machinery is distributed by Namboard so that 50% of the total goes to Central and Southern Provinces and the other 50% to the rest of the country, hardly any to the North and a minor quantity to the North West. In this way, the distribution of Zambia's population is also taken into consideration to a certain extent (see Population map).

10. The training of the cattle is also a problem in those parts of the country where there are no tsetse flies and cattle is used. There are agricultural operations (e.g. sowing in lines, ridging, cultivation, etc.) for which only well trained cattle should be used. Because of lack of a central animal training centre, the general use of animal-drawn implements is considerably hindered, or the result is not as good as it should be, although this would be the only way to change from hand cultivation to animal-drawn cultivation.

11. As far as hand seeders are concerned, they are in demand, but the imported models cost about K30 to K40 more than if they were made locally, in series. The seeders are being tested at Mansa (Luapula Province) by the French S.A.T.E.C. rice project. The production plan and calculation of the seeders can only be made later on.

12. The actual cutting of the plants is not satisfactory with the traditional scythe used; another type of tool, with different shape and execution, the sickle, should be used.

13. The mechanization of ground nuts is not yet solved either (ground nut lifter, sheller, etc.). The ground nut is produced by small farmers only. Because of lack of this mechanization the ground nut cannot be produced by commercial farmers, although this would mean a further step in developing the local food industry, i.e. the production of cooking oil which is often in short supply.

14. There are too many types of tractors used on the commercial farms, which means that for most of them there are constant shortages of spare parts, or it is impossible to obtain them at all. There is a similar problem with the implements which cannot be adapted to any type or capacity of tractor. Owing to this situation it will be very difficult to start standardizing the tractor implements.

Quotation from the A.F.E. Market Study:

Distribution of tractors among various Government bodies from January 1964 to March 1969

Govt. Bodies	Massey Ferguson	Nuffield	Ford	International	John Deere	Zetor	Honda	Leyland Motors	Howard	Total
Agric. Stations	44	29	13	4	-	-	-	-	2	92
P.A.M. & Project	112	59	1	2	-	-	-	-	-	174
Co-op.	49	101	22	-	-	154	-	-	-	326
C.P.C.M.A.	-	-	40	-	-	-	-	-	-	40
Training	7	1	1	11	2	-	-	-	-	22
Research	13	3	1	2	-	-	-	3	-	22
Forestry	5	6	34	44	2	-	1	-	-	92
Roads	4	-	-	46	5	-	-	-	-	55
Game & Fisheries	12	-	6	-	-	-	-	-	-	18
Mechan. Services Branch	8	3	1	1	8	-	-	-	-	21
Water Affairs	1	1	-	-	1	-	1	-	-	4
Education	4	-	-	-	-	-	30	-	-	34
Veterinary	3	-	1	-	-	-	-	-	-	4
Tsetse Control	12	-	-	1	-	-	-	-	-	13
Prison	5	-	-	1	-	-	-	-	-	6
Miscell.	8	1	-	2	-	-	-	-	-	11
Total	287	204	120	114	18	154	32	3	2	

15. The importers of tractor and animal drawn implements do not have enough stocks of different spare parts. The implements are usually sold in Lusaka and transported to every part of the country where nobody deals with their maintenance and repair.

16. One of the reasons for the early failure of the tractors is is that the tractor drivers are little educated and trained and do not even do the minimum maintenance required. There is no tractor driver's school. Well trained tractor drivers could prevent many failures and breakdowns, i.e. many spare parts could be saved.

17. There are not enough technical personnel at Magoye ...... Agricultural Research Station. For this reason they can only deal with a very limited number of subjects. Consequently they cannot take part with the necessary activity in the development of agricultural mechanization, in spite of the fact that it is urgently required.

18. The salesman of Namboard are not interested in the number of tools or implements sold, as they do not get any percentage of the business turnover, though they could do a very good service by publicizing the use of the agricultural tools and machinery in the nearby villages.

Diagnostic conclusion: the economic mission of Namboard is right and noteworthy; its activity means significant progress in agriculture, but should go further. Namboard should look to the future and develop along the lines outlined in the foregoing paragraphs.

19. Agricultural development is hindered for those situated in remote parts of the country by lack of proper roads, and appropriate transport facilities. Contact with the capital or line of rail is very difficult. In such places, like the Northern, North-western and Western parts of the country, real agricultural development, with the creation of big commercial farms will not develop until the transport of goods, machinery, fertilizers, crops, etc. is solved.

For this reason one must take into consideration that the construction of new roads and railways will bring about agricultural prosperity in these areas. A main road should be completed in 1973 to Western Province: Lusaka - Kaoma - Mongu; and a railway is being built by the Chinese in Tanzania and Zambia to connect Dar-es-Salaam and Lusaka via Tunduma (frontier station) - Kasama - Mpika - Serenje - Mkushi - Kapiri Mposhi; here the new railway line will join the existing main North-South line (59 stations altogether).

The line of rail especially will have a positive effect on the development of big commercial farms, because the railway will be able to transport the important quantity of maize, etc. to be produced along the line. Another effect of the new railway will be the formation of communal villages. Industry and especially the agricultueal industry must be prepared for the completion of the roads and railway, although in my estimation, the outcome will not be fully realized for 8-10 years. The industry will have to be able to supply these territories with the appropriate machinery.

20. The commercial farms are badly in need of a tractor-drawn implement, i.e. a plough which can plough in dry soil, after the maize and tobacco have been harvested, turning the dry stalks into the soil before the rainy season comes, preparing the seed-beds without any cultivation, etc. Since the farmers have not got this implement, they have a very short period at their disposal when the rainy season starts, to prepare the soil, plough and seed, after the 7 to 8 months long dry season. In many places people are unable to do all the work they want, if one or two tractors break down and no spare part is available. This naturally means less crops at the end of the season. In order to eliminate these imperfections, I propose the introduction of the roller plough (see details in Chapter IV).

21. The economical and agrotechnical advantages of sprinkling irrigation, as compared to flooding irrigation are well known to many people. The introduction of this method is hindered in most of the developing countries, including Zambia, by numerous reasons, such as by the water lifting pumps and driving motors being difficult and expensive to obtain and needing special attention, operation, maintenance, etc. This difficulty can be solved by the introduction of the "Hydrolift", which needs no special attention when in operation - no maintenance, no fuel, etc. (see details in Chapter IV).

22. Although I am mentioning it last, one of the most important facts is that Zambia has certainly not yet prepared, through the technical personnel at her disposal, for planning, constructing and setting up a new agricultural machinery factory. On the other hand, the Zambian Government is short of the necessary capital. The lack of technical personnel is of course natural, as for the time being there is no agricultural machinery production in Zambia, so nobody has ever had an opportunity to gain practice in this field.

In order to get over the initial difficulties, it would be desirable for the Government to apply for the services of UNIDO experts, technical engineers with appropriate practice and industrial economists. Besides, it is recommended to think of the possibility of co-operating with a large agricultural machinery factory from a well developed industrial country. The economical and technical advantages of such co-operation will be set out in detail later.

B. Proposals

1. Zambia's need in agricultural machinery (see Chapter III) is important enough to motivate the setting up of a new agricultural machinery factory in Zambia.

Its total area would be 15,000 m^2 and its production area 10,500 m^2. The estimated investment cost of the building (see calculation in Chapter V) is:

	K1,065,000
machinery, equipment:	K 362,000
Total	K1,427,000

I propose that the new factory should be built at Kabwe township, for many reasons (see Chapter V). The setting up of this factory would supply the whole of Zambia with the necessary hand tools and animal-drawn implements, so that their importation would not be necessary any more.

Another possibility is for Zambia to co-operate with an experienced agricultural machinery factory and partly to produce, partly to assemble their products, such as tractor-drawn implements, irrigation equipment, water pumps, etc. By doing so a considerable part of the import expenses could be cut. When the factory is working at full capacity, Zambia may even export agricultural tools and machinery to neighbouring countries.

2. The prices of the new factory's products will be rather favourable. All the hand tools which will be made in the forge-shop will be better in quality, have a longer useful life and be cheaper in price than the imported ones, with a larger choice of type.

On average, the hand tools can be produced approximately 40% cheaper than the imported ones. As far as the animal-drawn implements are concerned, their production price will be:

24% less in the case of cultivators;
34% " " " " " ridging ploughs;
39% " " " " " zigzag harrows;

than that of the imported ones.

Regarding ploughs, it is rather difficult to compete with political prices (Chinese plough is K15/piece; S. African K17/piece), and it will be difficult to cut down the production price of the ploughs. A good solution, however, presents itself, and that is to subsidize the plough's price by profits made on other products.

Even if the prices of the local products could not compete with the actual import prices, the reason for the factory's existence is still justified. One reason is that the factory itself will create an important number of possibilities for work, which is an important aspect in Zambia. Also, a new technical staff will be trained in the factory. This personnel might have a significant effect on the development of other industrial branches in Zambia.

3. Production at Kabwe might start relatively very soon. The Kabwe railway repair workshop has a complete forge-shop with equipment which is entirely unutilized. This workshop could be taken over by the new factory as it is now.

Originally, this workshop was intended to repair steam engines, but in the meantime, Zambia Railways has decided to buy only diesel engines and thus the forge machines cannot be used any more. The Zambia Railways Repair Workshop is ready to sell these machines.

When producing agricultural machinery the forge-shop is most important. For the first year of operation it should do approximately 1,800,000 operations, such as 400 pieces of harrow-teeth, 100-100,000 hoes, Canterbury hoes, panga knives, scythes, etc. In the second year, when the whole workshop is ready, about 18,000 animal-drawn implements should be produced. At full capacity, the factory will be able to produce 22,800 pieces of animal-drawn implements.

These calculations are approximate estimations, on the basis of the data at my disposal, and the experience gained during my visits to the country, since no market research or general investigation has been done. I know the essential hand-tools and agricultural machinery needed for certain agrotechnical operations, as well as the machine types necessary for the different types of soil.

According to investigations, one plough in general would wear away in 8-9 years of usage. The breast-board, wheel, axle of the plough must be changed every 4 years, while the ploughshare should be changed every 3 years. Hand hoes are worn away in 3-4 years. As far as the number of pieces is concerned, I have the following figures at my disposal:

Situation in 1965, in 1,000 acres (latest figures available):

Province		Total surface	Cultivated by ox	tractor	hoe	Total cultivated area	Uncultivated land	Total population	Farmer families of 7 members	Farmer families of 5 members
Southern	1	21074	300	77	350	727	600	359130	51304	71826
Central	2	28736	55	120	400	575	2500	270320	38617	54064
Eastern	3	17076	100	6	456	556	3500	448710	64101	89742
Northern	4	36529	4	-	700	704	7000	537556	76793	107510
Luapula	5	12495	1	-	500	561	3000	351730	56247	70346
Copperbelt	6	7741	1	3	70	74	500	56860	8123	11372
N-Western	7	31092	1	-	356	351	3500	199690	28527	39938
W.Barotse	8	31231	29	-	500	529	9000	351690	50241	70338
		185975	491	206	3320	4017	29600	2575680	367953	515136
%		100	0.3	0.1	1.8	2.2	15.9			

Cultivated area in %	ox	tractor	hoe	
1	41.3	10.6	48.1	100%
2	9.6	20.9	69.6	"
3	18.-	1.1	80.9	"
4	0.6	-	99.4	"
5	0.2	-	99.8	"
6	1.4	4.1	94.6	"
7	0.3	-	99.7	"
8	5.5	-	94.5	"
	12.2	5.1	82.6	100%

On the basis of the information gained in 1969 the population of the country was 4.07 million (3.5 million in 1963) and will reach 4.6 million by 1976. According to this 6 years' data, the increase in population is 2.7%/year and it will reach 2.9% by the period 1970-76. About 75-80% of the country's population is living in the rural areas, i.e. on agriculture.

<u>Tendency of the number of families working in agriculture:</u>

Year	1964	1970	Estimated for 1976
Those living on wages (from emergent and commercial farms)	35,100	34,600	38,000
Subsistence farming	340,000	387,000	400,000

One family consists of 7 members on average, out of which about 3 persons (including women) can constantly work on the fields, that is to say about 1.3 million people are working in agriculture.

On the basis of the above data and my experience I work out the approximate market demand. The capacity of the proposed factory and the types and number of machines, as well as their parameters, are based on these estimations (see details in Chapter VI).

4. In order to ensure a good supply of spare parts, the importers should be compelled by order or restricted by import permits with special conditions, to buy, together with the machinery, especially in the case of tractors, 20% of the value of the machine in spare parts, arriving in the country together with the machines. No permission should be given to clear goods at the Customs until sufficient spare parts have arrived with the machines. In this way, getting out of regulations could be avoided.

In the proposed Kabwe Agricultural Machinery Factory at least 10% of the total production must be spare parts, first of all for the factory's own products.

5. The Small-Scale Industries Project of Rucom Industries can take an active and effective part in the local production of agricultural machinery. The proposed Kabwe A.M.F. would promote the activity of the rural handicraftsmen by its cheap spare parts. By way of reciprocity the two sectors would not compete but co-operate with each other, e.g. the woodwork section of the Small-Scale Industries' workshops could make the yokes (about 14 kg/piece) which might reach 5,000 pieces/year.

Those people working in rural workshops are generally from villages, often dealing with soil cultivation either before or at the same time, so they know the circumstances. These people would be excellent for learning how to use the locally made or assembled implements and for teaching other people in the villages.

On the other hand the Rucom workshops might deal with the longer or shorter training of people with manual skill, coming from small villages, and at the end of the training going back to become blacksmiths of one or several small villages. The villagers would pay attention to the activity of the blacksmith. They would consult him and certainly listen to his good advice as far as the maintenance, sharpening, etc. of the hand-tools and oxen-drawn implements are concerned. This craftsman class of society plays an important role in the national rural development.

The general execution of this idea might be realized by a very primitive and cheap smith's hearth made at Magove Research Station. It is made of a 200 litre petrol drum (see description, drawing and photograph separately). These simple smith's hearths could be made by Rucom workshops fairly quickly. The provision of charcoal is no problem at all since people living in the bush are even producing it for marketing.

I experienced in Zambia that simple farmers in the country do not like to buy new, unknown things, saying that they do not want to experiment and spend their money on what they do not know. Only the small blacksmiths on the spot could explain the use of something new and better, so that people would accept it more easily. The proposed agricultural machinery factory could give a few items to the blacksmith on loan (e.g. ploughs, cultivators, new-shaped scythes, etc.) which would make general use of new things and propagation of new ideas easier, even if it concerns the change from hand cultivation to animal-drawn cultivation. The blacksmiths would give good advice as to how to use new machinery and how to maintain and repair it. The publicity work of the rural blacksmiths would increase the market demand, also.

6. An independent Agricultural Machinery Directorate, with technical, economic and agricultural experts, within the Ministry of Rural Development, would be able to co-ordinate the industrial activities of the proposed A.M.F. and Rucom, to publish the results achieved, to help the rural artisans and blacksmiths and to draw up regularly an estimation of the market demand at a later stage, enabling the proposed A.M.F. to base its production on these estimates.

This is imperative, for the less stable the economic future, the better should the industry know what is to be expected, what are the prospects, how the raw material prices are going to change in the world market, etc. Looking into the foreseeable future, it is up to the industry to prepare itself in time.

7. The Agricultural Machinery Directorate, besides its market research activity mentioned above, could also give its ideas to Namboard, as far as the foreseeable market demand is concerned. The Director should also deal with the prevention of importation or local production of certain types of machines which are not required and cannot be used in the country.

8. The Agricultural Machinery Directorate would standardize the agricultural machinery used in the country, lay down the technical parameters, the quality requirements of the machine and would impede the marketing of inferior quality goods, either imported or produced locally.

9. The A.M.D. could decide on the choice of different hand-tools necessary and the factory would change its production according to the requirements. The A.M.D. would advise Namboard on the tools and machinery required in certain provinces, according to local conditions.

10. One of the most important duties of the A.M.D. would be - although its name does not seem to cover this field - the organization and creation of ox-training centres which would have the functions:

- either to sell to the farmers well trained, draught animals;
- or to train the farmers' own oxen, against payment.

The average weight of the Zambian ox is about 350 kg. Oxen can work 6 hours a day without exhaustion if they work with a tractive force equivalent to 1/7 of their weight, i.e. the average tractive force of an ox is approximately 50 kg. The traction of the proposed 38 kg plough, in medium soil, needs approximately 70 to 80 kg tractive force, i.e. two oxen would be necessary. The 115 kg plough requires about 170 kg tractive force, i.e. four oxen. The price of 1 ox, more or less trained is approx. K60 and can work for 5 to 7 years.

The change from hand cultivation to animal-drawn cultivation is a step between physical work and the use of tractors. This step, nevertheless, should never be left out for to try to get very simple people to work with sophisticated tractors immediately after they had been using hand-tools, would mean a failure in developing agriculture.

11. When producing the seeders in big series, the small foundry of the factory will be able to produce the cellular wheel by precision casting. Thus the production cost of the machines would be very favourable, since the other parts of the seeder are simple plate-work.

Should the plastic production of the Small-Scale Industries Project be realized, it is also possible to produce the cellular wheel of plastic by injection moulding. The plastic would not rust and would supply the seeds in a perfect manner, owing to its good sliding surface. The above spare part can just as well be cast of aluminium and then broached by milling machine.

As far as the animal-drawn seeder of several lines is concerned, I did not write about it on purpose, because the introduction of this machine is not yet desired. I believe that if it were used in Zambia, the sowing area of subsistence and emergent farmers would increase without reason. Although it would mean a larger sowing area statistically, at the same time the cultivation would be sparse with low yield and very high production cost. This would only be a waste of physical energy and material.

12. The traditional type of scythe actually in use requires a rather bent position of the body and as a result is very tiring. The use of scythes and sickles with different shapes proposed in the new factory's product list would be much more favourable.

13. The lack of suitable special machinery is the reason why ground nuts cannot be produced in bigger quantities in Zambia, e.g. no animal or tractor-drawn ground nut lifter is available on the market. The modified cultivator would be suitable for this purpose and its experimentation and adaptation to local conditions by Magoye Research Station should be urged on. In S. Africa, U.S.A. and Japan very good ground nut lifters are used and they would find a good market here too.

At the same time good quality ground nut shellers are also required. The ground nut shellers actually used break too often from the seeds and people prefer shelling by hand, although it is a very painstaking task with little yield.

14. It is almost impossible to determine the size and capacity of tractors in use in Zambia, for the farmers buy many different types with various capacities, according to their fancy or rather the market supply. Agricultural work generally requires three types of tractor: light, medium and heavy. The present very confusing situation results in a very poor spare parts supply. Radical changes can only be expected if the Government or the proposed A.M.D., takes the necessary steps in order to prevent the importation of so many different tractor types. It will be up to the A.M.D. to determine the necessary types which should certainly not be more than 5-6 types.

It is very difficult to determine the tractor categories required by farmers, unless one knows all the components such as soil conditions, configurations of the terrain, the optimal timing fes certain work in the fields, etc., in order to make it possible to do the different operations with the smallest cost but the greatest efficiency, etc.

It is, however, certain that tractors with bigger and bigger tractive capacity are going to be used, since it means many advantages for the farmers:

- increase in level of production;
- decrease of costs;
- increase of labour productivity;
- decrease of specific requirements in machinery;
- improvement in the quality of machine work;
- optimal working time.

For this reason I do not think it is right to introduce a new, 35 HP tractor to the country (it is being tested at Magoye) because it would mean a setback in development. Should these small tractors be intended to serve the small farmers, it is still more economical to use big capacity tractors than to buy small ones for a few acres.

On the basis of labour productivity index I can say that tractors above 1.4 t (50-60 HP, weight over 2,200 kg, universal) are ideal for use in Zambia, with the following working capacity in ha/hour:

Operation	Tractor category under 1.4 t ha/working hours	Tractor category above 1.4 t ha/working hours
Ploughing max. 21 cm deep	0.24	0.57
Discing	0.86	2.74
Fertilizing	1.85	2.09
Sowing	0.93	1.71

Looking at the future trend, (after 1976), the ploughing and cultivating, etc. speed will increase until it is approximately 8 km/hour, which needs about 80-85 HP, i.e. the 50 HP tractors used today or imported tomorrow will not be able to keep abreast of development.

I find that in general no sophisticated machinery should be taken into account. For the time being most problems are caused by the rather complicated hydraulic lifting system, which is also the most difficult to repair. The electric system, i.e. the starting of the engine, makes many troubles. It is not possible to recharge the accumulator, the tractors being used in places without electricity. I would recommend the use of tractors which are started by a 2-3 HP petrol engine, built together with the tractor engine (e.g. the Russion Bjelorusz MTZ tractor). Most farmers are forced to use anthills for starting tractors (see photo.).

Tractors unused because of lack of spare parts slowly wear out, though they represent a large amount of money:

Make	Type	HP	Price in K
Massey Ferguson	135	45	2,900
" "	165	60	3,575
" "	178	72	4,100
" "	1080	90	5,980
John Deere	1020	46	2,850
" "	2020	63	3,450
" "	2120	71	3,940
" "	3120	85	5,670
" "	4020	106	6,700
Leyland	154	25	1,960
"	344	55	2,950
"	384	70	3,400
Universal	650	73	2,860
"	651	73	3,150
Zetor	3511	30-40	1,930
"	4511	40-50	2,250
"	5511	55-60	2,790

15. Many of the failures could be prevented if the tractor drivers knew something about the engine and could accept and understand the necessity of everyday service. Tractors are often used until they break down, because they do not know anything about regular maintenance.

16. It will be an indispensable duty of the proposed A.M.D. to establish several tractor driver training schools in the different parts of the country.

17. The creation of the Magoye Agricultural Research Station was a bright idea but owing to its rather limited number of technical staff - they are unable to do all the necessary experimentation required in very part of the country, thus they certainly will not be able to give all the necessary data to the proposed A.M.F.

If the Zambian Government intended to expand this research and experimental activity, it would be desirable to set up a new Research Station near the proposed factory, possibly at Kabwe. This would be very fortunate for the factory itself and also for the Research Station, the soil, etc. being different from that at Magoye.

In order to improve the effectiveness of Magoye Agricultural Research Station, it will be necessary to purchase some more measuring and testing instruments, though the invested money would not be refunded to the Research Station but in the agricultural sector. Magoye Research Station workshop, with new machinery, is suitable for the production of some prototype machines, except some spare parts.

UNIDO and FAO respectively will certainly give any assistance needed for a possible new Research Station.

18. In my opinion, the Namboard storeman should be made interested in the quantity sold, by giving him some percentage according to business turnover. This stimulation would certainly increase the propagation activity of the storeman.

19. I have already mentioned the improvement of transport facilities as far as new roads and a railway line are concerned. Furthermore, it is necessary to urge on the propagation of animal- and tractor-drawn scotch carts, because they are essential in agriculture (e.g. for the transport of fertilizers, yield, etc.) especially on long distances, i.e. above 500 metres, on dirt roads or rough, bumpy roads. The use of a wheelbarrow requires enormous physical energy on bumpy reads with big rolling resistance. If we must accept a compromise - if no animal-drawn scotch carts can be used - the cleverest solution is the Chinese wheelbarrow, transporting the goods on a one metre diameter wheel, in a screened basket. The diameter impedes the loose, wet soil piling up and results in excessive [illegible] resistance being avoided.

20. The Hungarian patented "Roller Plough" is excellent for preparing the seed beds simultaneously with ploughing, in the dry season. The roller plough has been in existence for more than five years and is being used in 31 countries, with excellent results. It must be mentioned that this plough is not only ideal for Zambia but also for a large number of development countries.

21. The "Hydrolift" is also very useful for lifting irrigation or any other kind of water. It can be used unattended and without fuel, etc. No special qualification is needed for its erection.

22. As is already clear from the previous paragraphs, the mechanization of Zambian agriculture is a many-sided, difficult job. It will require technical people, economists and capital for investment. One cannot only do what makes a profit and is relatively easy, to compromise. In this case, the results in the long run would be sad and negative, resulting in a failure. Technical experience has many times proved that the aims, and the main technical methods and plans necessary for their implementation, cannot be separated from each other.

One must take the opportunity to accept Government resources and possibilities of co-operation which may occur. Now, there is a possibility, which should be exploited, to co-operate with an overseas partner, probably from West Germany, which produces agricultural machinery. In this way, not only technical staff - UNIDO experts - would be at disposal but also foreign capital, necessary for investment.

The factories from among which the future co-operating partner could be selected are:

1. Bayerische Pflugfabrik, 891, Landsberg am Lech Kühlmannstr. 25, Federal Republic of Germany

2. P. Mühlhoff, Maschinenfabrik, 4182 Uedem, Federal Republic of Germany

3. Hassia-Rau Vertriebs G.m.b.H., 7315 Weilheim/Teck, Federal Republic of Germany

4. Goldsaat G.m.b.H., Bergisch-Born, Federal Republic of Germany

III. Summing up of the situation and economic analysis on the field of agriculture and supply in agricultural machinery

Before analysing the actual situation of agriculture and the technical and industrial side of it, it will be worthwhile raising some reflections of economics. They would be able to back up the suggestion that a central agricultural machinery factory should be established at Kabwe, even if on a small scale.

On the basis of the demographical investigations (from June 1963 to August 1969), taking into consideration a six year average, the increase in population was 2.7% in Zambia and will reach 2.9% by 1970-76. This very quick increase in population and the necessity of supplying the population with foo on the same level - though it cannot be an aim, but a minimum duty of the Zambian Government - show that it will be essential to keep abreast of this development and ensure an . ease of at least [illegible]% in the agricultural produce (a general increase of 5.4% is envisaged between 1970-76). In fact, it is already planned to increase the maize production of 2.53 million bags (1 bag = 90 kg) (in 1969 the requiremet of the country was 3.01 million bags) to 5.5 million bags by 1976. This objective will be surpassed this year already, by the means of maize seed and fertilizer subsidies and very attractive maize prices, and the help of favourable rainfall. According to estimates, this year's yield will be between 6 and 7 million bags, out of which about 4 million bags are already in depots.

In my opinion the maize production of the country could easily be increased by 3-4 million more bags, making use of complex mechanization and with the subsequent subsidies of the Government, since soil and climatic conditions are good. The increase in agricultural produce in Zambia between 1964 and 1972, on average, was 12.8%, with exceptionally good yield. On a world scale this number is 3.3%, which means that the Zambian results were very good, but as compared to 1962-63 the increase was only 6.1%.

It is a fact that all the tools, machines, equipment, necessary for agricultural development are imported for the moment. At the same time there is no technical (specialist) and financial base (factory equipment), thus, when realizing the idea of a new agricultural machinery factory, it will certainly be necessary to ask for the technical assistanct of UNIDO and to co-operate with an experienced overseas factory (advantages see later in this chapter).

As far as other fields of development are concerned, we can find an increase of 34.2% between 1964 and 1970 in mining, food industry (beer production, tinned food) etc. On this basis it is easy to find that this outstanding figure is very promising for the establishment of the local agricultural machinery industry. The farm machinery industry could make it possible for at least about two thirds of the country's population to have the benefit of those advantages offered by mechanization, while the benefits of other industries do not affect more than about 1 million people out of the 4.5 millions, a picture which is more gloomy than the previous statistical data.

According to the statistical data in 1970 the national income per capita was 293 Kwacha/year, but it was mainly those living in towns (about 1.6 million inhabitants) who had a share of this income. About two-thirds of the inhabitants live in villages.

The average earnings/year of the agricultural workers was K248 in 1967 and K348 in 1970.

No. of bread-winners:

	1964	1970	(projected for) 1976
Paid employees (commercial and emergent farmers)	35,000	34,600	38,200
Self-supporting	340,000	387,000	400,000

On average, one family is composed of 7 persons (wife and children), which means that about 3 million people are deriving a living from agriculture = 66.7% of the population. One more item to complete the previous data: the average yearly earnings of those living from wage and salary (officials, mine-workers, ministers, domestics, etc.) was K666 in 1967 and K928 in 1970.

Reverting to the economic analysis and approaching the significance of the agricultural and farm machinery industry in the country's material production from another aspect, we find that its importance is determined by its function in the economic life from the point of view of:

(a) its contribution to the country's material production;
(b) its participation in meeting the requirements of the public finances;
(c) the number of inhabitants employed and supported by the production branch of agriculture;

a. The trend of the national income:

Sectors	1969	1970
1. Mining	37%	46%
2. Communications	18.1%	15.7%
3. Agriculture	11.8%	11.1%
4. Industry	10.4%	8.5%
5. Commerce	10%	8.9%
6. Construction	6.7%	5.4%
7. Transport	3.9%	3.3%
8. Electricity and water	1.3%	1.1%
	100%	100%

According to these data there is a regression in agriculture, and a strong development in the mining industry. It is worth mentioning that the income of the mining industry depends, to a certain extent, on the fluctuation of the world market price and a low price level would threaten the budget considerably. This is why it would be better to set up another branch of the production industry in order to ensure satisfactorily the material income; and this production sector is agriculture.

Many political economists doubt that the mechanization and technical development of agricultural production would have the effect of increasing the yield; they maintain that these factors only have the effect of replacing manpower, or they help in reducing the work done in unhealthy conditions and in improving working conditions in general. There is no doubt that mechanization does not create basic production capacities in agriculture (except for the distribution of fertilizers and plant protection); it can only increase the utilization of those already existing. By this means certain working processes have an indirect effect of increase on the yield (ploughing in time, seeding in optimal agrotechnical conditions, etc.). Pronounced attention must be paid to these factors in Zambian circumstances where there is a very short period at disposal for the preparation of soil, at the beginning of the rainy season.

It must also be noted that the increase in average yield depends greatly on the climatic and biological as well as technological conditions. The beginning of the ploughing season depends on climatic conditions, i.e. the beginning of the rainy season, which is actually the end of October.

A further agrotechnical requirement is the preparation of smooth seed beds. For this reason, several (2-3) discings are necessary after ploughing.

The period when the maize can be harvested depends on biological factors. From the beginning of June onwards the ears of maize are ready for harvesting but the harvesting will not start before the end of June/beginning of July, because of the high moisture content (about 20%); it cannot be accepted with a moisture content exceeding 12.5%. Commercial farmers usually do not possess drying machines. It is a fact that, to a certain extent, drying machines depreciate the quality of the maize, but this loss is still much less than the damage caused by rodents to the maize standing in the fields for as long as 1.5 months. Owing to these factors and to the actual equipment of the farmers, the increase of the average yield is rather limited and the farmers acknowledge this compromise.

When using the roller plough (see details in Chapter IV), the seed beds can be prepared in one working phase during the dry season and the seeds can be sown just before the rain starts, so that the germination of the seeds can start much earlier; thus the grains will be bigger and stronger, considering that the plants get more precipitation during the later periods of their development.

The more modern technology - including the chemical processing of the crop - cannot be introduced to a larger extent than that already in use, without the complex mechanization of agricultural production. Preparation of the soil and sowing should be done in one working phase and the transport chain for the harvested maize should be worked out where drying machines would also be used. In my opinion, complete sectoral mechanization, besides the work of the hand, animal and traditional implements being replaced has the effect of increasing the yield and very often of decreasing production costs.

The decrease of production costs will not, of course, be bound together with the mechanization under a certain level, i.e. at least 2.7 to 2.9 t/ha should be produced (the average was 1.1t/ha in 1971), so that the income level obtained by the traditional technology should not be debased by the complete sectoral mechanization of the commercial farmers. One should naturally imply that the State purchase price of the maize will not change (which is actually K3.5 = US$4.9/bag (=90kg) in the country and K4.3 = US$6/bag in the towns) and that the Zambian Government will go on subsidizing fertilizers and sowing seeds for several years.

b. On the basis of the requirements of public finances, agriculture, among others, would mean an important raw material base for the creation and development of the local food industry.

Owing to insufficient supply of agricultural raw materials the Second National Development Plan (from 1972 to 1976) only mentions the local processing of meat and dairy products and the manufacture of biscuits. The other products, such as cooking oil, fruit, vegetables, starch production, leather and skin industry, etc. are not even mentioned.

It is superfluous to give details on the fact, which is well known, that in the case of mass production it is much more profitable to feed animals (poultry, pigs, granger's cattle, etc.) with the fodder and sell them than to sell fodder directly.

c. As far as agricultural machinery is concerned from the point of view of those making a living from agriculture, it is imperative to produce cheap and good quality hand tools and animal-drawn implements. This means that the proposed A.M.F. should work with relatively low profit, thus contributing considerably to the development of the country. The development rate of not only Zambia but all other countries depends greatly on the development rate of agriculture, on the cheaper agricultural products and on the better financial position of farmers, which increases their purchasing power. This means that - even if many people do not see it and do not agree to it - the industrial development depends, to a certain extent, on agriculture being up to date. The two sectors are interrelated. It is therefore in the interest of industry to promote agricultural development, resulting in balanced economic conditions in the country.

Finally, I beg to remark that there are people in every country who are for and who are against agricultural development, the latter being sometimes misled by cheaper solutions (e.g. favourable import prices) although in future there are always heavy penalties to be paid for not having developed agriculture.

<u>Machinery requirements</u>

When deciding on the following figures, I took into consideration the findings of the "LENCO Study", the data (1965) of Mr Savage (Department of Economics and Marketing), as well as different pieces of information received from entirely different sources, and my personal experience gained on my visits to several parts of the country, learning from farmers the length of wearing out of different machinery, etc. Last but not least I took into consideration the size of economic series. Under the key words "spare parts" and "commission work" I took into account the requirement in spare parts for the agricultural machinery already in use in Zambia, which are, for the time being, one of the most important needs.

No.	Denomination	Weight per piece in kg	1974*	1975	1976	1977	1978	Total
			No. of items to be produced					
1.	Hoes	1,00	100.000	500.000	600.000	600.000	500.000	2.300.000
2.	Picks	2,50	10.000	20.000	25.000	25.000	20.000	100.000
3.	Shovels	1,20	5.000	8.000	10.000	10.000	7.000	40.000
4.	Pange knives	0,85	100.000	300.000	500.000	600.000	[illegible]	2.200.000
5.	Maize hooks	0,15	300.000	600.000	400.000	400.000	300.000	2.000.000
6.	Harrow teeth	0,35	400.000	400.000	400.000	300.000	200.000	1.700.000
7.	Sickles	0,42	150.000	300.000	250.000	200.000	100.000	1.000.000
8.	Scythe blades	0,75	100.000	250.000	200.000	150.000	50.000	750.000
9.	Canterbury hoes	1,52	100.000	200.000	150.000	100.000	100.000	650.000
10.	Combination hoes	0,66	150.000	350.000	250.000	200.000	200.000	1.050.000
11.	Cowchain's hooks	0,42	85.000	-	500.000	300.000	300.000	1.185.000
12.	Commission work	à 2,0	300.000	200.000**				300.000
13.	Ploughshare for all the ploughs as spare parts		-	20.000	50.000	150.000	400.000	620.000
			(1.800.000)	(forge operations)				
14.	Animal-drawn plough	35	-	2.000	3.000	75.000	3.000	15.500
15.	" " "	36	-	1.500	2.500	5.300	2.000	11.300
16.	" " "	50	-	1.000	2.000	4.440	1.800	9.240
17.	Reversible plough	115	-	500	800	3.000	2.500	6.800
18.	Ridging plough	35	-	2.000	2.500	5.000	3.000	12.500
19.	Heavy zigzag harrow	25	-	1.500	2.500	6.500	3.500	14.000
20.	Cultivator S 51	38	-	1.500	3.000	7.000	3.000	14.500
21.	Roller plough GEF 335	)***	400	450	500	550	650	2.550
22.	" " " 435	)	30	40	50	80	100	300
23.	" " " 535	)	20	20	30	30	50	150
24.	" " " 835	)	-	10	10	15	15	50
25.	Tie ridger	)	50	150	200	300	300	1.000
26.	Hydrolift (for irrigation)	)	50	100	250	500	300	1.200
27.	Tractor drawn and driven hose reel with winch, 18 ha	)	40	80	100	140	160	520
28.	Complete sectoral mechanization for maize	)	30	50	50	120	150	400
29.	Agricultural scotch cart	)	80	150	150	200	300	880

* production starts with forge shop

** free capacity for commission work

*** in the case of international co-operation mounting and part-production

IV/A. Proposals for the development of agricultural tools and machinery actually in use in Zambia

I should be glad to be able to assist, to a certain extent, through the ideas included in this chapter, the activity of Magoye Agricultural Research Station, and to make the products of the proposed Zambian Agticultural Mathinery Factory of improved quality and technical execution. I am sure that the technical analyses enumerated in the following are more or less known to the technical people dealing with agricultural machinery and implements, but some new ideas may still help to improve the future products.

There are some aspects, technical reasons and experimental data, the adoption of which would make the use of the agricultural machinery easier and would also eliminate their requirements in physical energy and thus an important quantity of bioenergy could be saved.

- The use of manual labour and animal-drawn implements plays an important role in Zambia, since the amount of mechanization is very low in the country - except for the big industrial farmers.

- Most of the agricultural implements are used in connection with the soil:

  - some of them work the land directly (hand tools, ploughs, discs, harrows), while
  - others put seeds into the soil (planting machines), or
  - just move on the surface of the soil (relieving wheels of the plough, means of transport, barrows, plant protecting machines, etc.).

Consequently the soil is a material which plays an important part in the agricultural machinery industry because of the hard conditions prevalent in Zambia (dry, hard and gritty soil); when designing agricultural machinery the physical and mechanical properties of the soil must be taken into account.

The other aspect - which cannot be treated at length - is the tradition and agrotechnics the people are used to, especially in the case of hand tools, e.g. the hand hoe with a comparatively very short handle. The use of this kind of hoe is necessary when weeding, so that they can use their other hand for shaking out the soil from the roots of the weed, which is necessary. The agrotechnical requirements must be taken into consideration when producing agricultural hand tools and implements.

When designing new types of agricultural machinery or adapting those already in use in other countries, to the requirements of the country, not only the economic but in the first place, the biological factors must be taken into account. It must be emphasized that the machinery which is not correctly constructed, and is produced with a wrong technology, would first of all affect those people using them. This does not seem to be a great loss since it only requires greater investment of physical energy and results in a poorer quality of soil cultivation, etc. These causes can be tools with edges easily worn, soil cultivating implements with cutting edges set at wrong angles, etc., which result in a greater resistance of the machines, thus requiring more and unnecessary physical energy from the farmer and from the animal as well. Most of the soil cultivating work is somehow or other in connection with cutting the soil, but very often clean cutting is disturbed by some sort of deformation, even if the implement belongs to the simplest sort of soil cultivating hand tools, such as spades, hoes, pick-axes, etc. These tools being simple but used in a different way, depending on the physical condition of the person who is using them (in the case of pick-axe, hoe, etc.) and on the angle they enter the soil, there must be a certain compromise as far as their technical specification (weight, length, width, angle of sharpening, shape, etc.) is concerned.

As far as the decision on shape and size is concerned, Zambian tradition plays an important role. Most of the hand tools have an accepted and preferred shape and size (e.g. hoe: weight approximately 1.14 kg; shape: longish, curved, with a handle encouraging a bent working position). The modification of these tools is a very delicate problem. Nevertheless, one factor remains unaltered, and that is the marketability of the hand tools, which will certainly not change for a long time (between 1973-77 the market will absorb about 2.3 million hand hoes, 2.2 million panga knives, 7 million maize hooks, 0.93 million hand-operated weeders, etc). Consequently it is important to produce hand tools which can easily penetrate into the soil and which can be used for at least 3-4 years.
IV/A/1.
In order to meet these requirements, i.e. shearing tools and durable and wear-resisting material, these tools must be made by forgeing and not by pressing. Forged material has a much better sliding surface than pressed. It is easier to understand the advantages of this if we examine, e.g. the operation of preparing the seed beds with a hand hoe: the hoe would cut a slice of soil of a certain thickness. This slice would be lifted and transferred to another place, in a certain distance, by the help of physical energy and the hoe. The slice is cut by the edge of the hoe while its transfer is made by lifting on and sliding down the surface of the hoe.

Consequently, the weight, shape and surface of the hoe are important for the farmer. It will be imperative to reduce to approximately 0.80 kg the weight of the hoes actually in use. On the other hand, it is no use going under this weight because it would result in the reduction of the kinetic energy to a level which would not be sufficient for cultivation of the hard Zambian soil (it has an approximate resistance of 70 kg/dm^2).

By forging it is possible to compact the raw material steel plate, which means that thinner but stronger, more wear-resisting hoes can be made. On the surface of a forged tool the soil can slip better, as the steel structure is more even, not like the ones sold at present. When forgeing in die, the surface roughness value can be reduced down to 3.2 micron while the same value is on the average 5.5 micron when pressing. The pressed surfaces are rough with scales, scratches, etc., on which the particles of soil adhere, making work much more difficult. Another advantage of the thin, forged hoe is, that no compact zone is formed by the edge, so that the hoe can enter the soil more easily.

I put down all these details because I want to emphasize the importance of making any soil-cutting tools or parts of implements by forgeing.

Small agricultural machinery to be used in Zambia (in order of priority):

IV/A/2. Hand seeders

These are used for any kind of crop which is sown by the farmer in rows, on land not larger than 1 acre, such as soya bean (about 30to 40 seeds/metre), haricot bean (about 15 to 20 seeds/metre), finger millet (about 150 to 200 seeds/metre) and cotton. Sewing by machine must occupy the place of hand sowing because it results in easier and more effective weeding, resulting in 30 to 50% more crop and 20 to 30% less seed.

One of the reasons for the low yield on subsistence and emergent farmers' land is the low plant population which predominates, especially on poor soil, i.e. in many places in Zambia. If the soil is poor in nutritive material, the plants will not develop satisfactorily even over large distances, i.e. by hand sowing. Even if the plants do not develop satisfactorily but they are in rather dense rows, having been sown by machine, the yield will still be tolerable.

The seeder required by modern agrotechnics must meet the following requirements:

- optimal distance of rows and plants;

- equal depth of sowing;
- the same number of seeds per hole;
- equal, continuous spreading of undamaged seeds;
- covering of seeds;
- variation possibility for different seeds;
- should be easy to handle;
- should require the minimum physical energy.

The type required is: seeding in one line with two wheels, good marking of the connecting rows. The portioning of seeds must be regulated by a simple sliding bolt, depending on the size. This is a simple and cheap solution, needing no more precision than some other, less sophisticated methods.

Cellular wheels can also be used, but are more expensive and require more precision. They can be made of aluminium or plastic material, with holes of different size in them, according to the size of seeds and depending on the number of seeds to be sown in one metre. The superfluous seeds are kept back by brushes or a piece of rubber, without damaging them. By this method the seeder sows only the required number of seeds.

The seeder must have two containers, or one divided in two. The first one contains the seeds and the second the fertilizer. The fertilizer is also measured out (to save fertilizer) by hoe coulter, after the seed is sown.

A disc furrower must be used on the seeder, with slightly convex-shaped cross-section. In this way one can solve the problem - which I have often seen myself, in the case of hand seeders - of the furrower picking up roots, pieces of maize stalk, etc. and pushing all this in front; the rows remain open and the seeds remain on the surface of the soil.

In the case of the disc furrower, it rolls over obstacles but enters deep into the soil which increases the seeders' resistance and the physical energy required. For this reason I propose the use of disc furrowers, slightly convex which will not enter into the soil and roll over obstacles.

After the furrower splitter there is a wide concave small iron roller composed of two parts, which presses down the furrows to cover the seeds. This covering instrument is very well designed on the "Planet" seeder.

Seeders can probably also be used when sewing sorghum, which is sown on flat land, not ridges.

Since the seeder will be used by subsistence farmers, no bigger or more sophisticated mountings are justified, and the seeder must be as cheap as possible. It must be mentioned that there are vast numbers of seeders all over the world but it is extremely difficult to find one which is suitable from all aspects. This is why one should not try to solve the problem by importing the cheapest one, which is not suitable for Zambian conditions.

IV/A/3. Hand cultivator (wheelhoe):

This hand tool belongs to the one line seeder and completes its role. Its work is quick and effective which is satisfactory on loose soil. Even women and children can handle it without any difficulty. It is cheap to produce and available for almost everybody.

The hand cultivator is used for the cultivation of plants between the rows. This is one of the most frequently used hand tools. It loosens the soil down to the depth of sowing, thus making the soil airy and the development of micro-organisms more favourable. For the hand cultivator can only be used for weed not higher than 5-10 cm; it must be applied rather often, at least 3-4 times during one season, depending on the plant and soil conditions.

It cannot be emphasized enough how important it is to economise on physical energy. This is why technical people try to ensure the most favourable conditions when designing hand tools and animal-drawn implements. Such a solution would be to ensure wear-resisting edges for the subsurface cultivator, by providing it with hard alloy insert. By this solution the subsurface cultivator becomes self-edging, being made of two layers (wear-resisting and softer). The basic material is worn relatively quickly but the 0.3 -0.5 mm thick insert ensures sharp cutting and needs no special attention for sharpening. Consequently, work with the tool does not get difficult during usage. In many cases the farmers do not know the advantages of sharp tools or they do not have the opportunity to sharpen them.

Reverting to the wheelhoe, this is the right tool to make subsistence farmers get used to regular, continuous work on the fields during the season, because it is very important as far as results are concerned. Very often subsistence farmers do not do anything on the land until it is covered with weed. Then they either try to weed what they can or do not do anything at all, hoping for the best.

IV/A/4. Harvesting tools

There are two crops which cause the biggest harvesting problems in Zambia:

a. finger millet which is almost the only and most popular plant in the Northern, Northwestern and Luapula Provinces of the country;

b. soya beans which are going to be introduced on a larger scale in subsistence and emergent farming.

a. Almost the only reason for the small area where finger millet is cultivated is the harvesting difficulty. The blade of finger millet being half ripe when the seeds are ripe and must be harvested, it is extremely difficult to cut or break it. Harvesting is actually done by knife, taking the millet beads one by one and collecting them in baskets. With this method, one acre of finger millet can only be harvested by a family in about 25-30 days.

Since finger millet is the only plant which is sure to grow even on very poor soil (the majority of Zambian cultivated land has poor soil), finger millet is certain to remain an important factor in the nutrition of masses of people.

The only solution for increaseng millet cultivation is if the Mageye Agricultural Research Station experiments successfully in designing some effective and very good cutting tool.

My proposal is to make a scissor mechanization which can cut the finger millet by one of the shanks and the other is fixed as a handle. A spring would always keep the scissors mechanism open and it would only close when the handle was pulled. The open pair of scissors would be pulled on the blade of the finger millet up to the head of millet. When pulling it a bit more, the pair of scissors would close and cut the head which would fall into the basket kept in the farmer's other hand. This hand tool would decrease the time of harvesting by at least half.

b. The straw of the soya bean is hard, its roots ane tough and the husks are prickly. These characteristics of the soya bean show that no publicity, no high prices, etc. can get the farmers to produce it while soya beans must be harvested by hand from 1-2 acres.

I may mention that there are tractor-drawn implements used for harvesting soya beans. They are similar to the hemp cutting device which has straight cutting blades and cutting pairs of large breadth. This implement cuts down the plants at ground level and the roots with the root nodules remain in the soil, providing it with some nitrogen.

IV/A/5. <u>Threshing</u>

On of the most difficult problems is the shelling of ground nuts. Several experimental machines have been made for this purpose. The cheapest and most suitable solution is a rubber disc operating as a mill. The problem becomes more complicated when the shells must be separated from the nuts. This cannot be done with simple winnowing.

In order to keep production costs low and not to use a complicated implement, the problem can be solved with a double-phase working process: the first one would break the shells into small pieces (with the possible smallest damage to the nuts); and the second one would separate them from each other. For the last process the use of beet seed cleaning screen seems to be the most convenient.

IV/A/6. Seed dressers

This machine is the most urgent need of every farmer, being indispensible in the case of almost every plant, especially when soil is mixed with the seeds and they cannot be separated by winnowing. Good machines have been constructed (in the U.S.A., Japan, South Africa) for tropical countries, to clean ground nuts etc., so I do not want to give details on this subject.

IV/B. Animal-drawn agricultural machinery

In the hope of the Ministry of Rural Development taking measures to provide more and more trained oxen for the farmers, I outline herewith the technical parameters of the animal-drawn implements which are suggested for production in the proposed Agricultural Machinery Factory:

Type and weight:	1 plough 35 kg	2 plough 36 kg	3 plough 50 kg	4 two furrow half-turn plough
Working width in mm:	230	250	300	240
Working depth in mm:	150	150	240	210
Size of beam (second hand rails):in mm:	50 x 17	50 x 17	50 x 25	50 x 25
Weight of knife furrow splitter in kg (with camp):	3	3	4.5	2 x 4.5
Relieving wheel in mm:	220	220	220	ca 500

5. Ridging plough: 35 kg; distance of ridges: 250-500 mm; weight of breast-board (with lifter) ca 13 kg; size of beam: 50 x 17 mm.

6. Cultivator: 38 kg; working width: 400-500 mm; number of hoes: 5 pieces in 3 rows; distance from each other lengthwise: 240-500 mm.

7. Zigzag harrow: 25 kg; with 4 lathes for the teeth; 20 pieces of interchangeable harrow teeth (weight 0.35 kg).

IV/B/1. Two-furrow half-turn plough

In order to see why I propose the introduction and local production of the two-furrow half-turn plough in Zambia, for the use of subsistence farmers, it will be useful to consider the following.

According to the working method, the ploughing can be:

a. conventional furrow ploughing;
b. plain ploughing.

a. Those ploughs which do conventional ploughing are equipped only with plough body turning to the right. This is why there are ridges and blind furrows after conventional ploughing. Rain water gathers in the blind furrows and the soil of the ridges contains less water; consequently the green crops will be uneven and so the development of the plants will be different and spotted along these lines. In order to avoid these defects, after ploughing, one should do transverse harrowing to smooth away the ridges and blind furrows.

b. This working phase can be omitted if the ploughing is done by two-furrow half-turn plough (plain ploughing). This plough has plough bodies turning to the right and to the left, which can be turned over the longitudinal shaft, parallel to the direction of movement. These plough bodies work alternately according to the direction, back and forth, thus the clods would lie side by side and no ridge or blind furrow will occur. Furthermore, the use of the two-furrow half-turn plough results in considerable time-saving - especially in the case of animal-drawn implements - the idle running being much shorter as the time of turning round is shortened to the minimum. By this method the ground ploughed during the same period of time will also be increased.

Considering that the arable land of the Zambian subsistence farmer is generally rather irregular (because of physical features and mainly because of the anthills), there is plenty of detouring to be done when ploughing. This is one reason for using the two-furrow half-turn plough.

As far as the disadvantages are concerned, this plough is 1.5 to 2 times heavier than the traditional plough, owing to the double plough body and skim coulter. Consequently the production costs are also higher, but the useful life of the plough is longer.

IV/C/1. The Roller plough

There are several reasons for the introduction of this revolutionary new plough, which can be used by commercial farmers (according to investigations there would be a market for about 400 to 500 pieces/year).

The most important and most frequently used machine for agricultural cultivation is still the plough. This is why it is important to have a plough which can meet the requirements best for a particular speed of work, which the traction resistance of the plough is the smallest, (the turning of the soil, loosening, under-covering, even spreading, etc.)

As far as the construction and functioning of the traditional plough is concerned, it is a special, complex instrument for soil cultivation. The slices of soil are cut (ploughshare), lifted (lower part of the breastboard), bent and turned (middle part of the mouldboard), by the different parts of the plough, while they are deformed and driven to the side. At last the mouldborad extension (tailpiece) transfers a certain kinetic energy to the slice of the soil. From the cutting to the turning, i.e. during the whole movement of the soil or rather of the particles of soil moving on the surface of the plough, they make a continuous friction-movement; consequently the operation of the plough needs considerable traction force.

An important quality of the roller plough is that it moves the particles of soil by a rolling movement and thus the necessary traction force is diminished remarkably (see illustration). This has the advantage that the roller plough works appreciably quicker than the traditional plough working in the same width and depth. In this way the ploughing capacity of the roller plough, depending on the type of soil and its state, is 30 to 60% bigger, expressed in m^3/h, than that of the traditional plough, while the fuel requirement of the tractor is 30 to 55% less, owing to smaller resistance. The roller plough has other advantages, too, which are to be evaluated from the point of view of characteristics of Zambian agriculture.

The main products of the commercial farmers are maize and tobacco. Both crops need different agrotechnics. In Zambia the cultivation of the soil (ploughing) starts with the rainy season (beginning of November). In the case of tobacco, if the farmers plough too early, the tabacco leaves would contain too much nitrogen and would remain green and fragile (deterioration of quality). In the case of maize, more nitrogen results in better yield.

In the dry season it is impossible to do the ploughing because of the dry soil. If the farmers plough during the rainy season the tobacco grows too quickly and then it is difficult to cope with its harvesting.

On this basis there is a 2-3 week ideal period when the ploughing should be done for agrotechnical reasons. Consequently the ploughing must not take too long and the seed beds must be done in time. The latter is sometimes rather difficult and often needs 3-4 discing, the soil being dry and cloddy.

In Zambia there is another task in the field which needs much time: to cut and burn the maize and tobacco stalks on the field or to transport it somewhere else and burn it there, if the cattle do not eat it.

All these jobs requiring much time and often being disadvantageous from the agrotechnical point of view, can be avoided by the roller plough, owing to its further advantages (see in prospect).

This plough is patented in Hungary and has already been introduced to 31 countries. Its production in Zambia could be realized in the proposed agricultural machinery factory, after having bought the licence and the know-how.

The plough is not at all complicated; it is composed of the soil cutting unit, two or more pairs of free-running rollers with rubber lining, the knife coulter, a traditional plough beam and the headstock for the hauling device of the tractor (see illustration in prospect). The principle of its operation is that the soil cutting unit cuts the slices of soil and by lifting them a little, moves them forward onto the cloak of the first roller. This roller, because of the effect of the forward movement of the whole plough and under the influence of the moving slice of soil, starts rotating and by spinning the particles of soil, moves them forward to the second roller which overturns and spreads them. This second roller rotates like the first but, owing to its angled position, in the opposite direction.

In this manner the particles of soil rolling and glancing off the elastic surface of the roller, crumble, thus preparing a seed bed suitable for sowing.

As far as the durability of the roller plough is concerned, its cutting device works longer than that of the traditional plough, since there are less heaping pressures and power impulses in front of the plough body. Owing to the elastic but wear-resistant surface of the rubber flaps they must be changed only after 2 to 3 seasons. Their mounting is very simple, the time required for it being minimal and their price very low. (Technical data of the roller plough - see in prospect.)

Finally, one can realize that the introduction and effective use of the roller plough in Zambian agriculture would result in the possibility of introducing new technology as well as in helping the Zambian Government to achieve its objective, i.e. to increase considerably the actual annual yield in maize, the average yield in maize and tobacco depending greatly on the level of the production technique.

The most machinery is needed on the agricultural farms specializing in the production of maize. Their activity is more profitable if they can concentrate expertise and technical knowledge, thus producing more economically, by reducing the prime costs, i.e. by increasing the yield on the same ground.

When making use of the new technology, there are several working phases which become superfluous (clod breaking, cultivation, smoothing). By omitting all these (by combining several working phases) a considerable saving in labour can be achieved. At the same time, this technology assures bigger productivity and effectivenss by increasing the ploughing speed, the ploughing width and by making the seed beds simultaneously.

IV/C/2. Tie ridger

In Zambia the rain does not start before the second half of October or in November. It is an absolute necessity for the farmers to have either animal or tractor drawn implements which can prepare the soil so that its water-holding capacity is the best possible and it should not let the water flow away. The use of disc and ploughs making big 'boxes' on the surface of the soil is very useful.

One should see in practice the effect of the rain on the ground and on its structure (cohesion, destruction), the need for a machine turning perfectly into the soil the organic matter and the fertilizer, etc., because it is almost impossible to tell from what the farmers say.

IV/D.

In a country like Zambia - where the main crop is the maize in an important quantity - it is paying without a doubt to introduce complete sectoral mechanization, for it can increase considerably the average yield and, as a result, it would contribute to the more intensive development of the country. In my opinion the complex mechanization of - among others - maize production results in better yield and very often in the reduction of costs beyond replacing hand work and traditional animal-drawn machinery. I have prepared in several ways the list of machinery necessary for the preparation of seed beds for maize and its sewing in a single working phase (see attached illustration) as well as some of the variations of the material transport chain both for maize in the ear and grain.

IV/E/1. Irrigation

The climatic conditions of Zambia are so varied that after a 4-month rainy season (from November to March) comes an approximately 8-month long absolutely dry season.

During the rainy season, the rainfall is between 1,200 mm and 600 mm, more in the North and less in the South. The temperature and sunshine duration in the dry season (winter) are so favourable that they would offer excellent conditions for plant cultivation if irrigation could be provided. For the time being the dry months are a dead season in Zambia, but by irrigation two harvests per year could be achieved in the country. For this reason every opportunity must be taken to make use of any water suitable for irrigation.

Apart from this possibility, one can state that the results of plant cultivation by sprinkling is always increase in yield; accordingly sprinkling is very profitable. Hereafter I shall quote data (from the Agrarhilfe 1971, Germany) on the increase in yield of the different crops, cultivated by sprinkling:

Cereals	0.6-1 t/ha
Maize	0.8-1.2 t/ha
Sugar beet	10-15 t/ha
Tomatoes	20-25 t/ha
Tobacco	1-1.5 t/ha
Fruit	100%
Cotton	40-60%
Ground nuts	30-40%
Coffee	25-30%
Sugar cane	60-80%
Bananas	30-40%

There are experiments in Zambia already (e.g. the irrigation scheme in the Gwembe Valley, directed by the Gossner Mission into the method of flooding).

Although almost every country has its traditional method of irrigation, the most generally used methods are irrigation on furrowed surface, flooded surface irrigation, striped streaming, furrowed surface with hose distribution and striped streaming with hose distribution.

These irrigation methods are very well justified by the special local circumstances (lack of energy, lack of repair and maintenance of possible machinery, etc.). These circumstances make it not possible to use sprinklers, though their use always leads to the following agrotechnical and economic advantages:

"1. Natural rainfall with even surface distribution;

2. Economical management of water-supplies as this method needs about 40-70% less water than surface

flooding. This means that the same quantity of water is sufficient for the irrigation of 1.5 to 2 times more ground;

3. It requires less labour;

4. It is independent of the slope of gradient and the configuration of the soil; no levelling or construction of dams is needed, etc. Thus the arable land remains even and will not be cut in pieces by a system of dams;

5. There is no need for irrigation canals and systems of dams, which, moreover, function with considerable loss of water;

6. The complete surface of the soil can be used, while the ground occupied by the canals and dams is completely useless for cultivation;

7. The soil will not become muddy which would prevent it from proper airing and the micro-organisms from development;

8. There is no deterioration of the soil, it will not become alkaline. One can use the sprinkling system for the even distribution of fertilizers and plant-protecting materials (e.g. against locusts) in solution on the required ground;

9. The quantity of the water sprinkled can be regulated and an average intensity of rainfall can be assured (which should not surpass the absorbent capacity of the soil, depending on its structure, moisture-content, mechanical and chemical composition, on the kind of crop cultivated, on the duration of sprinkling and on the diameter of the sprinkler's drops). By the method of sprinkling the yield is also higher than by flooding irrigation."

For instance, in South Africa, on an experimental orange-plantation irrigated by sprinkling the average yield was 75t/ha, while those irrigated by flooding had an average yield of 35t/ha only. In Azerbaijan, the average yield of cotton was 400 kg/acre by sprinkling and 90kg/acre by flooding. In Puerto Rico the sugar cane average yield was 45t/acre by sprinkling and 33.5t/acre by flooding.

These examples are only to demonstrate that any kind of investment for irrigation by sprinklers, e.g. motor pumps, hydrolift (see description later), reservoirs, irrigation pipes, sprinklers, etc. - will be refunded very soon, owing to the higher yield and all the advantages enumerated above.

The motor pumps used for the lifting of water, can be replaced by the hydrolift in places where one can find water-courses or water reservoirs. The hydrolift is then capable of supplying the sprinklers with water (see attached leaflet).

I should like to show and give an idea of the difference between the different methods of irrigation, by enumerating some of the most important index numbers of the political economy: live labour requirement, (referring to Central Europe):

	Irrigation systems	Live labour requirment in shift/100 ha (1 shift x 8 hour)
1.	Irrigation on furrowed surface	543
2.	Flooded surface irrigation	537
3.	Striped streaming irrigation	301
4.	Irrigation on furrowed surface with hose distribution	207
5.	Striped streaming irrigation with hose distribution	284
6.	Sprinkling with portable sprinkler lines	1,009
7.	Sprinkling with mobile sprinkler lines	378
8.	Sprinkling with piping under surface with half-fixed sprinkler lines	883
9.	Sprinkling with piping under surface with self-propelled sprinkler line (on wheels)	156

According to the utilization of the sprinklers for the different crops (one year or several years) and for the different types of soil in Zambia, the piping system can be:

a. permanent
b. half-fixed, and
c. mobile

The latter one can, at any time, be re-layed in another place. The pipes should be made of light steel, aluminium alloy or plastic. These are equipped with the so-called quick coupling, which are made leak-proof by the pressure of the water. Thus, the coupling of the pipes can be done in no time. What is more important, anybody, even those without any skill, can do the coupling and uncoupling, i.e. the shifting of the pipes to another place. The sprinklers and the fertilizer and the fertilizer dissolvent can just as easily be fixed up. If the pipes are adequately zinced, they can last as long as 10 years. In order to make the pipes hard-wearing, the following measures are recommended for the steel pipes:

outside diameter in mm:	89,	102,	127,	169,	180
wall thickness in mm:	1.0,	1.0,	1.0-1.2,	1.2-1.5,	1.5

One pipe unit is generally 5 to 6m long. The pipeline is able to follow the unevenness of the ground since the radial distance between the pipe and the pipe coupling as well as the elasticity of the material between them make possible an inflexion of 10% in both directions to the axle of the coupled pipes.

As I have already mentioned when enumerating the advantages of the irrigation by sprinkler, or can adapt to any point of the piping, a so-called fertilizer container. By this means the sprinklers can distribute e.g. a solution of 34% ammonium nitrate. This method is extremely advantageous, quick and cheap, assuring an even distribution. For this purpose a fertilizer dontainer, namely an insertion pipe with a pipe tightener in the centre, must be connected to the irrigation delivery pipes. On the effect of the tightener the water gets through to the fertilizer container through a connecting pipe. A jet of water flowing out of a sprinkler dissolves the fertilizer in a sieve and the solution is moved forwarded by the help of another connecting pipe, to the irrigation piping. After the solution in the sieve, by the effect of its own weight, further fertilizer gets into the stream of water. Therefore this method is of continuous running, simple and its operation requires no special skill.

IV/E/2. Irrigation pipes

If the sprinklers are going to be used widely, not only by emergent farmers but also commercial farmers, I would suggest the introduction of the tractor-drawn and driven hose reel with winch, the resettlement of which is very quick from one place to another. The settlement of the main and branch pipes is done from engine driven winch, suspended on a tractor, the pipe being made of synthetic fibre hose, which can be wound. The settlement of the sprinkler lines is done from hand-winch, slung round one's neck.

Their specification is the following:

length of the main pipe:	300 meters	
" " " branch pipe:	216 "	
" " " sprinkler lines:	48 "	(2 x 24)

No. of branch pipes:	2 pieces
No. of sprinkler lines:	48 pieces
No. of sprinklers:	24 pieces
Territory covered by the above piping:	18 ha
Sprinklers' optimal distance:	18 x 24 metres
Sprinklers' intensity:	12.8 mm/h

IV/F. Machinery for tobacco cultivation

The machinery for tobacco cultivation reflects the lack of mechanization in Zambia. In this case actual tobacco types, Virginia and Burley, grown in Zambia are not suitable for machine cultivation.

The development of such a type will enable the competent organization to elaborate the appropriate series of machinery, necessary for planting and tobacco leaf wreathing, for the care of plants and plant protection by machine has already been solved in the case of the types actually existing.

Special machinery such as ridgers, tobacco presses, etc. actually used for tobacco cultivation, were bought from South Africa (Bentall Co.) until 1968.

According to the method in use one should bed out the tobacco plants just before the rainy season starts, theoretically between 20-28 October. In one acre about 6,000 plants are transplanted by hand. Harvesting is finished around 10 March the following year.

The average yield of a farmer in Choma (Southern Province) is 590 kg/acre; in Mkushi (Central Province) 500 kg/acre; the tobacco produced in the vicinity of Kabwe (Central Province) is the best export quality.

Owing to the favourable climatic and soil conditions, Zambian tobacco ranks in second or third place after the American.

As far as the profit per same area is concerned, the tobacco is far in the best place. Tobacco cultivation is so profitable, it is to be expected that more and more farmers will grow it, although it requires accuracy and skill.

V. Economic conditions of the proposed new Agricultural Machinery Factory, guiding prices of the investment, economic efficiency calculations

On the request of Mr K. Levison, Project Manager, Small-Scale Industries Project, I prepared an economic calculation on the profitability of a possible A.M.F. This calculation is required to prove that the factory can be run profitably. Nobody would make such an investment without seeing that it is worthwhile.

On 2 November 1972, I paid a visit to Mr D. Luzongo, Director of Agriculture. He told me that the World Bank seemed to be willing to give a loan for Zambia for agricultural investment, which can be used for a machinery factory.

Naturally, it is very important not only to create employment possibilities for a number of people but also to have a profitable economic base for the factory.

Because of lack of time, I could make the calculation for two years only, on a book-keeping basis. I.e., amortization of buildings is calculated for 45 years and that of the machinery for 10 years. In reality, the rate of return can be much less, approx. 15-20 years for buildings and 5-8 years for machinery. If we take as a basis the amount invested and deduct the yearly profit, the rate of return can be even less, depending on the profitability of production.

The economic calculation is a method of investigation which helps in choosing the best solution out of several possibilities, which helps to achieve an aim (e.g. cheap production, qualitative production, quick rate of return, etc.) with the smallest possible investment.

When doing the economic calculation of the proposed factory, I took into consideration the production plan, equal to the Zambian requirements:

- the guide numbers of the Lusaka Engineering Co. (Lenco) being used in its workshops;
- the size of series, and
- the total production costs.

I must mention here that out of the 300 thousand pieces of free capacity of the forge shop, about 60,000 pieces of shovels and 15,000 pieces of picks/year, as well as unspecified spare parts are needed by the mining industry.

The production costs of certain goods have been calculated on the basis of raw material prices (forge shop and other shops separately), on a percentage basis. Thus I have only calculated the production cost of certain goods, with 25% profit for products of the forge shop. In order to have a basis of comparison, I have indicated the actual import prices besides the production costs.

I have not proposed any selling prices because these depend on the policy of the Zambian Government.

The definitive calculation can only be prepared at a later stage (owing to several missing components), possibly with the Feasibility Study.

Reasons for proposing the new Agricultural Machinery Factory to be built at Kabwe

I find that the most possible ideal place for setting up this new factory would be Kabwe, about 140 kms to the North of Lusaka, on the line of rail and on the main North/South road, situated in the centre of not only Central Province but also of Zambia, as well as in the most valuable and most developed agricultural region of the country.

In order to ensure the cheapest possible production of agricultural machinery of big series, I propose to choose Kabwe for the following reasons:

1. The transport of raw material, the weight of which is generally several times more than that of the finished product, would be via the new line of rail from Tanzania, [illegible] Kabwe. Zambia is poor in raw materials, so almost everything must be imported, except for goods coming from the Copperbelt by rail. The factory must be as near as possible to the arrival place of raw material and that of secondhand material. The new line of rail will meet the already existing one at Kapiri Mposhi, near Kabwe.

2. As far as economic policy is concerned, it is recommended to produce goods to and from where it is easy to transport them (not only raw materials, but also finished goods). Agricultural machinery production should take place in the central of the agricultural area, not only because of transport but also because of easier development possibilities. The area surrounding Kabwe is one of the best agricultural areas in the country with the best soil (production of maize, tobasso, etc.). Near the Copperbelt there are large centres of vegetable production.

3. Kabwe is not only in a central position for agriculture but is also in the centre of the country which makes transportation from here very favourable.

4. In the industrial zone of Kabwe there is a very advantageous area for the proposed Agricultural Machinery Factory, on one side of which runs the main line of rail (with the possibility of building a side-track up to the factory) and on the other side is an asphalted road.

The site is supplied with public utilities, which is another important aspect when building a new factory.

5. There are several works at Kabwe (e.g. Zambia Railways Central Repair Workshop, zinc mine, etc.) which could give commission work to the factory's forge shop and foundry. Also there are always reciprocal advantages if several factories are near to each other, profiting from one another's equipment.

6. The Zambia Railways Central Repair Workshop has a complete forge with equipment almost perfectly unutilized. There is a possibility that this could be taken over by the proposed A.M.F., or the workshop could be hired until the factory is constructed and start production over there.

7. There is a technical school near Kabwe, training students for lathe operation, welding, mechanics, etc. This school could supply the factory continuously with the necessary skilled workers.

8. Besides the extra transport costs, there are other reasons for not building the factory in Lusaka. In particular, there are already urbanization problems in the capital which would be even worse if a new factory attracted even more people to town.

Estimated territory required by the agricultural machinery factory at Kabwe, size of buildings, approximate prices of investment (construction and eqipment, furniture, etc.), for informatory purposes only

No.	Denomination	Technical data of building	Acreage	Cost of construction	Equipment furniture	Total
1.	Production building (blacksmith shop, foundry, metal-cutting and joint screw-making shop)	Brick steel frame suitable for the installation of 5 ton cranes, top daylighting with shed-roof, concrete flooring; with electricity, water, sewers Three hall units/12 m width, 5 m inner height	5,500 m^2	K500,000	K245,120	K745.120
2.	Auxiliary shops, transit stores	Steel frame with corrugated strap, top daylighting, concrete flooring; with electricity, water, sewers. Two hall units /12 m width, 4.5 m inner height	2,500 m^2	K250,000	K30,000	K280,000
3.	Office buildings (management, technical offices, commercial section)	Two storey, brick wall bulding 2.5 m inner height, with the necessary offices, conveniences; concrete flooring	1,200 m^2	K150,000	K15,000	K165,000
4.	Social buildings (dressing-room, lavatory, dining-hall, first aid room, etc.	Brick wall building, one storey 2.5 m inner height, with the necessary conveniences	800 m^2	K100,000	K5,000	K105,000
5.	Other buildings (cabin substation, apprentice school, incendiary stock-house, fuel store, etc.)	Buildings with brick walls and steel beams, mixed	500 m^2 10,500 m^2	K50,000	K12,000	K62,000
6.	Contingencies	-	-	-	K142,880	K142,880
7.	Total territory required (buildings and yard)	Levelling of the plot no. 1239 at Kabwe costs approx. 1K/m^2	15,000 m^2	K15,000	-	K15,000
				K1,065,000	K450,000	K1,515,000

Plus additional cost of design work.
N.B. Constructional costs advance by 8 to 10% per year.

Summary of the proposed A.M.F. calculation, determination of the no. of years for the investment to be refunded (in k)

Name	1974	Name	1975
1. Complete building of forge shop	76.500	1. Foundry, cutting and heat treating shops, complete factory (except buildings)	441.300
2. Shop equipment, machinery	178.261	2. Shop equipment, machinery	166.859
3. Contingencies	70.000	3. Contingencies	30.000
Fixed assets:	324.761	Fixed assets:	638.159
4. Raw material landed cost (in factory)	245.641	4. Raw material landed cost (in factory)	397.243
5. Spare parts bought	171.000	5. Spare parts bought	219.932
6. Cost of energy, water	8.000	6. Cost of energy, water	19.000
7. Wages	77.000	7. Wages	237.900
8. General expenses	28.700	8. General expenses	77.000
9. 8% interest on capital	49.944	9. 8% interest on capital	83.292
Variable assets:	585.885	Variable assets:	1,034.367
10. Ex factory selling price of finished products (forge shop)	842.805	10. Ex factory selling price of finished products (forge ship)	1,105.025
Less variable assets	585.885	Other workshops	314.980
Result (profit):	256.920	Total:	1,420.005
		Less variable assets	1,034.367
		Result (profit)	385.638

Name	1976
1. Office buildings and auxiliary buildings	547.200
2. Office equipment in the whole factory	62.000
3. Contingencies	42.880
	652.080
Fixed assets of total investment:	1,515.000

Determination of the no. of years, for the investment to be refunded (in K):

Average profit

Profit of 1974		256.920
" " 1975		385.638
" " 1976	(1975 + 5%)	404.920
" " 1977	(1976 + 10%)	445.412
" " 1978	(1977 + 5%)	467.683

1.960.573 : 5 = K392.115 (average profit)

$$\text{year} = \frac{\text{fixed assets}}{\text{average profit}} = \frac{1.515.000}{392.115}$$

= 3.86 years

Preliminary Calculation of the Kabwe Agricultural Machinery Factory's profitability for 1974

$$\text{profitability} = \frac{\text{result}}{\text{investment}}$$

When putting into service the forge-shop and the edging-shop: 1.8 million operations/year

No.	1. Denomination	2. weight per piece in kg	3. No. to be produced in 1974	4. total weight of products	5. material consumption+3% in kg	6. % of total weight	7. price of raw material + transport forging steel 170 K/kg **40K/t	8. cost price and handling charges of spare parts bought	9. cost of energy & water in K	10. amortization rate of fixed assets 2,5 % in K	11. investment cost (building) in K amortization*	12. direct wages	13. general expenses	14. contingencies	15. rate of interest of capital 8 % in K	16. production cost	17. sales 25 % profit	18. profitability	19. factory's selling price K/piece ex factory	20. import prices (selling K/kg (price/weight)
1.	Hoe	1,00	100.000	100.000	103.000	7,02	17.510	-	634	1169	60	5445	2015	4914	3506	35.283	44.104	1,25	0,44	Malawi: 0,99/1,25 Chinese: 0,65/1,44
2.	Pick-axe	2,5	10.000	25.000	25.750	1,75	4.378	-	158	292	7	1358	502	1225	874	8.794	10.993	1,25	1,10	Malawi: 1,95/3,5
3.	Shovel	1,2	5.000	6.000	6.180	0,42	1.051	-	38	70	44	326	121	294	210	2.154	2.693	1,25	0,54	Malawi: 2,40/1,2 with handle
4.	Panga knife with handle	0,85	100.000	85.000	87.550	5,96	14.884	10.000 (handle)	535	993	90	4.625	1.710	4.172	2.977	39.986	49.982	1,25	0,50	Malawi: 0,75/0,85 with handle
5.	Maize hook	0,15	300.000	45.000	46.350	3,16	7.880	75.000 (leather)	284	525	281	2.452	907	2.212	1.578	91.120	113.900	1,25	0,38	
6.	Harrow's teeth	0,35	400.000	140.000	144.200	9,82	24.514	16.000 (bolts & nuts	384	1.636	374	7.620	2.818	6.874	9.904	65.624	82.030	1,25	0,21	Malawi: 0,60K
7.	Sickle (with handle)	0,42	150.000	63.000	64.890	4,42	11.031	15.000 (handle	397	736	138	3.430	1.268	3.094	2.208	37.302	46.628	1,25	0,31	Malawi: 0,45/0,2
8.	Scythe blade (with handle)	0,75	100.000	75.000	77.250	5,26	13.133	25.000 (handle	473	876	90	4.082	1.510	3.682	2.627	51.473	64.341	1,25	0,64	
9.	Canterbury hoe	1,52	100.000	152.000	156.560	10,66	26.615	-	958	1.776	90	8.272	3.059	7.462	5.324	53.556	66.945	1,25	0,67	English: 5 K with handle, larger
10.	Combination of hoe and Canterbury hoe	0,66	150.000	99.000	101.970	6,94	17.335	-	625	1.156	138	5.385	1.992	4.858	3.466	34.955	43.694	1,25	0,29	Malawi: 0,80K
11.	Cow chain's hook	0,42	85.000	35.700	36.771	2,51	6.252	-	230	418	77	1.948	720	1.757	1.254	12.655	15.818	1,25	0,19	
12.	Commission work (e.g. plough-share for spare part) (free capacity)	a 2,0	300.000 (for '74-'75)	***600.000	618.000	42,08	105.060	30.000 (commercial articles)	3.787	7.010	281	32.654	12.078	29.456	21.016	241.342	301.677	-	-	
	Total:		1.800.000	1.425.700	1.468.471 1.468,5 t	100,-	249.641	171.000	9.000	16.658	1.700	77.600	28.700	70.000	49.944	674.244	842.805			
	Total capital requested:						249.641	171.000	9.000	178.261	76.500	77.600	28.700	70.000	49.944		Grand total	910.646 K		

N.B. Calculations for the amortization rates of fixed assets and buildings and that of total wages see separately.

* Amortization in 45 years

** steel scrap from the mines

*** Including the yearly requirement of the mining industry (approx. 15.000 pick and 60.000 shovels) as well as spare parts, etc.

Calculation for the amortization rates of fixed assets and buildings and that for wages

Forge-shop

10. Amortization rates of fixed assets: (Calculation for 1974) in K

	Name	piece:	basic price/ machine	total	cost of foundation & erection /machine	total
a.	10 Cwt electro-pneumatic hammer	3	18.827,20	56.481,60	2.300	6.900
b.	Electric forge furnace	3	5.000	15.000	400	1.200
c.	36" radial drilling machine	1	9.479,75	9.479,75	750	750
d.	Eccentric press	1	14.000	14.000	2.100	2.100
e.	Friction press	1	9.000	9.000	1.600	1.600
f.	Floor standing grinder	3	1.200	3.600	300	900
g.	Framed saw	2	650	1.300	200	400
h.	Power alligator shears	1	840	840	150	150
i.	Portal crane (0,5 t)	3	1.200	3.600,,	420	1.260
j.	Travelling bridge crane (5 t)	1	4.300	4.300	1.300	1.300
k.	Complete compressor plant	1	22.000	22.000	6.000	6.000
l.	Welders (2 electric, 1 gas)	3	1.100	3.300	-	-
m.	Other equipment (work bench, water and oil containers, etc.)			3.000	800	800
n.	Complete set of smith's tool			12.000	-	-
			K	154.901,35/10 years		23.360/20 ys.

yearly amortization cost of machinery	K 15.490	1.168 /year
foundation & erection	+ 1.168	
	K 16.658	

N.B. The machinery are supposed to work in double shift.

Calculation for the amortization rates of fixed assets and buildings and that for wages

Forge-shop

11. Amortization rates of buildings: (Calculation for 1974) in K

The building cost of the forge-shop and auxiliary biildings:

36 X 25 = 900 m² à 85 K = 76.500 K

amortization for 45 years: 1.700 K / year

N.B.: The offices & administration, etc. buildings will temporarily be accomodated in the auxiliary buildings.

12. Wages: (Calculation for 1974) in K

Employee:	Person:	Cost/year/person	Total
Skilled workers	6	1.000	6.000
Semi skilled "	8	600	4.800
Unskilled "	10	500	5.000
Technician	1	5.000	5.000
Certified engineer	1	13.600	13.600
Manager	1	16.000	16.000
Clerk	1	2.400	2.400
Maintenance mechanics	2	600	1.200
Material handler	1	400	400
Cleaners	3	400	1.200
Quality control inspectors	2	3.000	6.000
Administration cost *		16.000	16.000

Total cost: K 77.600

* is certain to increase

13. General expenses: (Calculation for 1974) in K

a.	Insurance	1.800
b.	Maintenance	2.100
c.	Town development contribution at Kabwe	2.500
d.	Semi-fixed assets (tools)	3.800
e.	Presecure	1.500
f.	Advertisment	2.000
g.	Transport (goods)	5.000
h.	Transport (personnel)	2.800
i.	Travelling	2.200
j.	Sundries	5.000
	Total:	28.700 K

14. Unestimated costs: (Calculation for 1974) in K
(contingencies)

The unestimated costs might result for 1973-74 (estimated period of starting to build up the factory is the 3rd quarter of 1973) from the following : change in price of construction raw materials, in transport hire, in connecting-up electricity, as compared to those in 1972; as well as from the cost of constructing the appr. 650 m long side track from the main line of rail to the site of the factory.

Preliminary calculation of the Kabwe Agricultural Machinery Factory's profitability for 1975

profitability = $\frac{\text{result}}{\text{investment}}$

The complete workshops of the factory planned (see function schema)

No.	1. Denomination	2. weight per piece in kg	3. No. to be produced in 1975	4. total weight of products in kg	5. material consumption + 5% in kg	6. % of total weight	7. price of raw material (forging steel) + transport 170 K/kg 40 K/t	8. cost price & handling charges of spare parts bought	9. cost of energy and water in K	10. amortization rate of fixed assets 2,5 % in K	11. investment cost (building) in K (amort. 45 yrs)	12. direct wages	13. general expenses	14. contingencies	15. rate of interest of capital 8 % in K	16. production cost	17. sales 25 % profit	18. profitability	19. factory's selling price K/piece ex factory	20. import selling prices K/kg (price/weight)
1.	Animal drawn plough (single furrow)	35 (12)* (23)**	2.000 (2.000) (2.000)	70.000 24.000 46.000	25.200 48.300 73.500	16,36	1.008 8.211 9.219	100	1.145	2.552	1.805	23,755	6.855		3.689	49.180	-	1	24,56	China: K 15 Malawi: K 17
2.	Animal drawn plough (single furrow)	36 (12)* (24)**	1.500 (1.500) (1.500)	54.000 18.000 36.000	18.900 37.800 56.700	12,62	756 6.426 7.182	92	883	1.968	1.392	18.324	5.288		2.846	37.975	-	1	25 32	
3.	Animal drawn plough (single furrow)	50 (18)* (32)**	1.000 (1.000) (1.000)	50.000 18.000 32.000	18.900 33.600 52.500	11,68	756 5.712 6.468	90	818	1.822	1.288	16.960	4.894		2.634	45.460	-	1	45,46	
4.	Reversible plough	115 (24)* (91)**	500 (500) (500)	57.500 12.000 45.500	12.600 47.755 60.375	13,43	504 8.121,7 8.626	120	940	2.095	1.482	19.500	5.627		3.028	41.418	-	1	82,84	Rhodesia 112,00
5.	Ridging plough	35 (12)* (23)**	2.000 (2.000) (2.000)	70.000 24.000 46.000	25.200 48.300 73.500	16,36	1.008 8.211 9.219	100	1.145	2.552	1.805	23.755	6.855		3.689	49.120	-	1	24,56	Malawi: 33 K
6.	Heavy Zigzag harrow with 20 teeth in 4 lines	25	1.500	37.500	39.375	8,76	6.694	90	613	1.366	966	12.720	3.670		1.975	28.094	-	1	18,73	Malawi: K 26
7.	Cultivator S 51	38 (15)* (23)**	1.500 (1.500) (1.500)	57.000 22.500 34.500	23.626 36.224 59.850	13,31	945 6.158 7.103	270	932	2.076	1.468	19.326	5.577		3.001	39.753	-	1	26,50	Malawi: K 33
8.	The metal part of hand weeders (with mounting)	4	8.000	32.000	33.600	7,48	5.712	70	[illegible]	1.167	326	10.860	3.134		1.687	23.980	-	1	3	
			18.000		449.400	100	60.223	932	[illegible]	15.598	41.032	145.200	41.900	the 8% of the capital: 281.885	22.550 is	314.980				
							60.223	932	[illegible]	166.850	441.300	145.200	41.900							

* steel scrap
** rolled section steel

Continuation of the Preliminary calculation of the Kabwe Agricultural Machinery Factory's profitability for 1975

Forge-shop only:

	1.	2.	3.	4.	5. material consumption + 3 %	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
9:	Hoe	1	500.000	500.000	515.000	25,85	87.555		3.102	4.306	439	23.963	9.073	7.755	15.701	151.894	189.868	1,25	0,37	
10.	Pick-axe	2,5	20.000	50.000	51.500	2,58	8.755		310	430	44	2.392	906	774	1.567	15.178	18.972	1,25	0,95	
11.	Shovel	1,2	8.000	9.600	9.888	0,50	1.681		60	83	9	464	176	150	304	2.927	3.659	1,25	0,46	
12.	Panga knife with handle	0,85	300.000	255.000	262.650	13,18	44.651		1.582	2.196	224	12.218	4.626	3.954	8.006	77.457	96.821	1,25	0,32	
13:	Maize hook	0,15	600.000	90.000	92.700	4,65	15.759	150.000	558	774	79	4.311	1.632	1.395	2.825	177.333	212.666	1,25	0,37	
14:	Harrow's teeth	0,35	400.000	140.000	144.200	7,24	24.514	16.000	869	1.206	123	6.711	2.541	2.172	4.400	58.536	73.170	1,25	0,18	
15:	Sickle with handle	0,42	300.000	126.000	139.780	7,02	22.063	18.000	842	1.169	119	6.508	2.464	2.106	4.264	57.535	71.918	1,25	0,24	
16.	Scythe blade with handle	0,75	250.000	187.500	193.125	9,69	32.831	35.000	1.163	1.614	165	8.983	3.401	2.907	5.885	91.949	114.936	1,25	0,46	
17.	Canterbury hoe	1,52	200.000	304.000	313.120	15,72	53.230		1.886	2.619	267	14.572	5.518	4.716	9.548	92.356	115.445	1,25	0,58	
18.	Combination of hoe and Canterbury hoe	0,66	350.000	231.000	237.930	11,94	40.448		1.433	1.989	203	11.068	4.191	3.582	7.252	70.166	87.708	1,25	0,25	
19	Plough share for all the ploughs as spare parts	1,58	20.000	31.600	32.548	1,63	5.533		195	272	28	1.510	572	489	990	9.589	119.862	1,25	-	
			2,898.000		1.992.441	100	337.020	219.000	12.000	16.658	1.700	92.700	35.100	30.000	60.742	804.920	1.105.025			

In order to achieve a more favourable price for the 35 kg plough, which is the most popular one, the price of this plough could be remunerated by those articles which are produced at a lower price than the actual import prices.

Denomination:	Production price:	Import selling price	%	savings/machine	Production pieces/year	*Total profit
a. Ridging plough	K 24,56	K 33	-34	+ 8,44	2.000	+ 12.660
b. Zigzag harrow	K 18,73	26	-39	+ 7,27	1.500	+ 10.905
c. Cultivator	K 26,50	33	-24	+ 6,50	1.500	+ 9.750
						+ 33.315

In the case we want to achieve an ex-factory price of K 19,50 for the 35kg plough, which will be produced at a price of K 24,56, K 10.120 (K 5,06 per piece) must be deducted from the total profit of K 33.315, in order to remunerate the 2.000 pieces of ploughs to be produced this year.

The above deduction would change into K 19.120 (K 9,56 per piece) if we want to achieve the Chinese price level, which is actually K 15.

The foregoing comparison is made on an ex-factory (local) and selling (import) price basis, which aims at proving that the local production prices can compete with the actual import prices.

Mention must be made of the forge-shop, the total products of which have an overall profit of 25 %. The ex-factory prices of the forge-shop's products are lower than the actual import prices, even at such a high rate of profit (rate of profitability: 1,25). This certainly means that all the other work-shops of the factory can be profitable.

* Proposed for Kabwe

N.B.: Calculations for the amortization rates of fixed assets and buildings and that of total wages see separately.

Calculation for the amortization rates of fixed assets and buildings and that for wages

10. Amortization rates of fixed assets: (Calculation for 1975 in K)

10/1. Equipment of foundry:

Name:	Piece:	Basic price/ machine	Total:	Cost of foundation & erection / machine	Total:
a. Three phase, arc-light melting furnace	1	22.000	22.000	3.000	3.000
b. Charging instrument with basket and casting ladles	3	1.000	3.000	400	1.200
c. Dies for 9 different machine types		-	13.100	-	-
d. Travelling bridge crane (5 t)	1	4.300	4.300	1.300	1.300
e. Floor standing grinder	1	1.200	1.200	300	300
f. Other equipment (work benches, hand grinders, pneumatic flogging chisel, supply of compressed air, oxy-acetylene chisel, etc.)		-	1.900	-	460
			K 45.500		K 6.260

10/2. Cutting and joint screw making shop:

Name:	Piece:	Basic price/ machine	Total:	Cost of foundation & erection /machine	Total:
a. Universal lathe; centre-to-centre distance: 750-2.000 mm	1	6.000	6.000	1.200	1.200
b. Automatic screw machine	1	10.609	10.609	1.500	1.500
c. Screw cutting automat	1	9.500	9.500	1.400	1.400
d. Drill press for a maximal boring of 40 mm	1	5.000	5.000	1.000	1.000
e. Bench drilling machine for a maximal boring of 10 mm	3	700	2.100	100	300
f. Framed saw	2	1.250	2.500	400	800
g. Other equipment (work bench, hand tools, tools, etc.)		-	1.400	-	-
			K 37.109		K 6.500

Calculation for the amortization rates of fixed assets and buildings and that for wages

10/3. Heat treating and edging shop:

Name:	Piece:	Basic price/ machine:	Total:	Cost of foundation & erection / machine	Total:
a. Continuous furnace for the heat treating of castings (in order to norma lize it; capacity: 1-1,2t/m² bottom	1	12.000	12.000	2.000	2.000
b. Flame hardener	2	1.600	3.200	200	400
c. Portal crane (0,5 t)	1	1.200	1.200	420	420
d. Auxiliary equipment (cleaning drum for castings)	3	330	990	60	180
e. Small size universal cutter grinding machines	4	1.000	4.000	150	600
f. Blade grinding machine	1	800	800	200	200
g. Grinding machines with double abrasive disc	2	500	1.000	150	300
h. Complete dust collector equipment		-	1.900	-	400
i. Other equipment (work. bench, material table, etc.)					
			K 26.090		K 4.700

10/4. Cold pressing and sheet shop:

Name:	Piece:	Basic price/ machine	Total	Cost of foundation & erection / machine	Total:
a. Shearing machine for rolled section steel	1	2.600	2.600	250	250
b. Eccentric press	1	12.800	12.800	1.200	1.200
c. Travelling bridge crane (5 t)	1	4.300	4.300	1.300	1.300
d. Electric alligator shears	1	700	700	100	100
e. Hand operated metal snips	2	300	600	50	100
f. Other equipment (material table, hand tools, mechanical attachments, etc.)		-	1.000	-	-
			K 22.000		K 2.950

Calculation for the amortization rates of fixed assets and buildings and that for wages

10/5. Welding shop:

Name:	Piece:	Basic price/ machine.	Total:	Cost of foundation & erection / machine	Total:
a. Resistive welder	3	1.500	4.500	-	-
b. Gas welder equipment	2	800	1.600	-	-
c. Equipment for gas absorption		-	500	-	450
d. Travelling hoist (1 t)	1	600	600	200	200
e. Welding cabin, work benches	3	66	220	33	100
			K 7.400		K 750

10/6. Locksmiths' shop:

a. Work benches, hand tools		2.400	2.400	100	100
b. Travelling hoist (1 t)	1	600	600	200	200
			K 3.000		K 300

10/7. Assembly shop, quality control:

a. Hand tools		1.000	1.000	-	-
b. Travelling hoist (1 t)	1	600	600	200	200
c. Other equipment		400	400	-	-
			K 2.000		K 200

Calculation for the amortization rates of fixed assets and buildings and that for wages

10/8. Paint shop:

Name:	Pieces:	Basic price/ machine	Total:	Cost of foundation & erection / machine	Total:
a. Electrostatic colour distributor	3	300	900	-	-
b. Electrostatic painting equipment	1	800	800	200	200
c. Easels, mobile drying hanger		-	300	-	-
			K 2.000		K 200

Total:	K 145.099/10 years	K 21.760/20 yrs	
		K 1.088/year	

Yearly amortization cost of machinery	K 14.510
foundation & erection	+ 1.088
	K 15.598

11. Amortization rates of buildings: (Calculation for 1975) in K

Forge-shop (complete)	36 x 24 m = 864 m^2	@ 85 K/m^2 =	73.440
Auxiliary buildings, stores	12 x 60 m = 720 m^2	@ 50 K/m^2 =	36.000
Cutting shop	36 x 24 m = 864 m^2	@ 85 K/m^2 =	73.440
Joint screw making shop	36 x 5 m = 180 m^2	@ 85 K/m^2 =	15.300
Heat treating and edging shop	36 x 12 m = 432 m^2	@ 85 K/m^2 =	36.720
Cold pressing and sheet shop	36 x 12 m = 432 m^2	@ 85 K/m^2 =	36.720
Welding shop	12 x 12 m = 144 m^2	@ 85 K/m^2 =	12.240
Locksmith's shop, assembly shop	36 x 36 m = 1.296 m^2	@ 85 K/m^2 =	110.160
Quality control, paint shop	36 x 15,8 m = 568 m^2	@ 85 K/m^2 =	47.280
	5.500 m^2	K	441.300

Amortization for 45 years: K 11.032 /year

The construction of the offices, administration and auxiliary buildings can be started at the beginning of 1975, for the planning won't be finished before the end of 1974. - Thus the amortization rates of these buildings cannot be calculated in before 1976.

Calculation for the amortization rates of fixed assets and buildings and that for wages

12. **Wages:** (Calculation for 1975) in K

Personnel for the following workshops: foundry, cutting and joint screw making shops, heat treating and edging shop, cold pressing and sheet shop, welding shop, locksmith's, assembly shops, quality control and paint shops)

Employee:	Person:	Cost/year/person	Total:
Skilled workers	30	1.000	30.000
Semi skilled "	40	600	24.000
Unskilled "	50	500	25.000
Technician	3	5.000	15.000
Certificated engineer	2	13.600	27.200
Maintenance mechanics	4	600	2.400
Material handler	3	400	1.200
Cleaners	6	400	2.400
Quality control inspectors	2	3.000	6.000
Administration cost		12.000	12.000

Total cost: K 145.200

Personnel for the forge-shop:

Skilled workers	10	1.000	10.000
Semi skilled "	14	600	8.400
Unskilled "	15	500	7.500
Technician	2	5.000	10.000
Certified engineer	1	13.600	13.600
Maintenance mechanics	2	600	1.200
Material handler	1	400	400
Cleaners	3	400	1.200
Quality control inspectos	2	3.000	6.000
Administration cost*		16.000	16.000
Clerk	1	2.400	2.400
Manager	1	16.000	16.000

Total cost: K 92.700

*is certain to increase

13. General expenses:

	Forge-shop	Other workshops
a. Insurance	2.300	2.600
b. Maintenance	3.100	3.400
c. Town development contribution	3.000	3.300
d. Semi-fixed assets(tools)	4.600	5.200
e. Presecure	1.500	2.500
f. Advertisment	2.000	2.400
g. Transport (goods)	7.500	9.000
h. " (personnel)	3.600	4.000
i. Travelling	2.500	3.000
j. Sundries	5.000	6.500
Total:	K 35.100	41.900

VI. Proposal for the equipment of the proposed new Agricultural Machinery Factory's workshops, with outline of the technological processes

VI/A. Forge-shop

Agricultural machinery and implements - should they be hand tools, animal or tractor-drawn implements - are expected to be attrition-resistant and of long life, considerang that they are exposed to considerable physical and mechanical bearing forces during the cultivation of soil. These bearing forces are especially considerable in the Zambian heavy, dry and often gritty soil conditions.

Consequently, several parts of the agricultural machinery and implements (e.g. ploughshare, furrow, harrow tine, subsoil knife, carriage axle, etc.) as well as some finished goods (hoe, spade, bush clearing knife, hatchet, etc.) must be forged in order to make them hard and long-wearing.

For several technical reasons a blacksmith's shop is absolutely necessary for the production of agricultural machinery. This investment is to be considered as elementary, especially if we take into account that this would be Zambia's first blacksmith's shop.

To produce certain parts by forging and generally by plastic shaping is much cheaper than shaping by machine tool. E.g. the production of a scotch cart's axle needs about 5 hours/piece by shaping by machine tool, and about 6-8 minutes/piece by forging in two steps in a die. Modern production technology requires that shaping by machine tool be only applied when it is inevitable.

Forging is the most economical and suitable manufacturing process for the production of agricultural tools and machinery, requiring great toughness and long duration of life, this technology being cheap, quick, accurate and forming the structure of the raw material so that the product will be considerably stronger and more compact and wear-resisting, with more durable edges.

Furthermore it is also important to consider that this forging-machine is very suitable for mass production of spare parts. These spare parts will be good for supplying the artisans in the future.

It is also the aim of UNIDO to provide technical advice for the Zambian Government and those competent, on machinery to be chosen correctly. For this purpose I should like to state some of the most important requirements concerning the forging machine. The forging machine must be able to do the following four main tasks:

- during the placing and turning of the pieces to be forged the hammer should stay in a secure, upper position (against accidents);
- if we want to press the work-piece against the anvil, the ram should stay let down on the work-piece;
- During forging, the hammer should perform alternate knocks;
- the ram should be conducted plumb so that the upper and lower parts of the die cannot move compared to each other.

In order to give a chance of choosing, the characteristics of three different kinds of forge shop are enumerated here:

1. mixed operated
2. with die
3. blacksmith's shop for the production of agricultural implements.

Products to be manufactured are: ploughshare, furrow, knife coulter, reversing lever, hoe, axe, pick-axe, bush knife, rake harrow tines, hand-operated weeder, sickle, fertilizer distributor spoon.

	Name of the blacksmith shop		
	Mixed operated	With die	For the production of agricultural implements
Weight of the piece to be forged in the case of free forging moulded, in kg	1-100	-	-
Weight of the piece to be forged in die, in kg	0.5-10	0.2-10	0.2-5
Character of the production	piece or small serial production	medium and large serial production	large series
Production/year in t/year	3,000-10,000	2,000-5,000	2,000-10,000

		Mixed operated	with die	for the production of agricultural implements
Productive equipment	Weight of the free moulding hammer's ram in kg	150-1,500	-	-
	Weight of motor driven pneumatic hammer's ram in kg	-	-	75-750
	Weight of die hammer's ram in kg	300-3,000	500-4,000	500-4,000
	Weight of push-pull hammer's ram in kg	-	6,000-13,000	6,000-13,000
	Weight of the drop-hammer's ram, provided with strap, in kg	-	-	50-1,000
	Pressing force of the flash press, in t	100-200	60-300	60-300
	Pressing force of the eccentric press, in t	-	-	50-200
	Pressing force of the frictional press, in t	-	-	50-200
Furnaces	Surface of the chamber kiln, in m^2	0.2-1.5	-	0.5-3.0
	Surface of the breach furnace, in m^2	0.1-1.0	0.1-1.5	0.5-2.0
	Capacity of the travelling furnace, in t/hr	-	0.02-0.1	0.01-0.3
	Surface of the retary furnace, in m^2	-	-	1.0-3.0
	Capacity of the contact heated or induction furnace, in kW	-	30-100	-
Transport equipment	Capacity of the beam crane, in t	2	2	2
	Capacity of the crane bridge, in t	3	5	5
	Capacity of the hand-operated rotary crane, in t	0.5-1.0	-	-
	Hand-operated trolley	necessary	necessary	necessary
	Electric trolley	"	"	"

		Mixed operated	with die	for the production of agricultural implements
Size of workshops	Width of the main workshop, in m	8-12	12-20	8-16
	Free height under the crane bridge, in m	6-8	8-10	7-9

The estimated capacity of the blacksmith's shop should be from about 800,000 to 1 million forging operations per year.

One will have to take into consideration several requirements before making a choice as far as the purchase of machinery and equipment is concerned. E.g. the soil conditions on the ground where the setting up of the workshop is concerned; the effects of the oscillation caused by the forging machine on the surroundings, neighbouring houses, etc; the price, possibility, etc. of the machinery to be purchased (commercial market research).

These are the reasons why the parameters, given above for the different types of machinery are aimed at on a basis only for a subsequent technical study, for the technolgical planning.

The main basic condition of mass production is the forging in die. The production of agricultural tools and implements and the forging in die require hammers with quick power impulse, rather than slow machines like the forge-press. As I said before, agricultural hand tools and spare parts must be hard-wearing as they are exposed to large bearing forces. The toughness of the material is ensured by forging in die, as the red hot steel takes on the shape of the die on the impact of the stroke. The amount of steel put in the die is always greater in volume than that needed for the filling up of the die, therefore the forged piece will be more compact. The structure of the material is formed very quickly during forging which enables it to meet the above requirements.

Auxiliary forging plants

1. Forging takes place when the material is in a malleable state, i.e. at a very high temperature. Consequently a furnace must be set up in the blacksmith's shop. The primary condition of a good furnace is a minimum formation of scale (it wears down the die very much), therefore the atmosphere of the furnace must not be oxidizing. This is why it is also important that the work-piece should not be in the furnace for longer than is absolutely necessary, the atmosphere of the furnace being more or less oxidizing.

Comprehensive table on the order of die forging equipment

Forge piece: Average of dividing plane in mm	Forge piece: surface of dividing plane in cm^2	Forge piece: average weight in kg	Mechanical pneumatic hammer, in t: min	Mechanical pneumatic hammer, in t: max	Drop-hammer, in t: min	Drop-hammer, in t: max	Push-pull hammer, in kg: min	Push-pull hammer, in kg: max	Flash press, in t: min	Flash press, in t: max
20	3.14	0.04	0.2	0.2	0.25	0.25	-	-	50	70
40	12.6	0.2	0.2	0.3	0.25	0.4	-	-	70	100
60	28.3	0.6	0.3	0.5	0.4	0.6	-	-	100	125
80	50.3	1.2	0.5	0.75	0.6	0.8	-	2,000	125	160
100	78.5	2.0	0.75	1.0	0.8	1.0	2,000	3,000	125	200
120	113	3.0	1.0	1.35	1.0	1.35	2,000	3,000	150	250
140	154	4.5	1.25	1.5	1.6	1.8	3,000	4,000	160	300
160	201	6.5	1.5	2.5	1.8	2.7	3,000	5,000	200	300
180	254	8.0	1.8	3.0	2.3	3.4	3,000	6,000	200	350
200	314	10.0	2.0	3.5	2.7	4.0	4,000	8,000	250	350

N.B. The minimum value is 6.5 - 7 kg/mm^2 concerning round-shaped forge pieces. The maximum value is 9 - 10 kg/mm^2 for long-shaped forge pieces. One can interpolate between the two values.

The second condition is that the rate of heating should not exceed a certain limit. If it does, i.e. the difference between the temperature of the work-piece and that of the furnace is too big, the surface of the work-piece would get overheated too quickly, while the inside of it would be heated more slowly. This process could easily result in considerable stress and strain. The outside, warmer parts would stretch better than the inside, colder parts. This could lead to fractures or to the breaking off of the cutting edges (ploughshare, knife coulter, etc.).

I mention the above requirements in order to show some of the precise procedures which are to be followed, as they are necessary for the perfect technology of forging.

The different kinds of furnaces, indicated in the first table of this chapter, can also be distinguished according to their need of combustible material. Taking into consideration the energy base of Zambia, the relatively cheap electric current would offer motives for using electrically-heated furnaces (electric, resistance furnace, induction and contact heating). There are also furnaces heated with liquid fuel (mazout, gas oil) or with gas (natural gas), but these latter ones cannot be recommended because of their being much more expensive than the previous ones.

The electrically-heated furnace, e.g. induction heating (by generator) is much quicker than any other kind of furnace. Its great economic advantage is that, owing to the short heating up period, the formation of scale is rather limited which ensures a negligible loss of material. The use of this system makes the forging process very fast, especially in the production of agricultural machinery which consists of the large scale production of parts of the same size (ploughshares, harrow tines, hoes, etc.).

2. The compressor plant supplying compressed air for the forge shop (for the blowing of the die, for the door-moving rolls of the furnace, etc.) also provides the complete workshop with compressed air, (e.g. in assembly shop: hand-drilling machine, screwing machine; painting shop: paint distributor, etc.). The capacity of the compressor cannot be specified until the detailed technological plan is ready.

Construction requirements

Owing to its heat output and flue gas pollution, the forge shop must be accommodated in a separate part of the building. The shop itself must be high, spacious, bright and easy to air with natural air draught. Artificial airing must only be used in the forge shop if inevitable. It is important to make the foundation of the forges, requiring important depth, at the same time as the foundation of the workshop, when there is no restriction.

Informatory values on the dimensions of the machinery's foundation

Type: Name	Type: Characteristic weight of ram in kg	Minimum depth of foundation in m	Area of bearing of the foundation in m^2	Volume of the foundation in m^3
Mechanical pneumatic hammer	750	2.3	8.7	20
	1,000	2.8	12.4	35
	2,000	4.2	13.1	55
	3,000	5.0	16.0	80
	3,500	5.3	18.0	95
Drop hammer	500	2.2	5.5	12
	750	2.4	6.5	15.5
	1,000	2.7	7.4	20
	t			
Flash press	150	1.2	3.9	4.7
	200	1.4	3.4	4.8
	300	1.6	3.5	5.6
	350	1.7	3.5	6.0

The data indicated above are valid only when the minimum depth of foundation is accompanied by a soil of adequate bearing capacity.

VI/B. Small Foundry

When manufacturing agricultural machinery and implements, there are several parts of sophisticated form (e.g. shifting device of the two furrow half-turn plough, wheel centre of ploughs, scotch carts, etc.) which will require the establishment of a small, mixed operated foundry for grey iron and steel.

In Zambia there are only two foundries, one in the Copperbelt and the other in Lusaka (Foundry Salvage and Supply Co. Ltd.). The foundry in Lusaka is already overcharged and that on the Copperbelt works only for the mines.

Thus the foundry proposed to be set up at Kabwe would be the third one in the country and besides manufacturing parts necessary for agricultural machinery and implements, it could also undertake commission work (e.g. for the central workshop of Zambia Railways at Kabwe, etc.) If the foundry were operated in two shifts, its investment costs would be repaid in a relatively short period.

Presumably the following parts should be manufactured by the proposed small foundry in a whole production year:

9,300	pieces	of	wheel centre for ploughs	(@ 1 kg)	9.3t	grey iron
5,500	"	"	" " " ridgers	(@1.2kg)	6.6t	" "
1,000	"	"	" " " seeders	(@0.8kg)	0.8t	" "
4,000	"	"	cellular wheel " seeders	(@0.5kg)	2.0t	steel cast
2,500	"	"	shifting device of two-furrow half-turn plough	(@2.5kg)	7.5t	"
3,000	"	"	wheel centre of many sided cultivator	(@1.3kg)	3.9t	grey iron
1,600	"	"	running wheel centre for roller ploughs	(@2.5kg)	4.0t	steel cast
300	"	"	lifting device for tie ridgers	(@4.0kg)	1.2t	"
600	"	"	wheel centre for scotch carts	(@3.0kg)	1.8t	"

According to the character of the product, the foundry will standardize production so that the preparation of moulds, the melting of metal, the casting and emptying are done simultaneously.

Technical equipment of the mixed operated foundry:

a. Melting equipment:

Considering that the price of electricity in Zambia is very favourable and other sources of energy are imported into the country (e.g. fuel oil, gas, coke), I can only propose the use of melting equipment operated with electric arc-light. This can be: (a) one-phase arc-light melting furnace, provided with graphite sticks; (b) three-phase arc-light melting furnace (Heroult in type); (c) melting furnace provided with arc-light and bottom-electrode; (d) arc-light melting furnace with inductive bottom-heating.

From among these furnaces the Heroult type has the best qualities for casting steel and iron, grey cast iron of quality and profile steel casting.

Considering that an economic analysis must be done prior to investment, in order to see how much commission work can be done in the foundry besides the factory's own requirements, I am indicating herewith some characteristic data of the arc-light furnaces of different ores, giving information for final investment planning: see following page.

The electrode regulation can be: electric - mechanical - electronic - hydraulic, etc.

The furnace-body tripper device of the arc-furnace can be: mechanical (with electric engine) - hydraulic.

Methods of charging:

- by hand; maximum efficiency of supply 65%
- by electric crane; maximum efficiency of supply appr. 45%
- by slipway, tripping the furnace by 45°; " " 50%
- with bucket; maximum efficiency of supply 95%

The production of steel-cast in converter requires cheaper investment and its running is also simpler, but the quality of this steel-cast would be the poorest.

Iron has a relatively low melting point and thus its melting in the electric arc-furnace causes no difficulty and requires no special treatment.

It must be taken into account that the chemical composition of the iron would change, to a certain extent, during melting: the silicon and manganese content of the iron would decrease and that of the carbon would slightly increase.

The carbon content of the iron-heat can be decreased on purpose, by adding steel scrap. The less in silicon and manganese can be decreased by adding sufficient limestone for scorification and by ensuring sufficient air for the melting.

The phosphorus content would stay almost unchanged and the increase in sulphuric content is negligible in the arc-furnace; in the case of core or fuel-oil heating the sulphuric content would considerably change according to the sulphuric content of the combustible. I do not want to give details here on the melting process of the chilled cast-iron, but it must be

Characteristic data of arc-light furnaces

(Hand charging up to a capacity of 3 t and loading with bucket only, from a capacity of 5 tons)

Nominal capacity in t	Capacity of the transformer in kVA	Energy required for melting in kWh/t	Cooling-water consumption in m^3/h	Diameter of the electrode (graphite) in mm	Time of melting in min	Carbon-steel produced by a one-slag basic operation: Consumption in electrode in kg/t	Duration of one complete heat in min	Specific output in t/h	Average melting capacity /year* in t/year	Requirement in energy of one complete heat** in kWh/t
0.5	500	560	2	100	45	6.0	75	0.40	2,900	840
1.0	1,000	530	3	150	45	5.6	75	0.80	5,750	800
1.5	1,200	500	4	150	50	5.4	85	1.05	7,550	750
2.0	1,500	490	5	175	60	5.2	105	1.15	8,300	730
3.0	2,000	480	6	200	70	5.0	115	1.57	11,300	720
5.0	3,500	470	8	300	75	4.7	135	2.22	16,000	700
10.0	5,000	460	10	300	85	4.2	155	3.90	28,000	690
20.0	7,500	450	15	400	110	4.0	200	6.00	43,200	670

* yearly production calculated on 300 working days' basis, three shifts a day

** informative data only (considerable differences are possible).

mentioned that its surcharge above approx. 1,456°C is definitely advantageous since it contributes to the refinement of the graphite granularity, thus increasing the solidity of the chilled cast-iron. There are other methods, too, for the regulation of the graphite's crystallization, for distributing it extremely finely (e.g. treating with ferrous silicon, etc.) but this must be worked out in detail in the production technology.

The steel casting technology has several important differences from that of the chilled cast-iron. Steel has a higher melting point than iron. The fusing of the steel takes place in the above-mentioned electric furnace which kind of furnace assures the best quality steel.

It is important that the electric arc-furnace must have a lining of acid reaction, which would prevent the dross, resulting from the melting of the steel, from sticking; consequently it is easier to manufacture mouldings in this kind of furnace.

There are several possible working processes for the melting of steel, re. the manufacture of steel-cast in the electric furnace, but the relating details must be worked out in the production technology.

Mention must be made of the fact that the rough cast structure is characteristic of any kind of steel-cast. In order to achieve a grain-refinement, the steel-cast must generally be heat-treated. The heat-treatment consists of grain-refining heating. On the effect of this heating the grains would become considerably finer and the expansion and shrinking power of the cast, and even its solidity would increase, which is an important standpoint in the case of the parts of agricultural implements, exposed to remarkable attrition and bearing forces.

In the case of steel-cast with thinner wall (about 10 mm thick with 0.1% carbon content), where the micro-structure is not so rough, owing to the quick cooling down of the thin walled cast, the heating is generally omissible, but even in this case the cast must undergo a heat-treatment releasing it from the stress and strain.

b. The casting moulds:

These are the negative forms of the parts of agricultural implements to be manufactured. They can be prepared of sand or metal. Taking into consideration that in the new agricultural machinery factory proposed for Zambia, the same part will have to be manufactured by mass production in large numbers, for several years, it is advisable to use metal moulds, in spite of the fact that the cost of shaping and production of the metal moulds is high. The use of these metal moulds allows a production of larger numbers at a time, which makes it pay and there is no need to do the countless operations necessary for the preparation of sand moulds. Also, the use of metal moulds does not require special qualifications, which is the case when using sand moulds.

When melting grey iron it must also be taken into consideration that the meta mould conducts the heat more quickly than the sand and thus the material of the mould will have an effect on the texture of the cast. For this reason the moulds must be lined with fireproof material when casting grey iron. The cast can touch the metal mould itself on places where we want to have a firm, cementite-bearing structure (e.g. the boring of wheel centre, the supporting surface of the shifting device for the two-furrow, half-turn plough, etc.).

On the surface where the contact with the metal mould resultd in quicker cooling down, there will be a firm crust developed, but the cooling speed of the inner parts is small for the development of grey cast iron by fallout of graphite.

When casting in metal mould, the surface of the mould, which is in contact with the cast, must be rubbed with oily graphite and the cast must be taken out from the mould when still in light red heat. The further cooling down must take place slowly to let a grey cast iron come into being. This is very important, especially in the case of parts of agricultural machinery.

From the technical point of view these casting processes are very advantageous, because the hard surface is wear-resistig while, owing to the inner grey part of it, the cast is not so brittle, as if it consisted of cast-iron in its full cross-section.

The formation technique of the steel-cast is, in principle, the same as that of the iron-cast. There are very important differences, however, between the gate-channels, the placing and size of the cut of the mould.

In order to make casting in metal moulds quicker and more productive, one mould can be used for casting simultaneously several, smaller parts of the agricultural machines. In this case one gate-channel can be used for one mould, containing several smaller moulds. The metal is then forwarded by a ramifying channel system to the individual moulds.

As far as the casting techniques are concerned, it is much more difficult to make steel-cast, than iron-cast. One of the difficulties is raised by the higher melting point of the steel. The steel-cast shrinks more, which should be taken into consideration when making the moulds, and precautionary measures must be taken allowing the cast to shrink without restraint, etc.

These factors must be emphasized in order to give an idea of the necessity of ensuring a UNIDO foundry expert for the periods when setting up the foundry and when it starts to function, for at least one year.

Since I propose the use of metal moulds, there is no need to give details of the techniques and technology of using sand moulds. When using sand moulds, which is a complicated process in itself, more space, material and machinery (moulding machine, mould drying furnace, etc.) as well as more manpower is needed than in the case of metal moulds.

c. Auxiliary equipment and casting appliances:

For serving, feeding and teeming the furnace, a five ton capacity electric travelling crane is needed in the foundry workshop. The materials must be transported when stocking, measuring and portioning. This can be done by magnetic lifter, mechanically controlled balance conveyance and mechanically controlled portion collecting conveyance, etc. mounted on different kinds of cranes.

In the case of the electric arc-furnace with material lifted by bucket, the transport of material can be solved by bucket transporting conveyance, operated mechanically, by goods lift or by transferable belt-conveyor.

The liquid iron and steel respectively will be drawn off and teemed into a crucible which can be transported to the place of casting by a crane equipped with crucible fork. The crucibles are made of steel and lined with refractory matter.

There are different types of equipment for cleaning the cast. The cast seam and the rest of the feed-head can be removed by compressed air chisel, oxy-acetylene or arc-light cutting device or by special saw or other equipment. The superficial cleaning of the cast can be done by different kinds of equipment. The final decision must be made in the investment plan, on the basis of the technological plan.

d. Composition of the heat:

For chilled cast iron this will be determined by the detailed technological plan and the production plan respectively. Nevertheless, when deciding on the location of the proposed factory at Kabwe, it must be taken into consideration that the mines on the Copperbelt, which are relatively near and easily accessible, appear to be a rather good source for foundry and steel scrap.

Finally, the composition of the required cast must be ensured by the mixture of crude iron, own and outside casts and steel scraps available. Only the smaller quantity of ready-made alloy can be used expediently. The finished casts will have to undergo a technical control before being used (outside defects, chemical composition, weight, structure, porosity, static properties etc.).

e. Requirements of construction:

These are similar to those of the blacksmith's workshop, with the difference that in front of the melting furnaces there must be a free piece of ground as well as a separate area for casting. In addition to this, there are strict requirements for the storing of the material.

The melting-shop building must be attached to the store. The height of the building must be greater than that of the average buildings (similar to the blacksmith's shop) in order to assure good, natural ventilation (see illustration), but the cleaning apparatus for castings must be equipped with a special aspirator and must be set up, as far as possible, in the outside hall of the foundry.

The flooring of the foundry is stiff clay. The arc-light furnace must be, if possible, at the end of the workshop hall. Separated by a heat-insulated wall, the transformer, choking coil, condenser, etc. of the electrical foundry (re. melting furnace) are also situated in this part of the workshop hall, so that they are easily accessible from outside.

f. Storage of material and equipment:

The raw materials, steel and iron scraps, will be transported by rail to the proposed Kabwe Agricultural Machinery Factory, partly from the port of Dar-es-Salaam, via the new Tan-Zam railway (presently being built), partly from the Copperbelt by the existing railway. The unloading will be done by lifting magnet, mounted on a crane-hook, into a covered material store (of iron or reinforced concrete structure); or into a reinforced concrete bunker on the surface or sunk into the ground.

The different kinds of materials must be stored in separate bunkers, on the basis of the quality certificate attached to the consignment. It is important that at least two bunkers are provided for every kind of material so that the materials in stock can always be used up entirely and the newly-arrived material must not be put on the old.

- It is recommended that the alloys be stored in carefully separated dry boxes or cases;
- the electrodes of the electric furnaces must be stored free of water and dirt;
- The slagging mediums (limestone, fluorite, magnesite, etc.) should be stored, as far as possible under shelter;
- when storing the cleaning agents (de-oxidizing, de-gassing unit, protecting salt, chlorine gas, sodium, etc.) the main point is the complete separation of the different agents and their protection from dirt and the inclemencies of the weather.
- the refractory material for the arc-furnace and the casting ladle must be kept under cover and well separated from each other;
- the auxiliaries for the foundry, etc. (tools, working dresses, etc.) are kept in a central depot;

- when deciding on the size of the store-house for finished products, the quantity of the castings to be stored and the duration of storage must be taken into consideration.

Considering that the proposed Kabwe Agricultural Machinery Factory will have to store commissioned work besides it own products, separate space must be assured for this purpose.

The inner ways of the storehouse will take up about 50% of the surface. The side track of the railway will be built up to the stores, with a platform.

In order to make the best use of the material hall's space, equipped with cranes, the bunkers near the rail-track should not be higher than the platform itself. In this way the distance betwenn the rail-track and the wall of the bunker will be reduced to a minimum. It is to be recommended that the rail-track to be used for the transport of materials be built so that it can serve the storehouse for finished castings too.

The space between the storing bunkers and the daily portion container, as well as between the rail-tracks must be paved, so that public vehicles can also use this space. The bunker for keeping dust and refuse must be put above one of the side-tracks, possibly outside the material hall.

On 1m^2 of the storehouse about 1t of casting can be store on average. In order to achieve quick and precise handling, the castings should be kept in sheet metal boxes, equipped with legs, so that they can be put on each other by fork-lift truck.

For information, I am giving here a summary of figures on the storage weight and height of the foundry's raw materials:

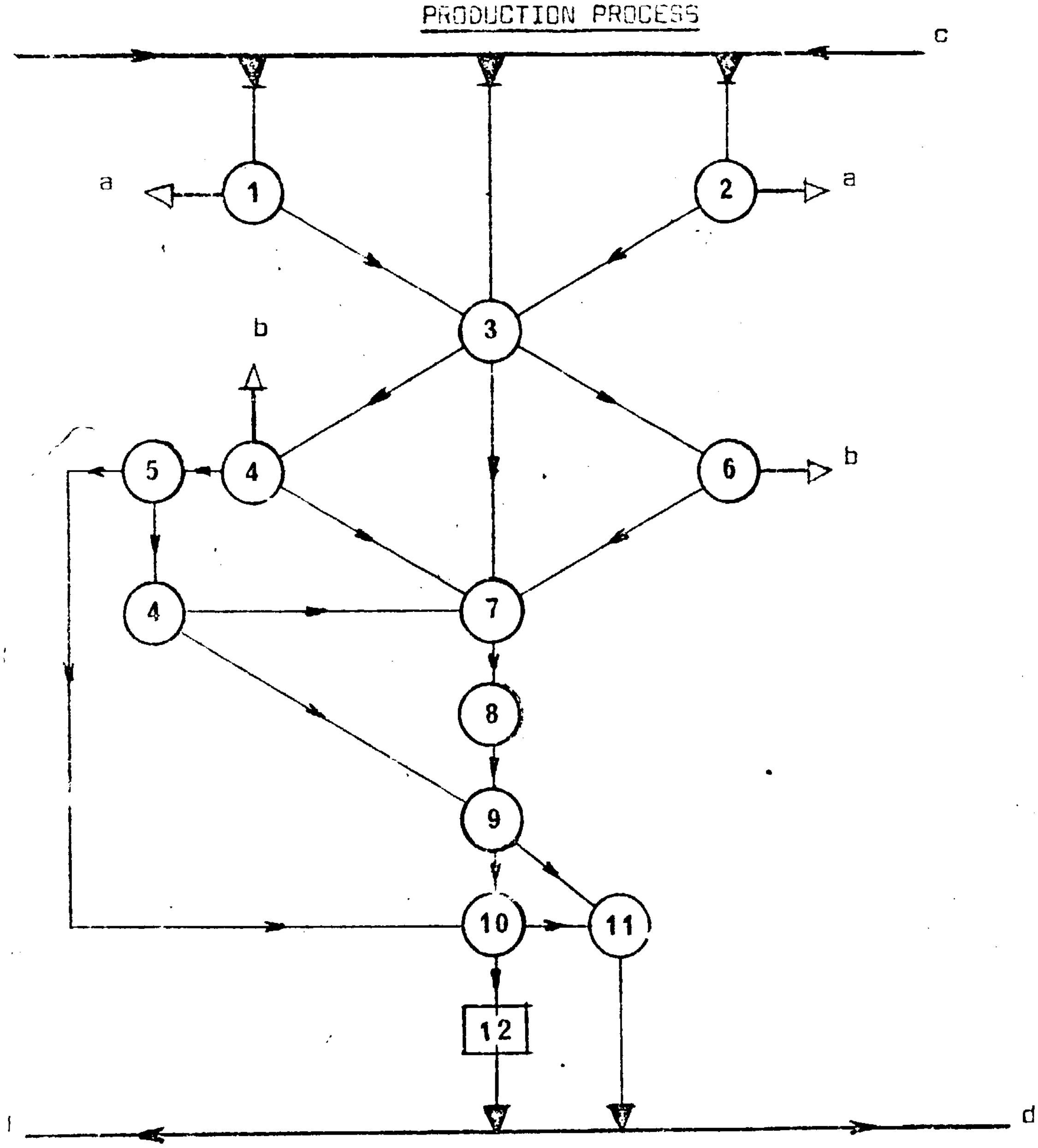
Material	Specific gravity t/m^3	Height of storage in m in non-mechanized store	Height of storage in m in mechanized store
crude iron	3-3.5	1.5	3
cast iron scrap	2-2.5	1.5	6
steel scrap	1-2.5	1.5	6
own scrap	1-1.7	1.5	1.5-2
alloy	3-4	1.5	1.5-3
coke	0.45-0.50	2	2.5-4
limestone	1.5-1.8	2	3-5
refracting sand	1.5-2	2	2-3
sand	1.2	3	5-8
clay	1.5	3	5-8
sawdust	0.6	2	3
peat	0.6	2	3
coaldust	0.8-0.9	2	3
slag	1.6-1.8	2	3.5
ash, flue-dust	0.7	2	3.5

VI/C. Other workshops

I have put down all these details on the above workshops because they are the most important ones.

It is proposed that all the other workshops be specified in the Feasibility Study.

The function schema of the Kahwe agricultural machinery factory's PRODUCTION PROCESS



1. Blacksmith shop
2. Small foundry
3. Transitional store for the cold workshop
4. Chipping and joint screw shop
5. Heat treating and edging shop
6. Cold stamping and plate shop
7. Welding shop
8. Locksmith shop
9. Assembly shop, quality and production control
10. Painting shop
11. Spare parts' store, joint screw packing
12. Finished goods' and commission work store

a. Combustion and foundry refuse
b. Chipping and plate scrap
c. Raw material supply, outdoor stores
d. sales, Namboard, spare parts' transport to Rucom workshops

Conclusion

After having finished and studied such a report, the question is raised in almost every case, whether the development of agriculture is effective or not?

As a matter of fact, it cannot be a determinant principle to produce only what is needed by a subsistance family itself (more than half of Zambia's population are subsistence farmers) i.e. to produce the minimum necessary for existence.

Zambian agriculture cannot meet the requirements and fulfil its obligations for development if it does not increase its effectiveness, i.e. if the majority of the population does not change from subsistence farming into emergent farming, etc. All the possibilities are given for this change, the country having favourable climate and sufficient rain.

In order to make use of these favourable conditions, more and up-to-date hand-tools and oxen-drawn implements are required. This means that agriculture cannot develop unless several branches of industry provide it with sufficient good quality and cheap implements. In order to meet these requirements, the first step is to set up a new Agricultural Machinery Factory in Zambia.

Having arrived at this concludion and made my proposals for its practical implementation, I wish success and good results. I hope my study will be put to good use and ensure an improved livelihood and prosperity for all the people of the Zambian nation.